

School of Education

Science and Mathematics Education Centre

**An Investigation of Exemplary ICT Integration: Enablers and
Inhibitors of Best Practice in New South Wales Schools**

Colin Robert Harrison

This thesis is presented for the Degree of Doctor of Philosophy of Curtin University

June 2017

DECLARATION

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature: 

Date: *29/5/17*

ABSTRACT

(200 words)

This study sought to apply the principles identified by self-assessed exemplary integrators of technology in New South Wales secondary science and mathematics classrooms. Information regarding inhibitors to, and enablers of, exemplary ICT integration were investigated through literature review, by the administration of an online survey and through qualitative interviews. The study sought to determine the critical factors which define effective integration of technology and whether they are common across a range of variables including sex, subject taught and the school's cultural emphasis.

Educators' self-assessment of ICT integration level was tested against responses relating to demographics, level of computer usage, types of activities carried out by teachers and their students, outcome expectancy and personal self-efficacy. The most statistically significant link was found between educator self-assessment of ICT integration and personal self-efficacy. The high level of statistical significance between self-assessment of ICT integration and personal self-efficacy persisted when moderated against cultural emphasis within the school, subject taught (science or mathematics) or sex of the educator.

Several inhibitors and enablers of effective ICT integration were identified and recommendations made for future professional learning around the integration of technology into secondary classrooms. Primarily time, training and tenacity were viewed as the most significant contributors to exemplary practice in the areas of personal qualities and professional practice.

Teachers from schools with a dedicated Head of eLearning or unofficial expert with a time allocation, who fosters multidisciplinary cohesion and who can be approached for pedagogical advice, independent of the infrastructure challenges, are more likely to report greater levels of professional technology expertise and an increase in student autonomy and transformative technology based activities. Future professional development which builds collegiate support groups and provides more

flexible time and delivery modes are recommended in order to foster more effective and exemplary technology integration practitioners.

ACKNOWLEDGMENTS

Any sizable study requires a generous investment of time from a large number of busy teachers. To each person who took the time to complete the online survey I offer my gratitude. To those teachers who went above and beyond by giving up additional time to be interviewed separately in order to enrich this study, my sincere thanks.

This project began several years ago on a different continent in a different hemisphere and throughout the journey, my primary supervisors, Professor John Williams and Dr Tony Rickards, have been a constant support and source of advice. I am very grateful for their feedback, helpful hints and encouragement. I also thank Dr Martin Cooper and Dr Jill Aldridge for their time, support and constructive critiques which helped improve the quality and readability of the final thesis and refine it towards its present iteration. For a thesis which has collaboration as an important finding, it has certainly been advantageous to have been involved in such a collaborative experience with a range of outstanding supervisors.

Several other people have made sacrifices and offered support as I worked slowly and sporadically through this work. I have been blessed with four supportive parents; Frank and Pam and Peter and Sandra. You have each offered support and encouragement, words of wisdom and help in so many large and small ways to enable me to keep at this until it reached its conclusion. Thank you.

To my four children; Paul, Steve, Jess and Mandy. You provide the inspiration to continue to be the best version of myself that I can be. The joy and laughter I enjoy in your company sustained my spirit as I continued to work towards becoming Dr Dad.

Finally, and most importantly, to my beautiful wife Jess. You have endured this thesis with me through each iteration. You have read and re-read chapter after chapter. You have stored a copy of every version and you have held my heart and my hand through each day. I love you. I thank you beyond words. It is time to start something new.

TABLE OF CONTENTS

List of Acronyms	14
Chapter 1 Introduction	15
1.1 Personal Reflections.....	15
1.2 The catalyst for this study	17
1.3 Research Questions	20
1.4 Context for the study.....	21
1.5 Focus of the Study.....	28
1.6 Significance.....	32
1.7 Purpose.....	34
1.8 Summary	35
Chapter 2 Literature Review	36
2.1 Introduction.....	36
2.2 Rationale	37
2.3 Government Investment in Capacity Building.....	39
2.4 Evidence of technology integration in Africa	40
2.5 Evidence of technology integration in Asia.....	46
2.6 Evidence of technology integration in Europe.....	57
2.7 Evidence of technology integration in the Middle East.....	65
2.8 Evidence of technology integration in North and South America.....	71

2.9 Evidence of technology integration in Oceania	80
2.10 Exemplary Integrators of Technology	89
2.11 Summary	103
Chapter 3 Research Design and Method.....	105
3.1 Introduction	105
3.2 Rationale for the study	105
3.3 Research Design.....	108
3.4 Study Sample	113
3.5 Online Survey	117
3.6 Qualitative Interviews	127
3.7 Data Analysis	129
3.8 Ethical Issues.....	137
3.9 Summary	140
Chapter 4 Results	142
4.1 Introduction	142
4.2 The Online Survey	143
4.3 Personal and Professional Computer Use	149
4.4 Reflection on Computer Usage	157
4.5 Level of Computer Use	172
4.6 Specific Applications for Instruction	174

4.7 Teaching with Technology – the MUTEBI scale	177
4.8 Qualitative Component of the Study.....	179
4.9 Correlation of predictive factors against self-assessment category	205
4.10 Testing for common enablers of exemplary integrators	220
4.11 Summary	237
Chapter 5 Discussion	239
5.1 Introduction	239
5.2 Evaluating the drivers of this study.....	239
5.3 Enablers of exemplary ICT integration practice in secondary education	243
5.4 Common Inhibitors of ICT integration practice.....	248
5.5 Factors which separate minimum adopters, competent users and exemplary integrators.....	253
5.6 Key competencies for professional learning around effective technology integration	261
5.7 Summary	267
Chapter 6 Conclusions	269
6.1 Introduction	269
6.2 The importance of this research	269
6.3 Summary of findings from the study	270
6.4 Contribution to the body of knowledge regarding exemplary ICT integration	277

6.5 Limitations of the Study.....	278
6.6 Recommendations for Future Studies	282
6.7 Summary	286
References	289
Appendices.....	311
Appendix A Keys to subject identifiers for personal quotes.....	312
Appendix B Email Approach to Professional Organisations.....	314
Appendix C Email to Secondary Principals.....	317
Appendix D Online Survey – Participant Consent Page.....	320
Appendix E Online Survey – Demographic Data	322
Appendix F Online Survey – Personal and Professional Computer Usage	325
Appendix G Online Survey – Reflection on Computer Usage	329
Appendix H Online Survey – Level of Computer Use	331
Appendix I Online Survey – Specific Applications for Instruction.....	332
Appendix J Online Survey – Microcomputer Utilisation in Teaching Efficacy Beliefs Instrument	333
Appendix K Email follow up for Qualitative Interviews.....	336
Appendix L Qualitative Consent Form and Interview Questions.....	338

List of Tables

Table 1 Relationship between research questions, data collected and analysis	130
Table 2 Self-assessed ICT Integration level.....	145
Table 3 Type of School.....	145
Table 4 School Affiliation.....	146
Table 5 School culture and heritage.....	146
Table 6 Current Role.....	147
Table 7 Main Subjects and Years Taught.....	147
Table 8 Academic Qualifications.....	148
Table 9 Teaching Experience.....	149
Table 10 Self-assessed Personal Use of Computers vs Age.....	150
Table 11 Self-assessed Professional Use of Computers.....	151
Table 12 Preferred Training Methods Part 1.....	152
Table 13 Preferred Training Methods Part 2.....	153
Table 14 Self-assessed Computer-based Activity.....	155
Table 15 Use of computers for different activities by integration category.....	156
Table 16 Internet Access.....	156
Table 17 List of programs identified by category.....	164
Table 18 Discriminators of Computer-using Educators.....	172
Table 19 Level of Computer Use.....	173

Table 20 Comparison between teacher use and student use of technology.....	175
Table 21 Descriptive statistics for MUTEBI Scale.....	177
Table 22 Comparison of means for outcome expectancy and personal self- efficacy.....	178
Table 23 Characteristics of Qualitative Interview Participants.....	180
Table 24 Correlation Coefficients based on TI and LCU.....	204
Table 25 Effects of self-assessed integration category with 5 dependent variables.....	207
Table 26 Correlation for LCU, OE, SE, TA and SA against TI by cultural group.....	207
Table 27 Correlation between Computer Use and Teaching Experience.....	209
Table 28 Pearson correlation coefficients for potential predictive variables.....	210
Table 29 Codes for teaching and learning activities.....	212
Table 30 Descriptive Statistics for Self-Assessment and Teacher Activity.....	212
Table 31 Correlation between Self-Assessment of Technology Integration and Teacher Activity.....	213
Table 32 Effects of self-assessed technology integration on teacher activities.....	213
Table 33 Descriptive Statistics for Self-Assessment of Technology Integration and Student Activity.....	214
Table 34 Correlation between Self-Assessment of Technology Integration and Student Activity.....	215
Table 35 Between group effects for student activities with technology.....	215
Table 36 Stepwise Regression Analysis Summary for Self-assessment of Technology Integration.....	217

Table 37 Stepwise Regression Analysis Summary for Level of Computer Use....	218
Table 38 Stepwise Regression Analysis Summary for Student Activities.....	219
Table 39 Stepwise Regression Analysis Summary for Teacher Activities.....	220
Table 40 Between group differences for experience, activities and training.....	222
Table 41 Between group differences for schools with a focus on ATSI Culture...	224
Table 42 Between group differences for schools with equal focus on different cultures.....	226
Table 43 Between group differences for key enablers for female and male participants.....	228
Table 44 Between group differences for key enablers for science participants....	230
Table 45 Between group differences for key enablers for female science participants.....	231
Table 46 Between group differences for key enablers for male science participants.....	232
Table 47 Between group differences for key enablers for mathematics participants.....	233
Table 48 Between group differences for key enablers for mathematics teachers based on sex.....	234
Table 49 Differences between groups for a range of activities by teachers.....	235
Table 50 Differences between groups for a range of activities by students.....	236
Table 51 Summary of self-assessed PD hours vs category.....	237

Table of Figures

Figure 1: Mind map of key components of the study	18
Figure 2: Gantt chart showing the timelines for the study	31
Figure 3 SAMR Model (Puentedura, 2010).....	91
Figure 4: Mean and mode for different training methods	154

List of Acronyms

AIS – Association of Independent Schools

CR – Coefficient of reproducibility

IBM – International Business Machines

ICT – Information and Communication Technology

K-12 – Kindergarten to Year 12

NSW – New South Wales

OECD – Organisation for Economic Cooperation and Development

OER – Open Educational Resources

PD – Professional Development

PISA – Programme for International Student Assessment

SITES – Second International Technology in Education Study

SPLAC – Science Professional Learning Advisory Council

SPSS – Statistical Package for the Social Sciences

TIMSS – Trends in International Mathematics and Science Study

UAE – United Arab Emirates

USA – United States of America

WRX – Watch, Read, eXplain - flipped classroom model

Chapter 1 Introduction

In the modern age of information and communication technology (ICT) where information is a global currency, it can be easy to underestimate the role of the teacher. This study has been developed to focus on the difference teachers are making with technology. The following chapters seek to identify the enablers and inhibitors of ICT integration into the secondary classrooms of science and mathematics teachers. Its purpose is to identify what actions or traits are common to the more successful ICT integrators and how they could be disseminated more widely through the teaching community.

This chapter includes a personal reflection on the driving forces behind this study. It will include the catalyst for the study, the context in which it has been set and the primary motivators used in narrowing the search criteria for the initial literature review and later online survey and qualitative interview components of the research. This study has been constructed around three research questions and these will be outlined in section 1.3. Some discussion of the significance and purpose of the study will draw this chapter to a conclusion.

1.1 Personal Reflections

In this section, I have attempted to explain the reasons behind my personal desire to investigate the key indicators of exemplary ICT integration in secondary science and mathematics classrooms. I have been teaching students and teachers for almost 30 years. I have done so in the public and private sector, in Sydney, Newcastle and Maitland in New South Wales, Australia and in Abu Dhabi in the United Arab Emirates (UAE). I believe teaching is a craft. Anyone can teach, but to be a good teacher, one who makes a difference, you need to constantly reflect on your teaching and refine your practice. You need to critically analyse what is working and what is not working and you need to maintain an awareness of the changing education paradigm. This is especially the case with information and communication technology. Teachers have always used some form of technology to assist with their teaching. During my own career, this has included chalkboards, overhead projectors,

white boards, flat and interactive, and data projectors, and these are only presentation media. As a science teacher, I have also used technology to enhance the explanation of a scientific concept, facilitate group collaboration through online shared spaces and have investigated the application of QR codes for presentations and multi-user virtual reality gaming for concept exploration. I have found that modern technologies; computers, laptops, tablets and their associated software, enhance the learning experience and increase student engagement. However, since I began my education as a student in the 1970s, the phrase “educational technology” has been in a constant state of flux. I have always enjoyed the challenge of mastering technology and seeking ways in which I could use its many advantages to support and enhance my own teaching. I have also found frustrations with computer technology and an associated determination to overcome technology challenges which are common to teachers independent of the country I visit, or the education system in which I have worked.

In the late 1990s I was working with students in Newcastle, New South Wales. I designed a basic website to assist with the delivery of content and the facilitation of student research projects (Harrison, 1999). It was an appropriate time to reflect on my own practice and to delve more deeply into alternate pedagogies to see how I could expand my skill base, so I began a Doctoral program in Science Education. Circumstances allowed me to complete some valuable course work, but not to complete the thesis.

A break from teaching of almost six years occurred before I worked in the Middle East. Early starts and searing temperatures meant an early end to most school days and plenty of down time in the afternoons. After observing how these students used technology and how diverse their teachers’ responses were, I realised there was great potential for a study which could analyse global trends and identify the ways in which good teachers could always find ways to teach more effectively with ICT, despite the challenges. It was no longer possible to complete the original Doctorate of Science Education, however in its place, this doctoral study began. Originally immense in its scope, sanity and wise counsel have trimmed the focus of the study

back to a more manageable and meaningful scale. It has evolved into the thesis presented here.

My own reason for undertaking this study was simply to become a more effective teacher. The process, as much as the findings, have helped me to critically evaluate what I am doing in the classroom and what I needed to change. I have found great enjoyment in the experience of creating and delivering new materials to my students as a direct consequence of my involvement in this research.

1.2 The catalyst for this study

This study stems from a piquing of interest, based on observations and experience, in the considerable investment which has been made to integrate ICT into secondary classrooms and the ways in which capable teachers have set about manifesting this government-funded vision with their classes. Despite the many ways in which the word ‘technology’ is used, for the purpose of this thesis, technology integration will refer to the specific application of ICT to motivate and enhance student learning in the classroom. Teachers who are integrators of technology in their classrooms have been asked to self-assess their integration level as a component of this study within the context of the application of technology to student learning. Thinking around the issues of effective technology integration based on personal experiences led to a broad mapping of components that might be useful to this study. These are shown in Figure 1 on page 18. The catalyst for this research was the desire to identify the features of classrooms where exemplary ICT integration was being practiced and to do so from an international perspective. Once established pedagogy and practice were identified it was determined to be relevant to the study to draw on the inhibitors and enablers of exemplary ICT integration in secondary science and mathematics classrooms and to determine their degree of commonality across a range of social, economic and cultural boundaries. To maintain a pragmatic approach, any quantifiable patterns in the data could be set into a context of future professional learning activities in order to increase their efficacy in improving the use of ICT in the identified secondary classrooms.

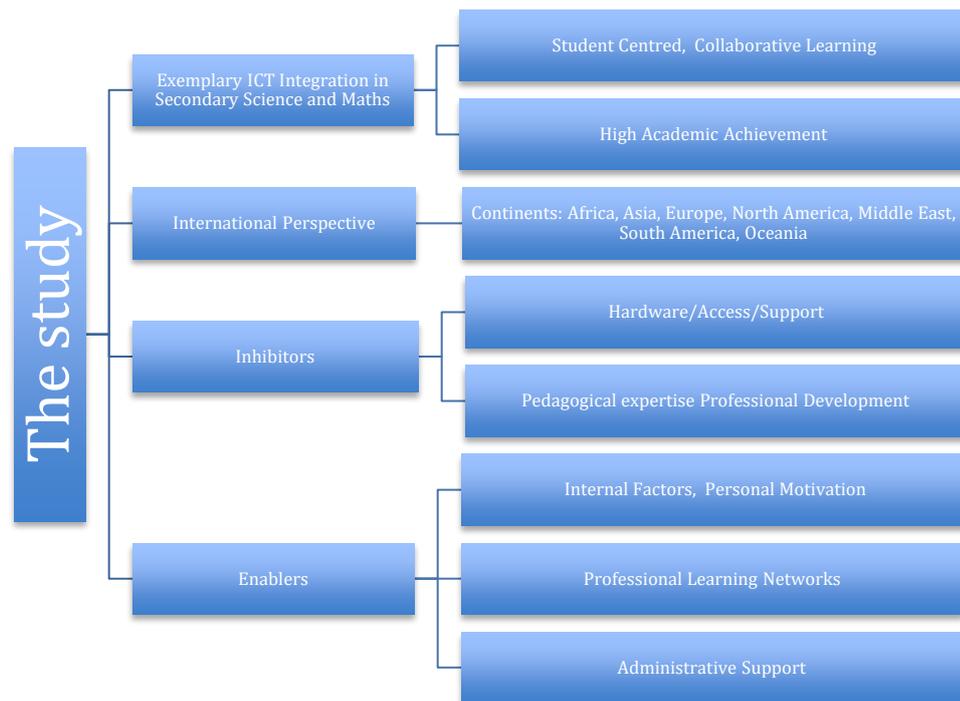


Figure 1: Mind map of key components of the study

The technology revolution has continued to gather momentum over the past 35 years. Schools were introducing policy statements regarding computers in schools in the early 1980s (Education, 1983) and pressure grew on teachers to incorporate ICT more regularly and more effectively into their practice (Gorny, 1995). Only ten years later, exemplary computer-using teachers were being recognised and discussed in the literature (Becker, 1994). Governments began wrestling with the incorporation of technology as an educational requirement, partly as a result of societal pressure, partly “to support the expansion and use of computers in K-12 classrooms” (Ertmer, 2005, p. 26). In the intervening years, teachers’ integration of technology, as a key component of their pedagogy, became more widespread (Webb, 2005) and yet in 2007 the lament remained “the majority of teachers do not believe they are able to make effective use of technology in everyday classroom teaching because they feel inadequately prepared” (Wycliffe & Muwanga-Zake, 2007, p. 474). This appears to be a global phenomenon (Blignaut, Hinostroza, Els, & Brun, 2010), with some authors sharing a view that “global education will be ineffective without e-learning empowered by information and communication technology” (Umeasiegbu &

Esomonu, 2012, p. 45). For the purpose of this study, e-learning will refer to electronic forms of learning which, in practice, is the accessing of tools, applications and knowledge beyond the classroom via electronic means, such as the internet.

Much has been written about the barriers and the promises of technology in the classroom (Abbitt & Klett, 2007; Al-Alwani & Soomro, 2009; Almekhlafi & Almeqdadi, 2010; Alwani & Soomro, 2010; Dunleavy, Dede, & Mitchell, 2008; Hui, Hu, Clark, Tam, & Milton, 2008; Keengwe, Onchwari, & Wachira, 2008; Kozma, 2003). Over the same time frame, there have been a number of studies which focussed on exemplary practices (Alsop, Bencze, & Pedretti, 2005; Angelo, 1996; McNamara, 2010; K. Tobin, Treagust, & Fraser, 1988). Twenty first century learners require the opportunity to make connections, experience competence and mastery, demonstrate autonomy and receive intellectual challenges (Danielson, 2009). Exemplary teachers are a difficult group to define and this has not been for the want of effort in seeking to do so. However, there does seem to be a correlation between teachers who provide opportunities for making connections, encourage autonomous student learning, generate authentic assessment and the competent and creative use of ICT. A few studies have tried to merge exemplary practice with ICT integration (Becker, 2000; Hakverdi-Can & Dana, 2012; Klopfer, 2008). Like any educational tool, computer technology has the potential to be used effectively to engage and motivate the learner. There appeared to be a great deal to gain from a study of exemplary ICT integration. Teachers effectively using ICT in their classrooms may have been doing so for all of their teaching careers and, in some cases, all of their lives (Richardson, 2010). This recent history of teachers using ICT, either for personal or professional reasons, provided a range of attitudes and approaches to the integration of technologies in the classroom from which to gather data about exemplary practice.

To adequately assess technology integration, a current definition was sought. According to Hsu (2016), technology integration is “the use of hardware such as laptops, scanners, smart boards, document cameras, digital cameras, digital camcorders, and handheld computers, as well as related software and the internet, in

classrooms for enhancing learning” (P.-S. Hsu, 2016, p. 31). Despite significant investment by successive governments to improve equity of access to technology (Australian Government Department of Education, 2011) the how of ICT integration continues to change. “Simply adding technology – the thousand-dollar pencil – to the current highly prescribed school culture won’t help very much” (November, 2012, p. 14). Teachers are teaching 21st century “students who have grown up in a visually saturated culture” (B. Tobin, 2006, p. 304). The merits of effective integration of technology as a productive pedagogy have been well documented and will be briefly revisited in the next chapter.

One catalyst for this change in approach has been the many discussions around how professional development needs to change in order to meet the needs of twenty-first century educators. In this thesis, an attempt will be made to distil the characteristics of exemplary ICT integrators and provide guidance and recommendations about the kind of professional development (PD) experiences teachers require to effectively integrate technology into their classroom. In order to achieve these goals, three research questions have been proposed for testing and evaluation. These research questions have been articulated in the following section.

1.3 Research Questions

This section seeks to articulate the focus of this study through the three research questions. The primary goal of this research is to gather data to inform teacher professional learning experiences so that they may be more effective in preparing and skilling educators to integrate technology in their classrooms. In order to do this, the thesis will focus on the following research questions:

1. What are the common enablers and inhibitors of exemplary ICT integration?
2. What are the sets of skills, outcomes and personal motivators which separate a minimum adopter of technology, a competent user of technology and an exemplary integrator of technology in the context of teaching practice?
3. Which of the key competencies could be delivered as elements of targeted

professional development for effective and exemplary ICT integration in the Australian Curriculum context?

1.4 Context for the study

This section will present the case for the need to examine what teachers are doing in their classrooms with regard to ICT integration. It will include a discussion of the ways in which governments around the world have sought to facilitate competent and engaging ICT integration into the teaching profession and the ways in which teachers have sought to incorporate ICT in the classroom as a part of their wider pedagogy.

Governments in many countries have recognised the potential impact of computers in education and have made considerable federal and state budgetary commitments over many years. Reports commissioned during the past 10 years, for example in Australia (Downes et al., 2001), the United States of America (USA) (Noeth & Volkov, 2004) and Ireland (Morrissey et al., 2008), as well as many of the Asian nations (D. E. H. Ng, 2008), have recommended major spending initiatives on infrastructure, equitable access and teacher professional development. This is nothing new. Governments around the world have been investing heavily in ICT for the education sector over the past 30 years (Twining, 2002). Unfortunately the requisite training required to make the most of these resources has been limited, or ineffective in bringing about the desired changes in pedagogy (Black & Smith, 2009; Downes et al., 2001). Professional development throughout this time has tended to be either systemic (Downes et al., 2001), school-based (Angrist & Lavy, 2002), individualised (Ebenezer, Columbus, Kaya, Zhang, & Ebenezer, 2011), mentor-based (Swan et al., 2002) or application-based (Wycliffe & Muwanga-Zake, 2007). Each approach has reported successes and made suggestions for future improvements. Despite the financial expenditure, change has been very slow internationally and tends not to be systemic. Pockets of excellence have emerged (Hakverdi, 2005), often a result of individual choices rather than by educational decree. The barriers, whether real or perceived, remained and many revolved around too few computers and/or too little time for technology-enhanced lesson preparation (Baylor & Ritchie, 2002).

Initiatives, such as the 'Laptops 4 Learning' program, part of the Digital Education Revolution (DER) in Australia, (Australian Government Department of Education, 2008; Australian Institute for Teaching and School Leadership, 2008) highlight the concerns facing government departments of education as they seek to support effective ICT integration in school classrooms. Most of the successes have been ad hoc or serendipitous. The allocation of funds and the identification of similar constraints and recommendations suggest there is value in pooling the data and analysing international trends. This was the impetus for research questions one and two relating to the defining of the characteristics of exemplary learning technology integrators and the degree of commonality of these characteristics across a range of categories, such as nationality, sex and subject specialisation. Kozma (2003) suggested that "technology-supported innovative classroom practices in many countries around the world have many qualities in common" (p. 12). It was the intention of this study to identify the degree of commonality in successful ICT integration between different secondary teachers and determine to what extent these common practices or traits can be formed into a cohesive skill set. Ideally, the skills and qualities which unite exemplary practitioners of ICT integration identified from the study can be used to generate specific recommendations informing future spending and targeted professional development. Data gathered for this component of the study was used to address research question three.

Major government spending programs to improve infrastructure and access to the internet are reflected in the rate of growth of internet users in many countries. Increased expenditure on connectivity is reflected, in part, through the link between internet access, ICT use and student performance in international testing. "An important observation comes from PISA (*Programme for International Student Assessment*) surveys showing that in OECD (*Organisation for Economic Cooperation and Development*) countries ICT use is positively correlated with student performance in mathematics" (European Commission, 2008, p. 8) (italics added). Whilst a positive correlation does not imply causality, it may indicate a higher concentration of exemplary teachers, including those who are exemplary integrators of technology in their classrooms. Data is available on the rate of growth

in internet penetration through internet world statistics (Miniwatts Marketing Group, 2015). The website provides global comparisons on world internet penetration rates and identifies rates of growth by country and by region. Any study of exemplary practice in ICT integration necessitates student and teacher access to the internet. Whilst the presence of a consistent, reliable internet connection does not imply exemplary integration of the technology in the classroom, its absence is one of the most highlighted inhibitors of ICT integration; access to reliable and adequate internet and school-wide networks. This consistently-identified barrier to effective ICT integration across the curriculum, has led to a consequent major focus of government expenditure; increased access to the internet (Ertmer, Ottenbreit-Leftwich, Olgun, Emine, & Polat, 2012). Significant allocations of federal and state budgets have been invested in improving infrastructure to increase internet speeds and bandwidth in schools. The significant expenditure on the part of most governments around the world has been directed at technology hardware, access and infrastructure. As a result, in many countries, “the majority of teachers now have access to and use computers on a regular basis making technical difficulties and lack of access less problematic” (Mueller, Wood, Willoughby, Ross, & Specht, 2008, p. 1524). The application of ICT encouraged by this expenditure has been summarised by geographic region in the following chapter. The organisation of literature relating to effective ICT integration on the basis of geographic region was chosen deliberately to highlight recurring inhibitors or enablers of ICT integration in different parts of the world so as to emphasise emergent commonalities.

There is evidence from the literature broadly linking student learning or student achievement with ICT integration (Balanskat, Blamire, & Kefala, 2006; Chandra & Lloyd, 2008). The direct link between the quality of ICT integration and student performance averages on international tests is less well reported. However, several of the studies reviewed as part of the ICT impact report: *A review of studies of ICT impact on schools in Europe*, (Balanskat et al., 2006) sought to link aspects of ICT presence and use with student achievement, eg PISA mathematics scores. This report drew on 17 separate studies as it sought to “establish a causal link between use of ICT and students’ outcomes based on analysing the statistical relationship between

the use of ICT and students' results in exams or tests" (Balanskat et al., 2006, p. 3). Global data exists for both science and mathematics performance in international testing (Fuchs & Woessmann, 2007) and for the integration of learning technologies into individual lessons. Mathematics and the sciences have also received considerable attention in terms of development of software and technology-based pedagogy to support teaching (Adams et al., 2010; Al-Alwani & Soomro, 2009; Alwani & Soomro, 2010; Baggott la Velle, Wishart, McFarlane, Brawn, & John, 2007; Barab & Dede, 2007; Dede & Barab, 2009; Dunleavy et al., 2008; Morrissey et al., 2008; Niess, 2005; Squire & Jan, 2007; Wycliffe & Muwanga-Zake, 2007). International studies have suggested a relationship between increased access to the internet and some improvement in academic performance in mathematics and science reflected in student performance in Trends in International Mathematics and Science Study (TIMSS) and PISA (Aypay, 2010; Bielefeldt, 2005; Fuchs & Woessmann, 2007; OECD, 2015; Sciences, 2012; Ziya, Dogan, & Kelecioğlu, 2010). It is important to highlight the fact that there is no causal relationship to be inferred from this data as many other uncontrolled variables impact on student performance. There are studies which issue significant warnings about trying to establish causality between technology use and student performance in international testing (Spiezia, 2011; Zhang & Liu, 2016). Without ignoring these warnings, internet penetration and student scores in international science and mathematics testing have been used as a starting point to select, predominantly, countries with a statistically high correlation between connection to the internet and academic performance in mathematics and science in order to identify potential sources of information regarding the ways in which exemplary ICT integrators were using technology in the classroom. However, countries with a lower correlation were also chosen to redress any perceived imbalance and avoid inadvertent exclusion of some potential sources of exemplary technology integration. The common enablers or inhibitors identified globally through the literature search were then used to inform and scaffold the later study into current practice in New South Wales schools to test the notion that such factors are commonly found amongst educators in disparate educational settings.

Whilst government spending on infrastructure is one significant factor influencing ICT integration, the attitude of teachers towards technology is another. Several studies incorporated statistical measures designed to predict whether particular individuals or groups would be more or less likely to use technology for a specifically stated purpose. Views of such measures are mixed. As computers first entered the classroom, initial studies sought to understand “why people resist using computers” (Davis, Bagozzi, & Warshaw, 1989, p. 982). Davis, Bagozzi and Warshaw (1989) concluded that “after a one-hour hands-on instruction, people formed general perceptions of a system’s usefulness that were strongly linked to usage intentions, and their intentions were significantly correlated with their future acceptance of the system” (Davis et al., 1989, p. 1000). The Davis et al model was refined in the subsequent years, but when critically reviewed in 2003, significant deficiencies with the model were identified; “even if established versions include additional variables, the model hardly explains more than 40% of the variance in use” (Legris, Ingham, & Colletette, 2003, p. 202). Ertmer (2005) proposed a more recent explanation for teacher-resistance to technology adoption, based on the application of pressure from either the school, state or national level to “change their pedagogy to accommodate new technologies” (Ertmer, 2005, p. 33). Trying to identify why some teachers, schools and districts have struggled to implement effective ICT integration is clearly a difficult task.

Exemplary practice, whether it relates to teaching in general, subject specialisation or ICT integration, is likewise a difficult concept upon which to find consensus. Numerous attempts have been made to define what separates best practice and exemplary teachers from ordinary practice and average teachers (Alsop et al., 2005; Angelo, 1996; McNamara, 2010; Mumtaz, 2000; K. Tobin et al., 1988). Most studies relating to exemplary teaching focus on the learning environment, the level of student engagement, the quality of teacher-student relationships and/or the use of ICT to enhance learning. There were “four factors that were common to exemplary computer-using teachers: challenges to frames of reference, situated learning, collaborative reflection and long-term collegial interaction” (Mumtaz, 2000, p. 337). Some definitions of exemplary practice focus on the methods, rather than the

outcomes. “Exemplary classroom teachers often make varied use of ICT resources, including the use of simulations, applications using problem-solving activities and drill and practice work and their use of technology tends to be highly integrated into their pedagogy” (S. Martin & Vallance, 2008, p. 35). However, warnings from those who try to identify exemplary practice echo through the literature such as the one issued by Angelo (1996): the identification of “exemplary teaching is only of use if other teachers can learn from the exemplars and improve their own practice” (p. 58). Such warnings underpin all research that seeks to make a difference. Exemplary ICT integration practice will only have pragmatic implications in this study if it leads to improved student learning outcomes and can be used, and duplicated, by other members of the teaching profession. The key is to present a mechanism for facilitating change; the purpose behind research question three.

The digital education revolution has also spawned a number of studies which focused on student learning outcomes. They have likewise reported mixed results. The studies have sought to describe improved student skills with specific technologies (Klopfer, 2008), improved student engagement (Harrison, 1999; K. Oliver, 2010; R. Oliver, 2008) or improved student learning outcomes (Abbitt & Ophus, 2008). In each case, much of the success came down to the qualities and willingness of the teachers to take on the technology and make it a cohesive element of their teaching practice. “Literature on exemplary technology-using teachers characterizes them as using more student-centred learning, viewing computers in terms of function rather than application, and using more complex project-based activities in their classrooms” (Pierson, 2001, p. 426). If one of the goals of ICT integration is to make a seamless transition between the learning activities which involve technology and those which do not, then one preferred outcome is a form of effective, focussed, multidisciplinary cohesion. Exemplary practice requires the blend of technology, pedagogy and content – the technology, pedagogical content knowledge or TPACK model. “Quality teaching requires developing a nuanced understanding of the complex relationships between technology, content and pedagogy and using this understanding to develop appropriate content-specific strategies and representations” (Mishra & Koehler, 2006, p. 1029).

The pressure on schools to prepare students for a world dominated by technology, multi-tasking and collaborative problem solving is increasing. “Collaborative learning requires learners to take greater responsibility for their own learning, albeit with support from the teacher, explore various options to solving problems, and draw on the experience, expertise and ideas of their peers in learning” (Jung, Kudo, & Choi, 2012, p. 1016). Teachers are expected to create “experiences that promote the new set of skills demanded by the 21st century while meeting the realistic constraints of classrooms, schools and other learning environments” (Klopfer, 2008, p. x). Schools have responded, in part, through the use of Web 2.0 tools (Donelan, Kear, & Ramage, 2010; Solomon & Schrum, 2007), Web 3.0 strategies (Rajiv, 2011), augmented reality (Dunleavy et al., 2008) and multi-user virtual environment games to provide experiences which “parallel the activities of twenty first century professionals in knowledge-based workplaces” (Dunleavy et al., 2008, p. 8).

Despite the need to better prepare students for the technological demands of the 21st Century, the reluctance by a significant portion of the teaching community to make the best use of these tools for teaching still remains after almost two decades of this century (Ertmer & Ottenbreit-Leftwich, 2010; Ertmer et al., 2012; Irish, 2017; Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010). One reason relates to the quality and/or quantity of information technology training. “Nearly always . . . technology and specific content . . . are not synthesised into a pedagogical approach that explains how to, and why, use this technology to teach this content” (Ebenezer et al., 2011, p. 8). This was a great challenge for this study.

Time has allowed many teachers to refine their techniques and become skilled in the art of effective ICT integration. Exemplary teachers exist everywhere and many of their characteristics have been identified in earlier studies (McCall, 2008; K. Tobin et al., 1988). Exemplary teachers “maximize student engagement”, ensure “academic work had a high level of cognitive demand”, maintain “a favourable psychosocial learning environment” and use what resources are available, including laboratories “as an integral part of the course” (K. Tobin et al., 1988, pp. 143-146). Exemplary teaching is recognised by students too and they have valuable information to

contribute regarding their teachers. “The best teachers, according to students, are stronger leaders, more friendly and understanding, and less uncertain, dissatisfied and admonishing than teachers on average” (Rickards & Fisher, 1999, p. 448).

The available resources have expanded significantly in the intervening years since such studies were undertaken, although many of the findings do not reflect significant progress within the teaching profession. “Science education literature indicates that school science is often delivered in a conventional way which is very similar across countries and includes transmissive pedagogy, unengaging curricular content, and in the case of physics and chemistry, associated with difficulty” (Boe, Henriksen, Lyons, & Schreiner, 2011, p. 47). Whilst the characteristics of good teaching and good teachers may be consistent over time, it is worth pondering the paradigm shift which is occurring around the role of technology in education (Fisser, Voogt, van Braak, & Tondeur, 2015). With the addition of technology knowledge to content and pedagogy, framed as TPACK (Koehler & Mishra, 2009), it is worth considering the question: ‘how effectively has technology changed the paradigm regarding how teachers teach and how students learn?’ In pondering such a question the focus returns to the character and qualities of the most successful teachers. Have the characteristics of exemplary teaching practice, particularly those of effective ICT integrators, undergone a consequent paradigm shift to seamlessly incorporate learning technologies? The benefit to educators of using common enablers of effective ICT integration to situate the ICT integration practices of New South Wales science and mathematics teachers and, potentially, to inform professional learning experiences would be very significant, particularly if these enablers could be specifically targeted by future teacher professional development programs. This research aimed to address the nature of this paradigm shift around technology and, hence, to contribute towards the achievement of that pragmatic goal.

1.5 Focus of the Study

In the previous section, the need for a description of the practices of exemplary ICT integrators was identified along with the reason for focussing on schools in countries which have high internet penetrations and high international student performance

scores. In this section, the focus of the study will be further developed. It contains an explanation of why certain literature has been chosen in which to orient this study and to justify the structure of the online survey tools and the reasons why particular questions were chosen in order to build on the current literature by expanding the knowledge base during the qualitative interviews.

In order to address research questions one and two, data were gathered from a variety of sources to provide sufficient richness from which some inferences can be made. This begged the question; where does one begin the global search for exemplary integrators of technology in the secondary classroom? One line of inquiry, as outlined in the previous section, is to look at countries with a statistically high correlation between connection to the internet and academic performance in mathematics and science. Other studies have demonstrated some levels of improvement in students' scores on standardised tests, problem solving and student self-concept with the use of technology (Hew & Brush, 2007). The correlations identified in the literature do not prove causality, however they provides a potential source of exemplary teachers and exemplary integrators of ICT. Representative countries were chosen from this pool and their research output scanned for evidence of ICT integration, both in terms of identified inhibitors and enablers of competent technology integration practice. This is the broad purpose of the literature review in Chapter Two. Each major geographic region of the world was examined in detail and the well performed, and highly connected countries represented in these studies were chosen as the focus of the review of exemplary practice for ICT integration. For the purpose of this study, these geographic regions were Africa, Asia, Europe, the Middle East, North and South America (with an emphasis on Canada and the United States of America) and Oceania (with a focus on Australia and New Zealand) respectively. From the researcher's experiences in a variety of educational settings, this process, as with any national or state-wide focus, may exclude some of the more talented educators making the most of what they have in their classrooms. However it provides sufficient information to identify any trends, group the data on the basis of common inhibitors and enablers of competent ICT integration practices and direct future professional development and research.

Debating the issue of effective ICT integration has long been a focus for international education researchers. As previously outlined, governments around the world have allocated large budgets to improve computer infrastructure and resources over the past 30 years (Angrist & Lavy, 2002; Australian Government Department of Education, 2011; Morrissey et al., 2008; D. E. H. Ng, 2008; Noeth & Volkov, 2004) on the understanding that better connectivity and more regular exposure to technology will lead to better student learning outcomes. While there have been isolated reports of success (Morrissey et al., 2008), few of the initiatives have proven to be a driving force in facilitating a pedagogy characterised by effective, systemic ICT integration, at least as is evident in the current literature. It seems logical to focus attention on some of the common inhibitors, often referred to as barriers in the literature (Alwani & Soomro, 2010; Bingimlas, 2009; P.-S. Hsu, 2016; Keengwe et al., 2008; Kopcha, 2012; Lowther, Inan, Strahl, & Ross, 2008; Schoepp, 2004) which teachers face in their quest to utilise ICT. From some of these inhibitors emerge common enablers that are critical in addressing and/or overcoming the inhibitors, characterised by effective or exemplary integrators of information and communication technology. This, along with literature and participant-identified enablers, leads to the pragmatic conclusions from this study which may inform future professional learning for technology-using teachers.

The focus of this research, then, was to identify an appropriate theoretical perspective and then use this to guide a research design which would facilitate the gathering of data around emergent, effective practices relating to ICT integration. With an intention to test for the common factors relating to ICT integration practices within the New South Wales context, specifically those of mathematics and science teachers, and apply the practices or factors which emerge from the study to strategic thinking about the future of ICT in education, the study must necessarily rest within an interpretive paradigm. This focus on the individual, their personal and professional qualities, along with their response to the challenges of effectively integrating ICT into their lessons led to a recognition of the commonality of responses by those teachers who were more effective or more comfortable with technology. Concern for the individual was paramount in seeking to understand how

New South Wales science and mathematics teachers made use of ICT in their teaching. A Gantt chart showing the broad timelines for the study is shown in Figure 2 below.

Task	Start	Finish	Duration	2014		2015		2016	
				Sem 1	Sem 2	Sem 1	Sem 2	Sem 1	Sem 2
Global literature search	Sem 1 2014	Sem 2 2016	3 years						
Development of online survey	Sem 2 2014	Sem 1 2015	9 months						
Contacting of educational agencies	Sem 1 2015	Sem 2 2015	9 months						
Pilot testing online survey	Sem 1 2015	Sem 1 2015	3 months						
Online survey	Sem 1 2015	Sem 2 2015	4 months						
Development of qualitative interviews	Sem 2 2015	Sem 2 2015	2 months						
Qualitative interviews	Sem 2 2015	Sem 2 2015	1 month						
Data analysis and collating of findings	Sem 2 2015	Sem 2 2016	18 months						

Figure 2: Gantt chart showing the timelines for the study

As a practicing science teacher, it was difficult for the researcher to adopt an objective, positivist approach to teacher behaviour in the context of ICT integration. As a developer of technology-based pedagogy, the researcher could empathise with the challenges associated with internet connectivity, network stability, multiple operating systems, as well as the rewards associated with high levels of student engagement through technology and the increased opportunities for student autonomy and differentiation. To separate the researcher from the research in order to ensure the study had an objective frame of reference was going to be a very significant challenge.

Studying the attitudes of teachers to technology and seeking to quantify some of the inhibitors and enablers of exemplary technology integration practice required a numerical base count to provide some validity to any degree of commonality between types of integrators, teachers of different subjects and teachers of different sex. However, it also required a deeper understanding of why teachers were using

technology in their classrooms and what outcomes they were expecting from its use, or its absence. This qualitative component of the study required levels of interactions with practicing teachers based, to some degree, on a level of empathy and this led to the need for a naturalistic, inquiry-based approach in which “individuals’ behaviour can only be understood by the researcher sharing their frame of reference” (Cohen, Manion, & Morrison, 2011, p. 15).

In the twenty first century, technology is a requisite tool for effective teaching and learning. In this framework, recent research suggests that “three important characteristics; autonomy, capability, and creativity are needed to develop good quality teaching and learning with ICT skills” (Philomina & Amutha, 2016, p. 603). It is now core business for all teachers to have excellent technology skills and knowledge. Therefore, the focus of this study was pragmatic. It sought to propose mechanisms for how these excellent technology skills, knowledge and traits or characteristics may be developed or transferred from one educator to another through an ethnomethodology which sought to understand how different teachers were dealing with the issue of ICT integration in their classrooms, in particular how they incorporate the use of technology to achieve their social and academic goals of teaching and learning.

1.6 Significance

This section outlines the wider implications for this study and how it contributes to the global conversation about technology usage in secondary teaching, and about exemplary ICT integration in particular. The section seeks to justify the importance of looking across different continents and different types of schools in the search for commonality of practice and hence to generalise about how these common practices might impact on future professional learning experiences within a local context.

This study was significant for three main reasons. Firstly, the Australian government has committed a significant portion of their budget towards improving teaching and learning from kindergarten through to university. A driver of this approach is a national curriculum which has been developed in consultation with key stakeholders

and which began implementation Australia-wide in 2013 and in New South Wales in 2014. This study contributed to the evaluation of the success of ICT integration by surveying a range of schools, including those exhibiting excellence and exemplary practice in New South Wales at a time of significant educational change.

Secondly, this study sought to determine the degree to which the qualities and characteristics of exemplary teaching practice are applicable within the New South Wales education sector. One purpose was to produce a comprehensive skill set for exemplary technology integration which has implications for teacher training programs, not only for New South Wales and Australia, but potentially into and beyond the Asia-Pacific region. As a result, the findings from this research project should assist other national governments seeking ways of effectively integrating ICT across their education sector.

Most importantly, the study identified the critical factors which need to be present for effective ICT integration. Many studies lament the paucity of evidence suggestive of a direct link between ICT integration in the classroom and improved student learning outcomes (Fuchs & Woessmann, 2007; Higgins, Xiao, & Katsipataki, 2012; S. Martin & Vallance, 2008; Newhouse, Trinidad, & Clarkson, 2002). Others suggest that students “learn with greater enthusiasm and also that they seem to be prepared to spend more strength and energy when media and ICT are involved” (Erixon, 2010, p. 1219). One UK study (Hennessy et al., 2007) linked successful technology integration with collaborative learning, constructivist practices and improvements in students’ conceptual understandings. More recent studies (Herreid & Schiller, 2013; S. Martin & Vallance, 2008) have started to evaluate new pedagogies involving blended learning and the flipped classroom. There appears to be a wealth of literature around how successful teachers are effectively integrating ICT into their classrooms, encouraging student autonomy, increasing student engagement and motivation and building twenty first century skills. What appears to be lacking in the literature is a focus on how the common qualities and skills of exemplary ICT integrators could be offered in a systematic, pragmatic way in a professional learning context. It is anticipated that the identification of a set of

enablers could result in the development of key indicators or required skills to assist individual teachers seeking to become more effective integrators of ICT in their classrooms. This would be useful to principals and directors of teaching and learning seeking to maximise their professional learning budgets and to the professional learning providers as a focus for their workshops, seminars and webinars. Whilst this study focussed on New South Wales (NSW) teachers and schools, the global component of the study suggests a much wider potential audience, both national and international, might benefit from these conclusions.

In its initial stages, this thesis has already provided stimulus for the Association of Independent Schools (AIS) Science Professional Learning Advisory Council (SPLAC) as the framework for a keynote addresses in their 2015 and 2016 Technology in Secondary Science Classrooms workshops. It will provide additional stimulus for a future instance of this type of professional learning during 2017.

1.7 Purpose

This section seeks to expand on the three key areas of significance of this study identified in the previous section. This study has grounded itself in pragmatism and this section seeks to outline the utility of the conclusions and how teachers may benefit from such knowledge in so far as it informs their own pedagogy.

The term ‘late adopters’ has been used to refer to those who resist technological advances. It is an unfortunate fact that late adopters exist within the teaching profession. However there are also those who stand in juxtaposition to the late adopters, those who were the early adopters, embraced the technology and have made it an indispensable part of their teaching practice. “These innovative individuals not only tend to adopt a new medium earlier and use it more frequently, but also tend to use it more creatively” (Yang, 2010, p. 76). The ubiquitous nature of the computer also provides an opportunity to determine whether the characteristics of exemplary ICT integration practice are common across geographic, cultural, gender or subject-specific boundaries. Such data may have intrinsic worth, however it becomes considerably more valuable if it informs future professional development in

the area of effective ICT integration. This is especially true when the paradigm is shifting: “there have been radical changes in the market, and growing demand for ICT literate teachers who can effectively prepare school graduates for (a) globalised world” (Abuhmaid, 2008, p. 163). It was the intention of this research to identify exemplary ICT integration practice, determine its degree of commonality and generalisability across several criteria and make recommendations regarding future professional development activities.

The final component of this study is to use the data gathered from principals, teachers and researchers to inform teacher professional development. Approaches which develop and encourage more effective ICT integration in all members of the teaching profession, including its more reluctant members, should be of some interest across the education sector.

1.8 Summary

In this chapter, some of the problems associated with exemplary ICT integration have been identified as well as some of the potential strategies to address these problems. There are global measures of student performance and there has been significant global expenditure on internet connectivity. Governments everywhere recognise the importance of spending money to increase the proportion of their populous who are connected to the world wide web (www). This inevitably flows through to the education sectors and ultimately to the classrooms. However the experience in different classrooms in different parts of the same suburb, much less similar cities or nations, can be very different. Common factors inhibit the effective integration of ICT but there are many teachers who have successfully overcome these barriers or inhibitors and are effectively integrating technology into their teaching. The next chapter will focus on the global inhibitors of ICT integration and the enablers which may be common to exemplary ICT integrators.

Chapter 2 Literature Review

2.1 Introduction

In the previous chapter, the personal context, aims and purpose of the study were outlined, specifically the identification of exemplary ICT integration practice, the degree of commonality and generalisability of successful ICT integration across a variety of criteria and the potential recommendations which may flow from the study regarding future professional learning activities. In this chapter, data is gathered from the literature regarding the patterns of ICT usage in secondary education on each major continent. Each continent is examined separately and includes research from several representative countries selected to highlight the enablers and inhibitors of ICT integration. The purpose of this was two-fold. Firstly it allowed for a comparison of the proportion of inhibitors and enablers emerging from the literature by geographic region. Some continents are better connected to the internet than others and this became more obvious with a continent by continent snapshot. Secondly, the continental organisation allowed for a more visible inventory of inhibitors and enablers of ICT integration allowing a clearer analysis of the common factors emergent from the literature. This formed a key component of the online survey and qualitative interviews discussed in future chapters. For brevity, representative examples from each continent, where identified, were chosen to address a specific inhibitor or enabler as an indicator of its presence. This review has not set out to obtain an exhaustive account of every instance of a particular inhibitor or enabler in the literature. The examples chosen have been selected on the basis that they emphasise the enabler or inhibitor to which they refer in order to make comparisons between these factors and those which emerge later from the study.

At the end of the chapter, recurring trends are brought together to address the research questions about the generalisability of exemplary ICT integration and to suggest specific lines of enquiry for the online survey and qualitative interviews to follow in subsequent chapters.

2.2 Rationale

As identified in the introduction to the chapter, the purpose of this literature review is two-fold. Firstly, the review was used to gather evidence of enablers and inhibitors of effective integration of ICT into the classroom. Secondly, it was used to compare instances of exemplary practice from different countries to determine some degree of commonality of practice. Gathering evidence of instances of good to exemplary ICT integration practice in various classrooms was used to investigate research questions one and two. Specific countries were identified within major geographic regions, based, primarily, on their performance in international science and mathematics testing. From these countries, the literature search focussed more on finding evidence of ICT integration practices from a range of cultures and communities. As it was not possible to cover the entire academic spectrum, and the major focus of this study will be in the area of ICT integration in Australian and in particular New South Wales high schools, the factors affecting the integration of technology have been focussed in the secondary subjects of science and mathematics. The Australian Government, through its education sectors, supports the establishment and success of religious, cultural and pedagogically driven Independent and Catholic schools alongside its public school system. For this reason, combined with the cultural and economic diversity amongst Australians generally, it is appropriate to examine ICT integration practices on a global scale and then map them backwards to identify potential areas of interest within the NSW Education sector for more detailed consideration. This forms the major component of this chapter.

The motivation regarding the second purpose of the literature review, namely, to compare instances of exemplary practice from different countries to determine the degree of commonality of inhibitors and enablers of ICT integration, is to build on the work of previous studies; “the characteristics of exemplary technology-using teachers have already been examined to understand how those teachers differ from other teachers by many researchers.” (Hakverdi-Can & Dana, 2012, p. 94). Despite this, there is limited research that examines “how exemplary science teachers use technology in the classroom and how their students use technology in the classroom”

(Hakverdi-Can & Dana, 2012, p. 94). Therefore, this research aimed to pull together some of the known threads in the literature and to use these common threads to survey New South Wales science and mathematics teachers about their use of ICT in the classroom in order to seek to redress this ongoing gap in our knowledge.

Previous research has identified significant inhibitors or barriers at a systemic level to the effective implementation of an ICT integration strategy (Barrera-Osorio & Linden, 2009; Hew & Brush, 2007; Jung & Latchem, 2011; Keengwe et al., 2008; Kopcha, 2012; Lowther et al., 2008). Despite many attempts on the part of governments and school bodies to address these perceived barriers, progress has been slow and disjointed (Alwani & Soomro, 2010; Downes et al., 2001; Morrissey et al., 2008; Noeth & Volkov, 2004). Several studies have also documented the characteristics of exemplary teachers and their teaching practices (McCall, 2008; K. Tobin et al., 1988; Twining, 2002); one study described exemplary teachers as “those who excelled on at least one of two dimensions: the ability to generate intellectual excitement in students and/or to generate interpersonal rapport in students” (Lowman, 1996, p. 35). By contrast, this study describes the characteristics and practices of exemplary integrators of technology and makes a determination about the level of transferability of these characteristics and practices across sex and subject boundaries.

In summary, the primary focus of the literature review was to contextualise what has already been achieved in terms of ICT integration around the world and to review the characteristics of exemplary teaching which involves technology on a global scale. These common threads are drawn together to identify elements of best practice and to develop a targeted survey tool for the purpose of gathering additional information about current teaching practice in Australian and particularly New South Wales secondary classrooms. The degrees of commonality in exemplary ICT integration were then assessed across the different categories outlined in research question two for their relative statistical significance. The results of these analyses are presented in Chapter Four.

2.3 Government Investment in Capacity Building

In seeking to address research question one, the first task was to determine how to divide the international education community into distinct geographical regions. As mentioned in Chapter One, this may be achieved through the identification of the consequences of various national governments' infrastructure spending on shifting their educational pedagogy and increasing the skills of their educators in the area of ICT integration. As a result, each geographic region has been mined to collect relevant literature from different countries on the basis of high internet penetration. This is founded on the assumption that one of the barriers to successful ICT integration is access to adequate technology resources (Ertmer et al., 2012; Noeth & Volkov, 2004). Arguments about the difficulty of measuring a causal link between increased expenditure on computer infrastructure and improved pedagogy regarding ICT integration (Twining, 2002) are countered by justifications that investments in computer technology produced "an average effect size of 0.4 standard deviations, which was claimed to be more cost-effective than a reduction in class sizes" (Newhouse et al., 2002, p. 6). One particular African government funded program, NEPAD e-Schools Initiative, lists several objectives, one of which was to "determine "best practice" and exemplary working models for the large-scale implementation of the initiative, which aims to equip more than 550,000 African schools with ICTs and connect them to the internet" (Isaacs, 2007, p. 15). Asian nations too have prepared long term plans for investment in education technology. "Hong Kong is one of the most advanced cities in Asia in terms of the education quality, internet penetration and technological infrastructure" (K. C. Li, Yuen, & Cheung, 2013, p. 24). Hong Kong, like Singapore (Lim, 2007; D. E. H. Ng, 2008) and Australia (Australian Government Department of Education, 2008, 2011; Australian Institute for Teaching and School Leadership, 2008) concurrently, developed a "5 year strategic plan" that aimed to promote "ICT integration in school education as a focus for related curriculum reform and innovation" (Richards, 2004, p. 340). It would seem clear that many countries have been allocating significant portions of their budget to ICT in education and are either hoping, or planning for a significant return on their investment. Published research from many of these representative countries has been

used to identify the common inhibitors and enablers of technology integration in the classroom, with a focus on exemplary practice, and to inform the process of data gathering for research question two.

Each of six major geographic regions has been treated separately in the next six sections; with ICT integration practices identified from Africa, Asia, Europe, the Middle East, North and South America, and Oceania. Whilst these are fairly arbitrary groupings, they provide an adequate starting point. The paucity of relevant, English-language literature from South America resulted in its inclusion with North American nations. In the review of the literature from each of the major regions, individual countries were chosen to represent some of the diversity of educational contexts which exist within each geographical region. In this context, the enablers and inhibitors of ICT integration have been placed to gauge levels of commonality, to identify any salient lessons which may be reported upon and around which future professional learning activities may be constructed.

2.4 Evidence of technology integration in Africa

As a geographic region, Africa is the most poorly connected, in technology terms, of the six studied regions with only 27.0% of the population being internet users (Miniwatts Marketing Group, 2015). African governments have been seeking to address the issues of technology in education, gender imbalance, equity of access and funding, paucity of local curriculum content and language specific resources (Farrell & Isaacs, 2007) over the past two decades. A 2007 report of 53 African nations found “all but a handful of countries surveyed already have a national ICT policy in place or under development” (Farrell & Isaacs, 2007, p. 1). As a result of these sorts of initiatives, several African nations experienced significant growth in the number of internet users over the past 15 years (Miniwatts Marketing Group, 2015; Stork, Calandro, & Gillwald, 2013). Despite this focus on improving access, progress across the continent has been steady but not equal. Recent studies looking at connectivity, either through mobile phone or computers connected to the internet, reported some progress in internet use with some countries, eg Uganda, Ethiopia and Rwanda tripling their internet user numbers, although much of this was coming from

a very low base. “South Africa has the highest internet penetration rate among all the countries under investigation, with 33.7 per cent of the population who are 15 years or older using the internet” (Stork et al., 2013, p. 42). In this climate of growth in technology access, there is evidence of ICT integration practices among the African nations and a selection of these will be discussed below.

Research on ICT integration from Africa is growing, not least as a result of the Annual e-Learning Africa Conferences. ICT integration is touted as a vehicle for improving the quality of education as well as a mechanism for the production of global citizens. Major corporate sponsors are partnering with African governments to improve ICT infrastructure, internet access and teacher professional development, including the World Bank, Intel and Microsoft. Despite many efforts to improve the quality of education, the unstable nature of many nations has hindered some of these efforts (Kagame, 2008; Nkohkwo & Islam, 2013). Growth in computer penetration in schools has mirrored that of the wider society and this has improved the situation for many African students, however challenges remain. The African nations have embraced a plethora of teacher professional development programs and computer/internet-based learning programs (Blignaut et al., 2010; Elletson & Burgess, 2015; Karsenti, Collin, & Harper-Merrett, 2012). This has provided a great richness and diversity of experiences but has also resulted in an ad hoc approach to the issue of ICT integration and pockets of excellence. Some representative countries have been selected to highlight the inhibitors and enablers of ICT integration in Africa. Due to the paucity of information, some of these countries have been chosen to highlight the development which is taking place in anticipation of future gains in technology integration. The following sections highlight the inhibitors and enablers of effective ICT integration from Morocco, Tunisia, Nigeria, Egypt and Tanzania.

2.4.1 Inhibitors of ICT integration in African nations

The literature reveals the African region as a relatively recent arrival in the knowledge and information economy. Many of the African nations are struggling to access the information superhighway and the ratio of computers to students remains

very low (Elletson & Burgess, 2015). It would appear from the literature that computer literacy is a low priority for many school systems, mainly because of the costs associated with connecting students through sufficient devices to facilitate technology-driven pedagogy (Elletson & Burgess, 2015). This, however, is not the only inhibitor to effective ICT integration. A search of the literature from African nations reveals inhibitors which may be grouped under the following broad headings: equity of access to technology infrastructure, inadequate professional development, lack of recognition of the pedagogical value of technology and low personal self-efficacy relating to computer use. Each of these will be examined in greater detail in the sub-sections below.

2.4.1.1 Equity of access to technology infrastructure

Educational equity has been a significant political issue in Australia, particularly through the much-discussed Gonski report (Gonski et al., 2011). Equity of access to technology infrastructure broadly refers to the equal opportunity of each and every student to be connected to the internet in their classrooms. This can manifest itself in many ways; through actual internet connection, to sufficiently high bandwidth within the school environment, to the ratio of computers to students, to the type of technology which dominates the school, including the devices and operating systems. The issue of equity of access and more particularly of a lack of equity of access, is not unique to the Australian nor African continents. In his opinion piece as a contribution to the 9th International Conference on ICT for Development, Education and Training (2015), Manji opined that “if one looks at the continent as a whole, something like less than 14% of the population has access to the internet. If you exclude Morocco, Algeria, Tunisia, Egypt and South Africa, you are left with 4% with access to the internet” (Manji, 2015, p. 22). This is despite the fact that there have been targeted efforts over the past 10 years by African governments to increase access to ICT for all citizens, including its school populations (Farrell & Isaacs, 2007).

2.4.1.2 Inadequate professional learning around technology integration

The issue of inadequate professional development was a significant inhibitor to effective ICT integration in the classroom in many African nations. Inadequate professional development includes professional learning experiences which are not differentiated, perceived as irrelevant or too broad in their scope. Many governments included professional development as part of their budgets to target improved technology integration, yet often this did not filter through to the classroom teachers. African nations have embraced a plethora of teacher professional development programs and computer/internet-based learning programs (Blignaut et al., 2010; Elletson & Burgess, 2015; Karsenti, Collin, & Harper-Merrett, 2012). This has provided a great richness and diversity of experiences but has also resulted in an ad hoc approach to the issue of ICT integration. A small study from schools in Ghana found “professional development opportunities concentrating on the actual integration of ICT into teaching should be provided to teachers to promote pedagogical practices of ICTs in schools” (Buabeng-Andoh, 2015, p. 111).

2.4.1.3 Lack of recognition of the pedagogical value of technology

A third inhibitor which has emerged from the African literature is the lack of recognition of the pedagogical value of technology in the classroom. This can be an imposed value permeating through an organisation, or an individual teacher’s view that mastering or using technology in the classroom is of a low priority. This, in turn, can affect the teacher’s attitude towards the value of the time invested in learning with and through technology. Some less effective integrators of technology manifest a justification for the minimum use of technology on the basis of a lack of evidence of the efficacy of technology as a legitimate learning tool. This is equally true when provisioning schools with technology specialists, as highlighted by Howie and Blignaut (2009); “one might assume that successful implementation of ICT in education is heavily dependent on the provision of qualified and well-supported staff. However, only 41% of South African schools have a technology coordinator in contrast to more than 70% of schools internationally” (Howie & Blignaut, 2009). There is some evidence that the lack of recognition of the pedagogical value of

technology is an inhibitor for several African nations, as emphasised by the Tunisian experience below.

The Tunisian government have made education their priority and were allocating more than 20% of the total budget to the education sector (Hamdy, 2007). By 2000, all Tunisian secondary schools were connected to the internet and in 2002 a Virtual School project was launched. The Tunisian Virtual School focused on distance education, e-Learning and sharing resources and expertise. Tunisia receives support from many quarters, including the World Bank however there is a residual reluctance on the part of Tunisian educators to fully embrace technology-based pedagogy. The significant inhibitor to effective ICT integration within Tunisia is the cultural resistance to technology by its teachers; “innovative teaching and effective use of ICT are observed only in a minority of Tunisian teachers at all educational levels” (Abdelwahed, 2014, p. 205). This is supported more widely among African nations as indicated in the Second Information Technology in Education Study (SITES) 2006 report. The SITES 2006 study “focused on the role of ICT in teaching and learning in mathematics and science classrooms” (Plomp & Voogt, 2009, p. 287). It included 22 education systems from 20 countries. In reference to ICT integration in South Africa, the SITES report suggested “an apparent contradiction in South Africa between the relatively low priority assigned to the ICT infrastructure by the principal and the relatively high investment in ICT maintenance” (Blignaut et al., 2010, p. 1559).

2.4.1.4 Low personal self-efficacy relating to computer use

According to self-efficacy theory, self-efficacy expectancy is “the belief that one can successfully perform the behaviour in question” (Sherer et al., 1982, p. 663). Personal self-efficacy in the context of technology integration is the belief that a teacher can effectively use technology to improve student learning, or at least, their own teaching. Low self-efficacy is the lack of belief in the effectiveness of technology use in the classroom. This low self-efficacy is often affected by personal factors, in addition to cultural and historic factors. One such example has been described from the experience in Tanzania. Despite the integration of computers into

education in 2002, and the formation of an “e-school forum in 2005” (Kafyulilo & Keengwe, 2014, p. 915), there were still “limited uses of technology in both pedagogical applications and activities other than pedagogical practices” (Kafyulilo & Keengwe, 2014, p. 915).

The reason proposed to explain the lack of effective technology integration was primarily due to teachers’ lack of confidence in “using technology to facilitate specific concepts or skills, to support creativity, and to support students to learn complex concepts” (Kafyulilo & Keengwe, 2014, p. 921).

2.4.2 Enablers of ICT integration in African nations

Although the challenges facing many African nations in pursuing an effective ICT integration program are many, there has been considerable interest and support for the International Conferences on ICT for Development, Education and Training. Inaugurated in 2006 in Addis Ababa, Ethiopia, these conferences have been held in Nairobi, Kenya (2007), Accra, Ghana (2008), Dakar, Senegal (2009), Lusaka, Zambia (2010), Dar es Salaam, Tanzania (2011), Cotonou, Benin (2012), Windhoek, Namibia (2013), Kampala, Uganda (2014) and Addis Ababa, Ethiopia (2015) (Elletson & Burgess, 2015). Most recently, the 2016 conference was held in Cairo, Egypt in May, 2016. The 2016 conference was attended by 1045 delegates from 72 countries and provided a showcase for ICT innovation, design, management and expertise.

Funding from different sources, both government and private sector, are providing many African nations with a means to build capacity and create experiences for students which expose them to the knowledge economy. Several initiatives focussing on teacher professional development are starting to have an impact (Blignaut et al., 2010). These include SchoolNet - South Africa’s Educator Development Network, Microsoft Partners in Learning and Intel Teach (Schoolnet, 2016). Whilst there is no clear evidence of exemplary ICT integration in the literature as yet, many of the potential inhibitors are being addressed and the SchoolNet initiative is fostering increased use of ICT in the classroom through targeted professional training programmes and modules focussing on “administrative

and classroom use of ICT, use of the internet” and “teaching and learning activities” (Pulkkinen & van Wyk, 2013, p. 123). Despite its infancy with regard to ICT integration in secondary classrooms, some research is beginning to emerge from many of the African nations relating to the “creation of elaborate projects involving learner-created websites, videos, field research and experimentation content” (Karsenti et al., 2012). There is cause for optimism as teachers struggle against the inhibitors of limited infrastructure, inequities of access, lack of targeted professional learning and lack of recognition of the value of technology in the classroom that exemplary practices are slowly emerging.

2.5 Evidence of technology integration in Asia

South East Asia is dominated by countries whose performance across a range of international measures has been steadily increasing over the past 10 years. This trend can be seen in the international science and mathematics testing data (M. O. Martin, Mullis, Foy, & Hooper, 2016; Mullis, Martin, Foy, & Hooper, 2016; OECD, 2015; Sciences, 2012). Asia has been a centre of high demand and a producer of highly educated students, according to international testing, for over a decade (M. O. Martin et al., 2016; Mullis et al., 2016). Like Africa, the Asian continent is large and diverse and its education systems non-contiguous. Many Asian nations have high populations, including China and India; the two most populous nations on Earth. This has had an impact both on their access to education and their access to technology, including the internet. As a geographic region, Asia is the second most poorly connected with only 38.8% of its enormous population using the internet (Miniwatts Marketing Group, 2015).

Education in Asia has been a priority for many years. Government expenditure has supported the education sector and in many countries has included significant budget allocation to ICT infrastructure and training (D. E. H. Ng, 2008). Unfortunately, the distribution of wealth and resources is not uniform and many Asian students have access to resources their neighbours do not (Altbach, Reisberg, & Rumbley, 2010). Asia has also produced a number of accounts of innovative education practices as well as many traditional, didactic pedagogies. According to the international testing

data from PISA and TIMSS (M. O. Martin et al., 2016; Mullis et al., 2016; Sciences, 2012) countries such as China are outliers in terms of student performance and internet usage; however this is probably due to the size of both the country and the population. China is easily the most connected country in the world in terms of number of users; with over half a billion Chinese being internet users. However the enormous population of China means that it only scores 38% on the internet penetration index (Miniwatts Marketing Group, 2014) which is a measure of the percentage of the population which has direct access to the internet. A similar case can be made for India which has the second highest number of internet users, however this accounts for less than 20% of its total population. Japan and South Korea are both well represented, high on the list of top Asian internet countries and number one and two on the internet penetration index. It would be reasonable to conclude that despite the enormous populations in Asian nations, most Asian students are well-connected to technology, specifically the internet. Many South East Asian countries have been allocating significant funds over many years to the development of ICT infrastructure. As a result, nations like South Korea, Japan, Singapore and Hong Kong have experienced consistent growth in the number of internet users since the 1990s (Miniwatts Marketing Group, 2015). Of course, Asia also has its challenges regarding equity of access both within and across national borders (Gao, Choy, Wong, & Wu, 2009; Richards, 2004). Financial inequities also constrain some countries from allocating sufficient resources to its citizens.

Many of the Asian countries have been involved in international testing for many years. Japan, Singapore, Taiwan and Hong Kong are the most well-connected nations and their student performance average scale scores are extremely high (M. O. Martin et al., 2016; Mullis et al., 2016; Sciences, 2012). The embedding of technology in these nations has already impacted on student learning and these countries have set such high standards that there have been only minor fluctuations in student average scale scores from 1999 to 2012. China's progress has been phenomenal and it has only recently become involved in international testing programs. Already its students are performing at the highest level on the world stage (M. O. Martin et al., 2016; Mullis et al., 2016).

2.5.1 Inhibitors of ICT integration in Asian nations

Research into ICT integration practices in Asia is both vigorous and prolific. The massive growth rates in infrastructure and accompanying professional development programs have assisted the Asian nations to sit on top of many of the key performance indicators of academic achievement (M. O. Martin et al., 2016; Mullis et al., 2016). Despite this, much of the research discusses the clash between older, didactic models of pedagogy delivered to disciplined, compliant students versus the more modern, innovative pedagogies delivered in less structured classroom environments (Richards, 2004). There is also evidence of targeted government programs designed to smooth the transition from the traditional approach to education to a more inclusive, student-directed pedagogy. In one example, the desired intent of a 2000 reformation policy in China was to shift the focus of Chinese teachers from teacher-centred to student-centred learning facilitated by technology use and access to an open source environment (Ge & Ruan, 2012). Open Education Resources (OER) in China, and also in Hong Kong, were touted as the vehicle to help facilitate this transition, primarily in the tertiary sector, by putting tools in the hands of educators wherever they may be located. Inhibitors to the successful implementation of the OER in the classroom identified by Li (2013) included the “lack of (1) awareness; (2) the ability to locate quality OER for teaching; (3) skills; (4) interest in pedagogical innovation amongst staff members; (5) incentive mechanism for staff members to devote time and energy; (6) support from management and (7) the ability to locate specific and relevant OER for teaching” (Y. Li, 2013, p. 39). Some of these inhibitors also appear in the subsections below.

Many of the Asian cultures have bred respectful, disciplined students that struggle with too much freedom in their learning. “In strong uncertainty avoidance cultures such as Japan, students are much more comfortable with learning activities that are clearly structured with precise objectives and outcomes statements, where the methods of, and criteria for, assessment are clearly stated, where the timetables are precise and realistic, and where the reward systems relate to the desired behaviours” (Jung et al., 2012, p. 1026). Educational change in such a context, particularly a shift

to student-centred learning, may take longer and require more patience, direction and resources from its educators, but there are some reasons for optimism. “The reconstruction of the 'Asian tiger' economies towards the aim of creating knowledge as well as applying it is also spurring moves towards greater flexibility in Japan, 'pleasurable learning' in Hong Kong, and 'thinking schools for a learning society' in Singapore. As a result, this is changing the kinds of skills and sophistication required from teachers in these societies” (Hargreaves & Lo, 2000, p. 174).

Taiwanese students were part of a study involving an evaluative program around the use of mobile devices to complete WebQuest-like activities. These are inquiry-based activities which pose a series of questions, often open-ended, the answers to which can be found on the internet. The study found the students were reluctant to involve themselves in more complex learning with the technology as “they lacked the abilities to express opinions and to make a report about their learning process” (Chang, Chen, & Hsu, 2011, p. 1235).

In this section, evidence of common inhibitors of exemplary ICT integration have been sourced from Asia’s top performing nations in the most recent TIMSS and PISA testing (M. O. Martin et al., 2016; Mullis et al., 2016; Schleicher, 2016); South Korea, Singapore, Hong Kong, Japan and China and one of its less well-connected nations; Vietnam. The research highlights several inhibitors of effective ICT integration including lack of recognition of the value of technology, the lack of practical support from the network of learners, low personal efficacy relating to computer usage and equity of access to technology infrastructure.

2.5.1.1 Lack of recognition of the pedagogical value of technology

One common inhibitor in many Asian nations is the lack of perceived pedagogical value in the use of technology. Learning is a serious business in many of the Asian countries and technology may be seen merely as a ‘toy’ which can distract from, rather than enhance, the learning. The example below from South Korea highlights this dilemma.

Korean students are among the top performers in international testing based on the

most recent TIMSS data for mathematics and science (M. O. Martin et al., 2016; Mullis et al., 2016). This is partly because of, and partly in spite of, “a very centralized and competitive school education system based on a standardized national curriculum” (J. W. Kim, 2004, p. 138). South Koreans are well connected to the internet and yet “despite plenty of pedagogically persuasive reasons for teacher integration of technology, teachers’ motivations to use technology are mostly based on convenience” or “to meet educational policies and mandates, students’ and parents’ expectations and because of the basic merits of digitalised media” (Baek, Jung, & Kim, 2008, p. 233). This lack of value placed on the use of technology to motivate and challenge students has resulted in the low level, convenience-type activities identified, which are often restricted to basic research and administration tasks.

2.5.1.2 Lack of practical support from the network of learners

An inhibitor of effective technology integration not previously identified in the African literature, is the lack of practical support from the local or national network of learners. Whilst this category overlaps with other categories, such as the lack of recognition of the pedagogical value of technology, this inhibitor is more about the effectiveness of collaboration and unity of purpose within the local, school or regional learning communities. It can also relate to the lack of establishment of a dedicated local (school level) expert in ICT integration. Ultimately the lack of practical support will almost always manifest itself to classroom teachers as a lack of time. This is highlighted in the following South Korean, Hong Kong and Japanese experiences.

Asia is not merely a leader of academic performance, as measured in international testing such as TIMSS and PISA (OECD, 2015; Sciences, 2012), it is also a producer of technology. It would seem an obvious coupling to link the many tools of technology with education. Whilst the reasons are diverse, like teachers in many parts of the world, South Korean teachers have “had to become multifunctional in schools with limited resources” and this includes becoming “good technologists in utilizing multimedia in teaching” (J. W. Kim, 2004, p. 133). Government policies

have forced teachers to take greater responsibility for not only computers in the classroom but also for a range of additional tasks from formalised assessment to after-school programs, with the net result of “intensifying teachers’ work and making teachers into technicians” (J. W. Kim, 2004, p. 137).

Similar frustrations have been recorded from studies in Hong Kong. “A one-off grant of \$200 million in 2008 was provided for Hong Kong schools to replace and upgrade their IT (*Information Technology*) facilities and provided another one-off grant of \$50 million in 2010 for schools to purchase e-learning resources” (K. C. Li et al., 2013, p. 17) (*italics added*). Technology resources, such as the array of OER were widely available and ever-expanding but were underutilised. Li and Wong (2014) in their evaluation of the uptake of OER concluded that a “lack of institutional and instructional support appears to be the main reason for students’ limited use of OER” (K. C. Li & Wong, 2014, p. 133). In 2008, CreativeCommon Hong Kong was launched with great expectations for its adoption across the education sector. Building a collaborative network of learners through the creation of an online sharing space has been identified as an enabler of competent technology usage, however, at the present time it remains underutilised. However, the spirit of collaboration has been slow to gain traction. “In Hong Kong, such a culture (of sharing education resources) is still lacking, partly because a common platform to enable sharing of education resources among teachers has not yet existed. It may take a long time to build up the culture” (Cheung, Yuen, Li, Tsang, & Wong, 2012, p. 202). This shift in culture towards an online collaborative approach remains an ongoing challenge in Hong Kong.

Japanese teachers too have also been encouraged to use online forums in an attempt to increase the instances of collaborative learning and sharing of exemplary practice. In evaluating the stress associated with participation in collaborative, online discussions, Jung, Kudo and Choi (2012) suggest “the concept of online collaborative learning may be new to many, the teacher-centred approach is dominant and preferred by many learners and while the learners may not be that confident in expressing themselves, in, or comprehending, English, this is often the

medium used in teaching and learning” (Jung et al., 2012, p. 1018). This seems a little counter-intuitive in the context of Japanese belief that “everyone gains when each member seeks to make the group more efficient or work as a whole” (Jung et al., 2012, p. 1019). The transition from collaborative group work within the classroom or tutorial room has not been made to the online world, possibly due to the predominance of English language usage in this space.

2.5.1.3 Low personal self-efficacy relating to computer use

As identified in Africa, low personal efficacy has also been suggested as an inhibitor of effective ICT integration amongst some Asian nations. This is highlighted by the Japanese and Vietnamese experiences. “Japan continues to be resistant to the global trend toward the increased presence of technology in the classroom” (Morrone, 2012, p. 1). “Traditionally, Japanese classrooms are teacher-centred and students are expected to be quiet” (Kusano, Frederiksen, Jones, & Kobayashi, 2013, p. 32). This traditional view of pedagogy has proven resistant to the introduction of technology integration. “Japanese students at the top ranked high schools tend to use computers in the classroom less frequently than those in other schools” (Kusano et al., 2013, p. 32). Encouraging the adoption of ICT in the Japanese classroom remains problematic. “Even if the effectiveness of ICT were acknowledged, many would still resist its adoption out of a concern that the teacher would appear lazy in an ICT-equipped classroom, robbed of his or her essential function and usefulness” (Morrone, 2012, p. 3). Inhibitors to effective ICT integration in Japanese schools appear to be systemic and closely related to a traditional pedagogy which has proven highly successful in preparing students for university. Low personal self-efficacy may be a contributing inhibitor to technology integration as several authors (Jung et al., 2012; Kusano et al., 2013; Morrone, 2012) have highlighted the importance to Japanese teachers of a didactic, authoritarian presence in the classroom and the fundamental belief that this is the ‘correct way’ to teach students.

The issues highlighted in the example from the Japanese education system are also pertinent in Vietnam. “Vietnamese teacher educators use ICT merely as a tool which makes teaching more easy, as a replacement of traditional, more teacher centred

teaching practice” (Anh, Peeraer, & Tran, 2010, p. 1). Despite the efforts of educational managers, the financial priorities of government expenditure and the consequent addressing of infrastructure inhibitors, “even though teacher educators had good basic ICT skills, they did not feel confident in using ICT, and ICT was mostly used to replace traditional teaching practice” (Peeraer & Van Petergem, 2012, p. 100). As with several of the other Asian nations, the teachers’ lack of belief about the efficacy of technology to bring about increased student conceptual understandings, combined with the lack of confidence or experience using technology in education is inhibiting the use of technology in Vietnamese classrooms.

2.5.1.4 Equity of access to technology infrastructure

The immense landmass and population size across Asia makes it almost impossible to ensure equity of access to the technology infrastructure. In support of this inhibitor, in recent years, the Chinese Government have been prioritising education. “In the past ten years, the Chinese government has adopted many effective measures to develop mass education which has really benefitted the general public. . . . However, the gap between developed and under-developed areas is still obvious in mainland China” (Y. Li, 2013, p. 35). In a country as large and populous as China it is hard to expect all students to have equal access to technology and the literature supports that assertion, despite the narrowing of the divide between the best and worst connected Chinese students (Ge & Ruan, 2012; Zhao & Xu, 2010).

2.5.2 Enablers of ICT integration across Asian nations

Asian nations are becoming increasingly dominant on the international performance scales and there may be several reasons for this. However, one reason may relate to the significant investment in technology in education (D. E. H. Ng, 2008). As noted above, many Asian education systems appear to be caught between the desire to reform teaching and learning and the traditions which are strong in many of the more populous countries; “Japan may be more hesitant to ICT education on societal and individual levels” (Kusano et al., 2013, p. 29). There has also been some investment

in professional development (Kozma & Surya Vota, 2014; Lim, 2007; Ra, Chin, & Lim, 2016; Richards, 2004), however, some of the research findings have limits placed on their generalisability. “Although this set of mechanisms may apply to other countries, it is unique in the context of Singapore where it is the shared belief among her people that the education system is a prime engine of growth for the economy, building of the nation, and formation of the identity” (Lim, 2007, p. 114). Despite this, and to further support effective ICT integration, the Singapore report proposed school level reforms including the need to “set a clear vision of ICT integration strategies for the school and this vision must be shared by all members of the school community”, “develop a framework for teachers within the same department to collaboratively design ICT-mediated lessons, and share ICT resources, and lesson plans” and “plan regular sessions for demonstrations of exemplary ICT-mediated lessons by teachers, mentors or seasoned practitioners to illustrate to other teachers, who are new to technology integration, effective ways to use ICT to teach existing and expanded content.” (Lim, 2007, pp. 112-113). This is an ideal place to start when seeking to identify the enablers of effective ICT integration in the Asian nations.

Traditional inhibitors to technology integration, such as infrastructure and connectivity have largely been addressed in many of these countries through government policies and budgetary spending (Ge & Ruan, 2012; Y. Li, 2013; Lim, 2007). Personal self-efficacy in relation to technology use in the classroom is strongly influenced by the authoritarian pedagogue which still looms large in the psyche of many Asian teachers, as previously outlined. There has been much discussion around the importance of traditional teacher-centred approaches and preparing students for success at the tertiary level. Despite this, many educators are using computer technology to replace older technologies and also to create and share content through Creative Commons and Open Educational Resources. Professional learning has also emerged in this section as an enabler of good technology integration practice.

2.5.2.1 Professional learning opportunities and methods

The importance of ongoing professional development and peer sharing was the focus of another study in Singapore schools seeking to increase the emphasis on student-centred pedagogy within a constructivist framework. The researchers noted that for sustained change, some of the focus must be on preservice teachers and their preparation for entering 21st century classrooms. “It is therefore imperative for teacher education programs to adopt various strategies to guide, model and support preservice teachers’ development of technology based pedagogy, until it becomes an integral part of their professional growth” (Gao et al., 2009, p. 727).

This high investment in both the technologies and the teachers is necessary to achieve high levels of integration. The technologies must be sustained and updated over time, along with the teacher expertise. “Any new technologies must continue to function consistently throughout their lives if they are to become a regular part of teachers’ classroom practices” (Webster & Son, 2012, p. 110). One example of effective and ongoing professional learning characteristic of the higher levels of technology integration was emergent in the literature from South Korea. In a comparison between the effectiveness of e-learning in South Korea and Chile, Sanchez et al (2011) favourably observed that “South Korea performs extensive teacher training and continuous pedagogical support activities in order to achieve and maintain high levels of student learning, through the use of well-developed e-Learning methodologies and systems” (Sanchez, Salinas, & Harris, 2011, p. 137) .

2.5.2.2 Increased student autonomy and differentiated learning

One proposition of this research is the importance of technology as a tool to facilitate increased student autonomy and effective differentiation in the classroom. Evidence exists for technology to be used merely as a management tool or expensive note-taker; “72% of all Korean teachers use ICT to teach and to manage their classrooms” (Sanchez et al., 2011, p. 138). However, there is also evidence to suggest that technology can be used to deepen student understandings and challenge the way they learn. A study partially funded by the Ministry of Education in Singapore proposed

that “for ICT to be effectively integrated in schools, it should be used as a mediational tool in these activities to engage students in higher-order thinking” (Lim, 2007). As a consequence of this study, recommendations were made at the classroom, school, and national level. This included “design and implement orienting activities to support learner autonomy so as to achieve the object of engaging students in higher-order thinking”, “adopt scaffolding strategies in all ICT-mediated lessons” and “plan just-in-time ICT skills training sessions to provide the necessary knowledge and skills for students to use the respective ICT tools for the purpose of learning” at the classroom level (Lim, 2007, pp. 111-112).

In China, there is evidence that school teachers have embraced the student-directed, technology-facilitated approach, particularly the recent graduate teachers and their “efforts indicate that the conventional education approach has been changed greatly, i.e., from a teacher-centred approach to a student-centred approach, from an examination-oriented approach to a quality-oriented approach” (Zhao & Xu, 2010, p. 51). A 2012 study summarised the apparent paradox in effective technology integration within China in its conclusions; “we are inclined to say that the development of ICT has become one of the determining factors promoting a paradigm shift in learning and instruction in China’s classrooms” (Ge & Ruan, 2012, p. 24) and yet there remains a “lack of research on systemic change and diffusion and educational reforms at a large scale in China’s education”. This was also the case in Vietnam, where “policy makers strongly endorse and support integration of ICT in education” and had the intent to act as a “hub for ICT development in South-East Asia” (Peeraer & Van Petergem, 2012, p. 91). The Ministry of Education and Training (MOET) “encourages educators to *reasonably* implement ICT applications in new and innovative methods of teaching and learning at each grade” (Anh et al., 2010, p. 6). Vietnamese educational managers believed their future classrooms would be an “open and friendly environment, where ICT is a tool to support creativity and exploration” (Peeraer & Van Petergem, 2012, p. 96). It would seem that technology is assisting educators to shift the pedagogy in Asian schools towards a more student-centred approach.

2.6 Evidence of technology integration in Europe

Europe has an established place as a centre of excellence in education. Finland in particular is held in high regard as a model education system (Sahlberg, 2010; Westbury, Hansen, Kansanen, & Bjorkvist, 2007) and the student achievement results support this assertion (M. O. Martin et al., 2016; Mullis et al., 2016). Finland is highly placed on the internet penetration index (97%), yet Finland does not make the top ten in terms of pure numbers of internet users due to its relatively small population (Miniwatts Marketing Group, 2015). The wealth, past or present, of many European nations provided opportunities for investment in youth, technology infrastructure and education. Based on 2014 figures, 10 European countries have internet penetration rates of greater than or equal to 90% (Miniwatts Marketing Group, 2015). This is exceptionally high when it is compared with other continents, few of which can match such high levels of connectivity. Germany and Russia have the greater number of internet users, however, Iceland, Finland, Denmark, Norway, Luxemburg, The Netherlands and Sweden lead the internet penetration statistics with 95% or more of their populations recognised as internet users. The United Kingdom (90%) and France (83%) both have in excess of 50 million internet users and both have increased access by around 10% in the past 4 years. Rates of growth in connectivity since 2011 range from the minimal (eg. Italy increased by 1%) to spectacular (eg Russia increased by 42%) reflecting differences in base statistics, government spending priorities or both. Targeted ICT in education programs, with accompanying funding have contributed to some extremely high penetration rates, particularly amongst the Scandinavian countries. The recently financially challenged nations of Portugal, Italy and Greece have internet penetration percentages of 65%, 59%, and 60% respectively while stronger financial nations such as Germany, have an internet penetration rate of 89%.

In broad terms the strong performing nations, based on comparative student average scale scores in mathematics and science tests according to TIMSS and PISA data (M. O. Martin et al., 2016; Mullis et al., 2016; Sciences, 2012), have either maintained their high performance or improved and the weaker-performing nations have either

held their positions or have small drops in their average scale scores. As previously mentioned, there are so many variables which impact student performance, so singling out one variable, whilst interesting, does not generate compelling causal data. Amongst countries which have different levels of investment in ICT for education, despite the improvements in internet connectivity, additional spending does not appear to have a predictive effect on improving student performance in international test scores for mathematics or science.

The Commission of the European Communities produced a staff working document in 2008, prompted by several findings, one of which lamented that “the impact of ICT on education and training has not yet been as great as had been expected despite wide political and social endorsement” (European Commission, 2008, p. 4). Commenting on the progress of e-Learning and the use of ICT, the working document reports the progress made in improving infrastructure, training teachers and encouraging the production of digital content for students. “86% of teachers think that pupils are more motivated and attentive when computers and the internet are used in class. 80% see advantages in using ICT at school” (European Commission, 2008, p. 7). This consequence of increased use of computer technology in the classroom builds on the previous discussion of increased access to the internet within European schools. “Making learning more fun may be an end in itself and may have additional positive effects on the learning process. But from a more applied point of view, we also want to make learning more attractive so that youngsters would spend more time doing it” (Lens, 2006, p. 220). Despite the potential of increasing student engagement and motivation with increased exposure to technology in the classroom, reports from European schools emphasise the paucity of evidence to support the construct that improved student learning outcomes justify the high cost of technology expenditure. The working document emphasises the importance of quality over quantity when it comes to ICT integration. The effective ICT integrators in Europe recognise that “interactive forms of e-learning can lead to a more reflective, deeper and participative learning” (European Commission, 2008, p. 11). This is particularly true when the technology is used to personalise the learning at all levels of the education spectrum. In the sub-sections which follow,

literature studies have been selected from a range of European countries, including the United Kingdom, Ireland, Germany, Finland, The Netherlands, France, Belgium and Italy to highlight the priorities of different governments in allocating spending to improve ICT integration and the methods by which different teachers in different schools have responded to this challenge. As in previous sections, these factors will be set in the context of the common inhibitors and enablers of exemplary ICT integration identified in the literature and are the focus of the next two sections.

2.6.1 Inhibitors of ICT integration across European nations

Europe has some of the world's best performing students on international scales and, by extension, some quality teachers within their education systems. However, despite targeted spending by many governments with the intention of improving ICT integration, (Balanskat et al., 2006; European Commission, 2008) significant improvements in student learning outcomes have not been commensurate. The lack of access to computers remains an inhibitor to many teachers, including those in European schools, and a consistent reason for their lack of effective ICT integration (Erixon, 2010). However, even when access to technology has been addressed, there have been concerns that it has not had quite the impact in education as anticipated. "ICT has not yet transformed teaching and learning as it has transformed processes in other key sectors such as enterprise or public service" (European Commission, 2008, p. 14).

In Ireland, the Minister's Strategic Group recommended seven objectives for investing effectively in ICT over a five year period: 2008-2013:

- Continuing professional development;
- Software and digital content for learning and teaching;
- ICT equipment – additional and replacement;
- Schools' broadband and services;
- Technical support and maintenance;
- Implementation structures and supports; and
- Innovative practice and research.

(Morrissey et al., 2008).

This plan was primarily prepared in response to an identified problem with ICT integration in Irish schools, namely that “the lack of a clear vision and coordination for ICT in learning and teaching has, in many cases, resulted in ICT being seen as an add-on to a pre-service programme or as an optional tool or curriculum module rather than a core element of curriculum delivery” (Morrissey et al., 2008, p. 7). The Irish challenge was to encourage schools to “form a school ICT committee which will plan and guide ICT integration and work collaboratively across the school to develop a whole-school shared vision” (Morrissey et al., 2008, p. 11). Such strategies are common throughout Europe and as a result many of the common inhibitors identified on other continents have already been addressed. However, one of the specific inhibitors to effective ICT integration in European schools is inadequate professional learning around technology integration. The following example is from the German education system, and whilst it is a dated example, its relevance to some aspects of current technology integration practice remains.

2.6.1.1 Inadequate professional learning around technology integration

For effective ICT integration, teachers needed to be taught the necessary skills. In analysing teacher education in IT in Germany, Gorny (1995) revealed the “net effect is that most novice teachers do not have a systematic introduction to the field, although they might have acquired some practical knowledge on their own by using computers as a personal tool” (p. 43). Effective professional development is a key enabler in fostering technology use in the classroom and finding a method which can support teachers has been one of the goals in the German education system. Like many countries, including Australia, England and France, Germany has developed a set of teaching standards and competences which, four years after first release, included the effective use of ICT in lessons as part of its “obligatory core curriculum” (Page, 2014, p. 191) in its educational reform agenda. However, there remain concerns about the self-categorisation of German teachers as mathematicians or scientists first and teachers second. This has led to a persisting gulf between teacher training and teacher practice (Page, 2014).

2.6.2 Enablers of ICT integration across European nations

Optimism for educational reform is strong in European nations, especially those with high performing students in international testing, based on the belief that the role of ICT in education will become more central and comprehensive; “ICT provides the means to support personalisation, where learners are also considered to be knowledge builders and creators and not just the recipients of transmitted knowledge” (European Commission, 2008, p. 12). A recent survey of European schools’ use of ICT in education found “students’ use of ICT for learning during lessons is related to teachers’ confidence in their own ICT competences, their opinion about the relevance of ICT for T&L (teaching and learning) and their access to ICT at school” (Wastiau et al., 2013, p. 19). Differences noted between countries tended to occur in clusters. The survey reported significant differences between the numbers of “digitally confident and supportive teachers” and “digitally supportive schools”. Professional learning was another critical factor examined in the survey in relation to teachers’ use of ICT in the classroom. “Teachers prefer informal methods of training, blended training and training that relates to real classroom settings” (Wastiau et al., 2013, p. 16). However to maximise the return from this sort of training, it needs to be facilitated in a climate of professional collaboration. A significant enabler of exemplary integration is the blending of informal, contextualised training and localised collaboration between educators (Wastiau et al., 2013). Another source of higher frequencies of ICT use may be found in the context of how schools approach ICT integration. School-level factors which encourage increased ICT integration include clearly stated policies and concrete support measures, especially “professional development and the provision of ICT coordinators” (Wastiau et al., 2013, p. 18), because “students in schools that focus on concrete support measures use ICT more frequently during lessons than those in schools with policies but no concrete support measures” (Wastiau et al., 2013, p. 18).

The following sections discuss each of the key enablers identified from the literature as they relate to the European education systems. They include collaborative development and dissemination of technology integration strategies and professional

learning opportunities and methods.

2.6.2.1 Collaborative development and dissemination of technology integration strategies

British governments have been allocating finances to many technology-related projects which have supported primary and secondary learning through technology over many years. The BBC (British Broadcasting Commission) documentaries and interactives such as those found on the BBC BiteSize website (BBC, 2015) and the Times Educational Supplement (TES) resource pages (Global, 2015) were created and financed in the interest of encouraging technology integration through the “development of significant amounts of resource materials for professional development, including CD-ROM-based and online materials” (Downes et al., 2001, p. 48). This support for the development of technology-based applications has resulted in the production of Wolfram Alpha and Wolfram Mathematica, browser-based web services that are used globally as a result of their impact on student learning. “Wolfram Alpha is a free, browser-based web service, developed by Wolfram Research, which dynamically calculates results to natural language queries by applying algorithms to its extensive internal database of facts” (Dimiceli, Lang, & Locke, 2010, p. 1061). Its mathematical derivative is Mathematica and it is being used in mathematics classrooms for algebraic computations and calculus (Jungic & Mulholland, 2014). Wolfram Alpha and Mathematica are being used by both secondary and tertiary educators, in some cases to replace computer algebra system (CAS) software, with some encouraging results; “current findings imply that Wolfram Alpha may have an equally good or faster adoption rate in math than other CAS technology” (Ersoy & Akbulut, 2014, p. 260). Such tools for educators have come from government commitments to “over £1.7 billion invested in training, hardware and software in UK schools” (Baggott la Velle et al., 2007, p. 339) in the early part of the twenty-first century. Twining (2002) noted that “the level of investment in ICT in secondary school appears to be higher in the UK than in most of the rest of the EU (*European Union*)” (Twining, 2002, p. 19) (*italics added*). The creation of software and support for teachers facilitates classroom-based activities

which incorporate the integration of ICT and/or encourage collaboration and resource sharing between teachers and/or students in different schools and across the globe. This significant investment in technology tools was a very subject-specific approach, targeting the teaching of science and mathematics. Despite this large investment, research into the impact that technology has made in changing pedagogy is inconclusive. Many of the studies seem more directed towards the evaluation of technology integration into existing practice rather than reflection on new or deeper learning (Downes et al., 2001).

Belgium research has also reinforced the concept of a local approach to effective ICT integration; “the development of an ICT school plan aimed at setting clear goals and defining the means to realise these goals is a crucial step towards actual ICT integration” (Tondeur, van Keer, van Braak, & Valcke, 2008). In seeking to identify a practical solution to the challenges of effective professional development, Tondeur, van Keer, van Braak and Valcke (2001), concluded “the most effective teacher training experiences are school subject-specific practices, immediately relevant for classroom instruction and connected to school policy” (p.214). This reference to ‘just-in-time’ teaching within a technology-based pedagogy assisted teachers to ensure their use of the technology was purposeful and targeted to a specific learning objective.

A 2006 review of teacher beliefs and ICT (Gobbo & Girardi, 2006) sought to link personal theories about teaching and ICT competency with ICT integration in Italian schools. An important conclusion from this study was the recognition of the significance of peer tutoring and just-in-time learning, as per the Belgian experience. “It was easier for a teacher to show weak points and ask a colleague for advice, rather than an expert outside the reality of the school context.” (Gobbo & Girardi, 2006, p. 81).

2.6.2.2 Professional learning opportunities and methods

One reward of the comprehensive education system in Finland is the exposure of prospective teachers to “strategies of cooperative and problem-based learning,

reflective practice, and computer-supported education” which are “common in all Finnish universities” (Sahlberg, 2010, p. 4). Much of the success in student performance, as well as the increased interest in the profession has been linked to teacher autonomy both regarding “responsibility for curriculum and student assessment” (Sahlberg, 2010, p. 6). This is particularly true of the attitude towards teacher professional development in Finland: “the goal is to develop teachers who will base their educational decisions on rational arguments in addition to experiential arguments . . . to develop teachers who have the capacity to use research and research-derived competencies in their on-going teaching and decision-making” (Westbury et al., 2007, p. 477). In the context of this study, teacher autonomy provides a significant enabler as teachers can experiment with pedagogies which are in the best interest of their students. This could include the use of technology to enhance student autonomy. Its relevance to this study is the shift in the “focus of professional development from the fragmented in-service training towards more systemic, theoretically grounded schoolwide improvement efforts” (Sahlberg, 2010, p. 6). The efficacy of professional training and ongoing learning is a key component of effective ICT integration in Finland. In this context, technology is not regarded as an add-on to be allocated a position within the curriculum, it is part of a planned and purposeful approach to exemplary teaching and learning.

The 2006 study by Gobbo and Girardi, referred to above, reached other conclusions which were consistent with those identified elsewhere; “high competent teachers, compared to low competent ones, increased their knowledge and practice through their own study, in addition to the formal training received” (Gobbo & Girardi, 2006, p. 79). They summarised much of the difference found on the basis of power and control. Many of the competent teachers were more likely to conform to a constructivist pedagogy and were prepared to allow “a less distant, less asymmetrical relationship . . . mentioning reciprocal learning between teacher and pupil” (Gobbo & Girardi, 2006, p. 75). It is not merely the type of professional learning undertaken which makes a difference. It is also the personal desire of the teacher to learn and when to take some of their lessons from their students.

2.7 Evidence of technology integration in the Middle East

A review of internet usage rates for 2014 for Middle East countries revealed a large range of values and represented an incredible rate of growth, from Bahrain's 96% internet usage penetration (up from 57% in 2011) and the UAE with 93% (up from 69% in 2011) to Syria's 26% (Miniwatts Marketing Group, 2015). Large population numbers for Iran, Saudi Arabia and Syria compared to most of the other, smaller nations have skewed the percentages. Iran has over 46 million internet users, well ahead of Saudi Arabia with 18.3 million, yet this represents just 57% of the total population of Iran. With the exception of the top five countries, including those mentioned above, most of the countries in the Middle East have similar numbers of internet users (Miniwatts Marketing Group, 2015). Most countries in the Middle East have experienced significant growth in the number of internet users over the past 15 years. As for other geographic regions, much of this growth has come from a low base percentage of internet users in 2000. In order to improve the quality of education, programs have been established in several countries to link local teachers with expatriate experts in teaching and learning. This has been an expensive exercise for the governments involved in the programs and has been accompanied by infrastructure and hardware upgrades for the education sector. This may account, not only for the high growth rate in the UAE, but also an internet users' penetration index of 93%, the second best in the region (Miniwatts Marketing Group, 2014). Similar education reform projects are, or have been, in place in Qatar and Saudi Arabia with concurrent outcomes. The catalyst driving much of the change in the region is the poor performance of students in international science and mathematics tests such as TIMSS and PISA. Most of the countries in the Middle East, which have participated in international testing programs, have not performed well when compared to the Asian and European nations (OECD, 2015).

The drive to improve student average scale scores in mathematics and science has resulted in a radical overhaul of education systems which have been very traditional in terms of pedagogy. It will be some years before the current efforts bear fruit and on current statistics only Israel, Iran and Jordan have comparable data. Jordan's foray

into ICT integration is a recent one (Abuhmaid, 2008). The average scale scores for students in Jordan remained the same for TIMSS mathematics but showed significant improvement in TIMSS science, over the 12 years of data (M. O. Martin et al., 2016). A similar pattern can be observed for Iran and Israel: a small decrease in average scale scores for TIMSS mathematics and an increase in the average scale scores for science. However, both of these nations improved significantly in 2011 (Bouhlila, 2011; M. O. Martin et al., 2016; Mullis et al., 2016). Israel students also attempted the PISA exams and their performance in both mathematics and science components showed significant increases (Aypay, 2010; Sciences, 2012). This may, in part, be due to Israel's positioning of itself as a global leader in ICT and the subsequent flow on to the education sector (Albion, Tondeur, Forkosh-Baruch, & Peeraer, 2015a).

Several studies have reported positive correlations between student performance and high computer to student ratios (Al-Rasbi, Al-Balushi, Al-Kharusi, Al-Harhty, & Al-Zadjali, 2008; Alsulaimani, 2012) with Alsulaimani (2012) reporting "in Bahrain, Egypt, Jordan, Lebanon and Saudi Arabia, students using computers inside the school outperformed students using computers outside the school" (Alsulaimani, 2012, p. 148). In the following sub-sections, experiences from Middle Eastern nations highlight some of the inhibitors and enablers of effective ICT integration, many of which are common to those already discussed.

2.7.1 Inhibitors of ICT integration across Middle Eastern nations

Nations in the Middle East have recently allocated large budgets to improving the education standards generally. "GCC (Gulf Cooperation Council) students generally have fewer educational resources available to them than their peers worldwide" (Wiseman & Anderson, 2012, p. 609). Many nations are only recent arrivals to the international testing programs and while some of the results have been disappointing, eg the United Arab Emirates, others have been outstanding eg Israel (M. O. Martin et al., 2016; Mullis et al., 2016; Sciences, 2012). Computers and technology infrastructure improvements have been, and in many countries still are, rolled out across the Gulf Nations in an attempt to provide additional opportunities for students.

“ICT plans in developing countries are generally not still connected to national education strategies with clearly defined objectives” (Abuhmaid, 2008, p. 43). Most of the inhibitors around the infrastructure are being addressed. However despite the influx of western educators, much of the teaching population remains very traditional in both culture and practice and this has slowed the rate of progress. “Evidence suggests that education systems in the Gulf that have increased access to ICT tools at the classroom level often still mirror the pre-ICT educational culture” (Wiseman & Anderson, 2012, p. 611). At a regional level, similar concerns were identified in Saudi Arabia; another country embracing major educational change. The focus of many of these studies in the region has been on the barriers to effective ICT integration. “The four groups (of barriers) were infrastructure and resources, policy and support, science teachers’ personal beliefs and staff development” (Alwani & Soomro, 2010, p. 39).

A more detailed study of Saudi Arabian mathematics and science teachers regarding the “primary barriers impending ICT implementation” (Alsulaimani, 2012, p. 149) listed ten inhibitors to effective ICT integration, with the top two being “insufficient time in the weekly schedule to acquire ICT skills” and “shortage of ICT equipment at school” (Alsulaimani, 2012, p. 149). Of the remaining eight, four of these also related to problems of access or infrastructure, whilst two related to planning and “inadequate ICT training pre-service” (Alsulaimani, 2012, p. 150) once again highlighting the importance of adequate infrastructure and planned teacher training in optimising technology use in the classroom.

Major reforms in the education sector in the United Arab Emirates provide a timely and convenient focal point for adding to the previous studies on effective ICT integration practice in the region (Almekhlafi & Almeqdadi, 2010; Fuchs & Woessmann, 2007). Recent studies identified similar inhibitors to those found in other education settings around the world; “male teachers indicated that there is a lack of training on how to integrate technology effectively” (Almekhlafi & Almeqdadi, 2010, p. 169). “Female teachers pointed out that a large number of students (class size), technical problems and expensive tools are the common

problems that negatively affect the effectiveness of technology” (p. 169). While these observations are not new, they may be a precursor to the establishment of a level of generalisability regarding the issues associated with effective ICT integration across different continents and cultures. Several of the identified barriers have been the focus of the following section. These include inadequate professional learning around technology usage, lack of recognition of the pedagogical value of technology, low personal self-efficacy relating to computer usage and the lack of time to adequately explore the technology.

2.7.1.1 Inadequate professional learning around technology integration

Many of the examples described previously looked at professional learning experiences as a totality, based on the question; how can technology enhance teaching? However there are also examples from the research which highlight the limitation in professional learning when it comes to the teaching of a particular strategy or software application. One such example comes from Israel. In evaluating the impact of a study into the effect of using a computer simulation to teach the kinetic molecular theory to middle school students in Israel, the researchers were concerned about the skill level of the teachers involved. “The three teachers in our sample lacked the appropriate background relevant for the effective use of a conceptual change-based unit that is available in Israel” (Stern, Barnea, & Shauli, 2008, p. 313).

2.7.1.2 Lack of recognition of the pedagogical value of technology

Negative feelings about technology were reported in a 2016 study from Iran (Mirzajani, Mahmud, Fauzi, Ayub, & Wong, 2016). The researchers reported on a series of interviews conducted with teachers about the factors which influenced teachers’ decisions to integrate technology into their classrooms. They found many teachers “lacked knowledge about the effectiveness of such technology in teaching, as they had not fully understood the importance of educational technology” (p. 32).

2.7.1.3 Low personal self-efficacy relating to computer use

As discussed previously, an individual teacher and their own beliefs around the value of technology has a significant potential to influence both whether and how effectively they use technology in the classroom. Another example from Israel exemplifies this assertion. In contrast to the objective of universality of success with technology desired by governments, a comparison of ICT use in education between Hebrew and Arabic Schools in Israel noted “teachers reactions to technological innovations are mediated by their cultural perceptions, norms and values, and school regularities and practices as well” (Nachmias, Mioduser, & Forkosh-Baruch, 2010, p. 494).

2.7.1.4 Lack of time to effectively explore the technology

In evaluating the various factors which enable or inhibit technology integration, it can be difficult to allocate certain factors to a specific area. Whether teachers are bureaucratically bound and unable to invest adequate time in technology, whether the school does not allocate time to technology exploration because they do not appreciate its value as an educational tool, or whether the teachers themselves do not believe in their ability to use technology effectively all manifest as a lack of time for adequate exploration of the power of the technology. For example, despite a bold plan to ensure 20,000 government employees across Jordan received “training to make them ICT-literate by the year 2005” (Abuhmaid, 2008), a World Bank (2003) report showed teaching methodologies remained the same despite successful upgrading of teachers’ own educational levels. In seeking to reduce the skill set required for a competent ICT integrator, Abuhmaid (2008) concluded “it is difficult to define what skills teachers could master in order to be called competent in utilising ICT for the school context”. In highlighting some of the issues associated with teacher resistance to ICT integration, Abuhmaid (2008) suggested that Jordanian teachers “may resist ICT not because of doubts about its value or effectiveness but because various issues engulf their work as teachers” (Abuhmaid, 2008, p. 189).

2.7.2 Enablers of ICT integration across Middle Eastern cultures

Considerable investment in western educational theory has resulted in many of the perceived barriers to effective ICT integration identified by Alsuliamani (2012) above being addressed. This has primarily focussed on increased connectivity, improved access to technology and professional development for teachers (Al-Alwani & Soomro, 2009; Alwani & Soomro, 2010). The last of these is highlighted as an enabler of effective technology integration within the Middle East context along with the importance of high personal self-efficacy.

2.7.2.1 Professional learning opportunities and methods

The integration of laptops into classrooms in Israel began in 2004. The KATOM (Computer for Every Class, Student, and Teacher) program had several goals, which primarily revolved around increasing technology access for Israeli children and to “test the effect of laptop use on learning processes” (Klieger, Ben-Hur, & Bar-Yossef, 2010, p. 190). In seeking to evaluate the most effective professional development model to support teachers in the roll out of laptops, Klieger et al concluded “when planning a model for PD that is aimed at supporting teachers who introduce innovative technologies . . . special focus should be placed on meeting the needs of the disciplinary communities” (Klieger et al., 2010, p. 197). This advice also overlaps with the previously discussed enabler of collaborative development and dissemination, highlighting the importance of a shared vision around technology integration.

This was also the case in a study conducted with Iranian teachers. They identified their sources of ICT information as primarily in-service training or from magazines with the researchers arguing for “effective teacher training as one of the important factors which influenced the integration of ICT in the classroom”(Mirzajani et al., 2016, p. 30).

2.7.2.2 High personal self-efficacy regarding the use of technology in the classroom

The traditional model of teaching has persisted in the Middle East and many of its elder practitioners struggle to adjust to a more modern approach, as highlighted above in section 2.7.1.2. However a study of Iranian teachers in found “that there was a relationship between self-confidence and using ICT in teaching. When a teacher had self-confidence, he or she would have a positive attitude toward ICT, and would be motivated to use the technology in the classroom” (Mirzajani et al., 2016, p. 31).

2.8 Evidence of technology integration in North and South America

In the United States, a policy critique of the state of ICT integration included in their recommendations that “administrators and teachers should receive adequate, tailored and continuing education about how to best integrate technology into their schools” (Noeth & Volkov, 2004, p. 26). As one might expect, internet penetration rates are high for the North American nations and somewhat lower for Central and South America (Miniwatts Marketing Group, 2015). It is immediately obvious in analysing this data that North America has the same population access to the internet as South and Central America combined. Canada has a slightly higher proportion of internet users than the United States. It is important to note, however, the size of both the population of the United States and its land mass in order to recognise the significance of an 87% internet penetration rate. There are many areas of the United States which are rural or remote from major cities and yet successive governments have been committed to continuing the technology revolution as they seek to increase equity of access to technology.

In analysing the internet penetration data for South America, Brazil has the greater number of internet users, however Argentina has the highest internet penetration of any Latin American country (75%). Four other countries: Brazil, Chile, Uruguay and Colombia all have more than 50% of their population recorded as internet users (Miniwatts Marketing Group, 2015). From the limited data available it may be

reasonable to assume high growth rates for South American countries in response to government pressure and funding to improve ICT hardware and infrastructure.

Both Canadian and American students' average scale scores fell from above average results in the previous decade of international testing (M. O. Martin et al., 2016; Mullis et al., 2016; Sciences, 2012), with small gains in TIMSS and small losses in PISA. What may be of concern to two first world nations who allocate significant budgetary funding to education is not the magnitude of the decrease, it is the fact that many other nations, particularly Asian and European nations, have outperformed the North American students by some considerable margin. The results from international testing of students' science and mathematics scores show a promising trend for the Latin American participants in PISA (Sciences, 2012). Argentina's average scale scores are the same for mathematics, while there have been some small gains in science. For Chile, Brazil and Peru, substantial increases have occurred in the average scale scores for both mathematics and science. In Mexico, there has again been an improvement in the mathematics average scale scores, accompanied by a small decrease in the average scale scores for science. All of the Latin American nation's average scale scores are in the bottom half of participating countries and all have come from a low base. Only Chile has demonstrated major improvement in TIMSS and PISA and this was over a 12 year period.

The International Society for Technology in Education (ISTE) based in the United States, has released standards for teachers, students and administrators. These standards are designed to "help measure proficiency and set goals for the knowledge, skills and attitudes needed to succeed in today's digital age" (O'Connell & Groom, 2010, p. 8). The ISTE Standards for teachers highlight the following standards and performance indicators:

1. "Facilitate and inspire student learning and creativity.
2. Design and develop digital age learning experiences and assessments.
3. Model digital age work and learning.
4. Promote and model digital citizenship and responsibility.
5. Engage in professional growth and leadership."

The quality of technology and education across North America has given rise to a plethora of research on ICT integration, innovation and methods for measuring success. As a result there is considerable research into the impact of technology in the classroom for both the United States and, to a lesser extent, Canada. There is not the same quality or quantity of research, in English language journals, from South America. The common enablers and inhibitors of effective technology integration from these two large and diverse continents follow in the next two sub-sections.

2.8.1 Inhibitors of ICT integration across North and South American nations

Studies in the United States have revealed “major barriers identified by teachers in the use and integration of computer technology in the classroom (which) include: lack of computers and relevant quality software, lack of time, lack of funding, technical problems, teacher attitude towards computers, lack of teacher confidence, resistance to change, poor administrative support, poor training and a lack of vision to integrate technology into the curriculum” (Keengwe et al., 2008, p. 562). These issues have been somewhat exacerbated amongst some of the South American nations, often due to a differential in the size of their education budgets. Two specific inhibitors are identified below; namely equity of access to technology and inadequate professional learning around technology.

2.8.1.1 Equity of access to technology infrastructure

In the past few decades, government interventions such as the ‘Apple Classrooms of Tomorrow’ (ACOT), ‘No Child be Left Behind’ and ‘Preparing Tomorrow’s Teachers to Use Technology Initiative’ (Downes et al., 2001) have all been pursued in the interest of increasing access for all American students to a quality education which is inclusive of modern technology. Despite the rhetoric and the spending, equity of access remains a significant inhibitor to technology integration across North America. So too in many of the South American nations where attempts are being made to “close the digital divide” (Blignaut et al., 2010; Sanchez et al., 2011).

2.8.1.2 Inadequate professional learning around technology integration

The targeted spending of successive administrations to seek to improve access to technology and reduce some of the issues around equity seemed to create other issues as well. “During the past decade, the U.S. Department of Education’s *Preparing Tomorrow’s Teachers to Use Technology* (PT3) program provided over \$750 million to projects focussing on new methods for preparing future teachers to effectively integrate technology into their teaching” cited in (Ottenbreit-Leftwich et al., 2012, p. 399). The strategies employed “tended to lead to different approaches being used for different groups rather than developing more flexible and generic approaches that might be useful across the groups” (Downes et al., 2001, p. 38). Unfortunately, there appeared to be a greater emphasis placed on the project outcomes rather than exploring systemic or individual teacher development in relation to technology integration.

Professional learning has been well-researched in the United States. However, not all of the findings have been positive; “the inability of teachers to integrate IT into the classroom seems to be a serious limiting factor” (Ebenezer et al., 2011). This was further evidenced by a survey of Michigan teachers reported by Newman, 2002 and summarised in Ertmer (2005) indicating “only a small proportion of the teachers (sometimes only 1 in 9) knew how to use high-tech tools such as spreadsheets, presentation software or digital imaging to enhance their lessons” (Ertmer, 2005, p. 26). Unfortunately 10 years further on, similar trends are identifiable and as Ertmer suggests; “if we truly hope to increase teachers’ uses of technology, especially uses that increase student learning, we must consider how teachers’ current classroom practices are rooted in, and mediated by, existing pedagogical beliefs” (Ertmer, 2005, p. 36).

The issue of inadequate professional learning is also evident in South America. In a comparison between the effectiveness of e-learning in South Korea and Chile, Sanchez et al (2011) reported on an initiative by the Chilean Government “with a budget of US\$200 million, in order to carry out the major pillars of the strategy for education: to close the digital divide, to increase teacher training, and to introduce a

new generation of digital technologies into the educational system” (Sanchez et al., 2011, p. 141). Unfortunately, when referring to the training in the integration of ICT, which was a key component of this initiative, Sanchez et al suggested that this “training tends to take place in teaching contexts in which the management of content and methodologies is weak, thus diminishing the effect that these training efforts could have on learning and teaching practices” (Sanchez et al., 2011, p. 141).

According to their international test scores (M. O. Martin et al., 2016; Mullis et al., 2016; Sciences, 2012) Colombian students have struggled to compete academically on the international stage. However, this has not discouraged the expansion of ‘computers in schools’ programs in Colombia, nor inhibited the flow of studies seeking to measure its effect. While both the absolute numbers of computers in Colombian schools increased as did student usage of computers, one study, in referencing the targeting of increased technology usage, concluded that “the program has little impact on students’ math and Spanish test scores” (Barrera-Osorio & Linden, 2009, p. 5). The caution about the “potential limits of ICT interventions aimed at improving the methods that teachers use in the classroom,” was, in part, due to the fact that the professional development program “simply assumed that once equipped and trained, teachers would voluntarily incorporate the provided technology into their classrooms. Mere training and equipment does not seem to be sufficient” (Barrera-Osorio & Linden, 2009, p. 25). This attitude to ICT expenditure is not unique and highlights the need for a targeted professional development approach.

2.8.2 Enablers of ICT integration across North and South American nations

North American nations have long recognised the advantages of an innovative and educated population and successive governments have sought to continue to foster innovation (Boss, 2012; Ormiston, 2011) and change (Fullan & Longworthy, 2014) within the educational sectors. North America is home to many of the innovative approaches pervading global education systems, including the flipped classroom (Fulton, 2012; Herreid & Schiller, 2013), mobile application (app) design (Y.-C. Hsu & Ching, 2013) and New Pedagogies for Deep Learning (NPDL) (Fullan &

Longworthy, 2014). The United States is also where some of the evidence about the efficacy of alternate pedagogical approaches incorporating technology originate; “learning gains nearly triple with an approach that focuses on the student and on interactive learning” (Mazur, 2009, p. 51). It is where students started to construct and/or use avatars or teachable agents (TA) to assist in their learning, with some positive effects; “students who taught TAs spent more time on learning behaviours and ultimately learned more than students who learned for themselves” (Chase, Chin, Oppezzo, & Schwartz, 2009, p. 348). It is also believed that “a teacher’s competence and confidence integrating IT tools into science curriculum will yield great dividends in student development of IT fluency” (Ebenezer et al., 2011). Clearly, there are lessons to be gained from encouraging student autonomy and exploration with technology and this is a significant enabler when applied to technology integration according to the North American research. These and other enablers of effective ICT integration are described in the following sub-sections.

2.8.2.1 Increased student autonomy and differentiated learning

There has been some attempt made to evaluate the impact of the ACOT initiative mentioned previously, with encouraging results. The successful “ACOT teachers changed their pedagogy to be more child-centred, with collaborative environments which had a more active orientation” (Newhouse et al., 2002, p. 22). This position was later reinforced in a study by Drent and Meelissen (2008). Successful ACOT teachers “over time, with supportive teacher development”, “did adapt to more constructivist approaches” (Masters & Yelland, 2002, p. 314).

Several educators in the United States are at the forefront of technology integration (Klopfer, 2008; November, 2012); leading and inspiring innovative applications of technology which are providing significant gains in student motivation and quality of work on a global scale. Technology integration advocates such as November, Klopfer and Robinson are encouraging teachers to unleash the creative potential of students (Robinson, 2011), providing authentic learning experiences (Klopfer, 2008; November, 2012) and encouraging creativity in assessment (Klopfer, 2008; November, 2012; Richardson, 2010; Robinson, 2011; Solomon & Schrum, 2007).

“These teachers have gone beyond the usual responsibilities to design activities and create learning environments that engage their students in meaningful technology use” (Hakverdi, Dana, & Swain, 2011).

Many creative practices in technology integration, which now have global appeal, originated or were fostered and developed in the United States, including:

- WebQuests (Abbitt & Ophus, 2008; Dodge, 1995; Gaskill, McNulty, & Brooks, 2006; Perrone, Clark, & Reppenning, 1996)
- Web 2.0 techniques for teaching, including social networking (Huang, Yang, Huang, & Hsaio, 2010; K. Oliver, 2010; Richardson, 2010; Solomon & Schrum, 2007)
- augmented reality (Squire & Jan, 2007)
- teachable agents (TA) “a “sentient” hybrid agent/avatar that has been specifically designed for educational outcomes” (Chase et al., 2009, p. 336)
- mobile apps (Y.-C. Hsu & Ching, 2013)
- teaching with the Internet (Wallace, 2004)
- multi-user virtual environments (MUVE) (Clarke & Dede, 2009; Dunleavy et al., 2008)
- digital, immersive games (Barab & Dede, 2007; Barab et al., 2009; Dunleavy et al., 2008; Joiner et al., 2010; Klopfer, 2008; Proctor & Marks, 2013; Steinkuehler & Duncan, 2008) and Massively Multi-Player Online Games (MMOG) (Nelson, Erlandson, & Denham, 2011)
- java applets and simulations such as PhET (Physics Education Technology) (which have and are being translated into many different languages) (Adams et al., 2010)
- graphical interfaces such as GeoGebra (developed in Vienna, supported by Florida Atlantic University) or Move Grapher “an application to allow users to generate and display, immediately, distance and speed time graphs of their own motion whilst walking and running” (Wood & Romero, 2010)
- class response systems (CRS) (Beatty & Gerace, 2009)
- peer instruction (Crouch & Mazur, 2001; Mazur, 1997) and

- the customisation of curriculum materials through technology; “if science is about the tentativeness of knowledge, debate, falsification and change, textbooks are perhaps a deadly detriment to learning of inquiry and the Nature of Science” (Romine & Banerjee, 2011).

Eric Mazur is a university-level lecturer, however his insights and altered pedagogical approach are being transplanted into secondary schools both in the United States and abroad. Mazur found that “interactive learning triples students’ gains in knowledge” although ultimately, “learning is a social experience” (Lambert, 2012). As a result, Mazur has flipped his classes in the most dramatic way; creating collaborative groups of problem solvers where previously he had students sitting in lecture theatres (Crouch & Mazur, 2001; Mazur, 1997, 2009). His peer instruction model, combined with flipped delivery of content, has been revolutionary and so successful it has been adopted by many secondary and tertiary institutions, including those in Australia (Gokalp, Sharma, Johnston, & Sharma, 2013).

In the current century, change agents, like Michael Fullan, have entered the ICT integration space and outlined bold plans for exemplary practice. Through their work around the globe, deep learning is being revealed in response to the application of new pedagogies. Fullan and Longworthy (2014) describe deep learning tasks as having “a constructivist orientation, with an emphasis on the application of new knowledge in real contexts” (Fullan & Longworthy, 2014, p. 23). The real benefit of such tasks lies in the fact that “ideally, deep learning tasks develop both a teacher’s pedagogical capacity and a student’s learning capacity” (Fullan & Longworthy, 2014, p. 28). These new pedagogies are “powerful models of teaching and learning, enabled or accelerated by increasingly pervasive digital tools and resources, taking hold within learning environments that measure and support deep learning at all levels of the education system” (Fullan & Longworthy, 2014, p. i). Their premise is that “digital access is freeing teaching and learning from the constraints of prescribed curriculum content” (Fullan & Longworthy, 2014, p. ii). There appears to be great potential for exemplary teachers to effectively use technology to enhance student learning and engage learners.

2.8.2.2 Professional learning opportunities and methods

Programs such as Apple Classroom of Tomorrow and Preparing Tomorrow's Teacher to use Technology have encouraged additional government expenditure, inclusive of teacher professional development. A subsequent evaluation of the utility of professional learning opportunities which have stemmed from these initiatives revealed that "technology uses that supported classroom preparation and teaching specific concepts" (Ottenbreit-Leftwich et al., 2012) were the most important topics covered for 30% of teacher educators.

A 2011 study of exemplary science teachers who were past winners of the United States Presidential Award for Excellence in Science Teaching found that "the best source of professional development in learning how to use technology" was "learned on my own" (39% of respondents). This study contributed some significant findings regarding exemplary science teachers. Firstly, the study highlighted a lack of regular technology usage by science teachers in general. Secondly, those science teachers who were using technology, tended to incorporate ICT at a substitution or augmentation level, with the observation that "online communication and information retrieval are the most commonly used internet applications by exemplary science teachers" (Hakverdi-Can & Dana, 2012, p. 101). Hakverdi-Can and Dana (2012) concluded that self-training and risk-taking were common to exemplary science teachers, but this was insufficient in itself to translate into exemplary ICT integration. More often ICT was seen as one of a suite of tools chosen when applicable to enhance student learning.

Targeted professional learning has also had a positive impact on some of the South American nations, according to the research. In the SITES (Second International Technology in Education Study) 2006 report, Chilean mathematics and science teachers report reasonably high levels of ICT usage in teaching and learning activities (56% and 66% respectively) (Blignaut et al., 2010). Even higher percentages of Chilean teachers report a positive impact of ICT integration on learner development in this study, which Blignaut et al (2010) attribute to targeted professional training.

2.8.2.3 Collaborative development and dissemination of technology integration strategies

As a long term advocate for change, Fullan understands the need to build capacity in teachers and also recognises the bureaucratic barriers which can hinder teachers' creative expression and exploration of the new pedagogies; including "student assessment, teacher evaluation and school accountability regimes" (Fullan & Longworthy, 2014, p. 9). It is critical to note that to foster the kind of radical change promoted by the new pedagogies requires effective professional development activities which focus on "1) collaborative, social learning, 2) relevance to the local context and 3) analysis of impact in relation to desired learning outcomes" (Fullan & Longworthy, 2014, p. 58). Despite acknowledging that "effective technology integration requires many elements", Fullan and Longworthy suggest that "the best examples of technology integrated with other elements of new pedagogies come when whole schools and systems – rather than individual teachers or classrooms – undertake the integration" (Fullan & Longworthy, 2014, p. 60).

Canadian studies have included a focus on laptops in science (Gundy & Berger, 2013). Canadian biology teachers demonstrated that "having professional development at the school was seen as a great advantage . . . preferably to address the needs they as teachers identified" (Gundy & Berger, 2013, p. 140). This personalised nature of professional development will be addressed in later chapters. However, Gundy and Berger (2013) conclude "a bottom-up implementation where individual teachers organize and manage the integration of innovations in their subject area and within their own classrooms by relying largely upon their personal knowledge, skill levels, and interests" (Gundy & Berger, 2013, p. 141) synchronises neatly with many of the findings from other continents.

2.9 Evidence of technology integration in Oceania

Oceania is dominated, in the context of international academic testing, by Australia and New Zealand. Australia dominates the Oceania Nations, both in population size and land mass. It has the greater number of internet users and also the highest

internet penetration (Miniwatts Marketing Group, 2015). New Zealand is also well represented with 85% of their 4 million people connected to the internet (Miniwatts Marketing Group, 2015). Due to the isolation and small population sizes of many of the Pacific Island nations, along with the narrowing focus of this study on ICT integration in Australian secondary classrooms and those in New South Wales in particular, this section will concentrate primarily on what has been happening in Australian and New Zealand classrooms with regard to effective technology integration.

Australian education is in transition, moving towards a National Curriculum where questions of what and how to teach are the subject of vigorous debate. In New South Wales, there has been a drive by the Science Inspector at the NSW Education Standards Authority (NESA) to evaluate the mandatory content in the hope that students pursue the senior sciences with greater passion and drive (Sheehan, 2016 pers. com.). Concurrently a National Broadband Network (NBN) is being rolled out to potentially increase access to communication technologies for Australians in rural and remote areas (Gonski et al., 2011).

Both Australia and New Zealand have been strong performers in education over many years, however the increasing dominance of many of the Asian countries has seen the performances of both countries in international mathematics and science testing slowly dropping by comparison (M. O. Martin et al., 2016; Mullis et al., 2016; Sciences, 2012). While Australian and New Zealand students continue to perform well in international examinations, they are being regularly outperformed by many of their northern neighbours (M. O. Martin et al., 2016; Mullis et al., 2016; Sciences, 2012). Significant funding towards ICT infrastructure and technology access characterised both Australia (Australian Institute for Teaching and School Leadership, 2008) and New Zealand (Jones & Cowie, 2011) and both have continued to show growth in the number of internet users. The rates of growth in internet penetration are not insignificant, even more so considering the strong base from which, particularly Australia, has emerged (Miniwatts Marketing Group, 2015). New Zealand has experienced even stronger growth than Australia, partly due to its

elevation from a lower base. New Zealanders are now well connected and able to access technology over most of the North and South Islands (Miniwatts Marketing Group, 2015).

The performance of Australian students in international mathematics and science examinations has gone down by a uniform amount across the board, except for a small rise in TIMSS from 2007 to 2011 (M. O. Martin et al., 2016; Mullis et al., 2016). New Zealand data for PISA is similar to the Australian data. The drop in average scale scores for mathematics is juxtaposed with a slight increase in average scale scores for science, though not from 2009-2012 PISA (Sciences, 2012). There is no data available for any of the other Oceania Nations. The following sections focus on the literature from Australia and New Zealand and finalise the search for global enablers and inhibitors of technology integration.

2.9.1 Inhibitors of ICT integration across Australia and New Zealand

Oceania as a region has been mined solely on the output of studies from Australia and New Zealand. Similarities in educational goals and strategies have allowed some blending of approaches and this continues with products such as the New Zealand-based Education Perfect learning platform. Yet while both governments have been keen to invest in technology, teachers are still reporting the need for additional targeted professional development. Teachers in New Zealand responding to the introduction of laptops “considered change would have been greater with more professional support. In addition, it was considered important that schools provide mechanisms for expert teachers to share what they learned from external courses with colleagues on their return, and for teachers to have time to experiment with and explore what they were taught” (Jones & Cowie, 2011, p. 10).

Australia is a significant producer of educational research. The federal government continues to support Australian researchers through the availability of grants and there are many examples of exemplary practice within Australian schools (Lloyd & Mukherjee, 2013; Newhouse et al., 2002; K. Tobin et al., 1988). “Australia is recognised internationally as an early leader in the adoption of, and research into, the

use of computers in schools” (Newhouse et al., 2002, p. 4). As a consequence, there has been considerable local research into the effectiveness and nature of ICT integration into Australian classrooms. Government departments have sought to define the exemplars of innovative learning, including the highly accomplished users of ICT who see “ICT as an integral component of broader curricular reforms that change not only how students learn but what they learn” (DEST, 2002).

The Victorian Government established the ‘Navigator Schools’ Project in 1995. Its brief was, in part, to “create a network of exemplar schools, with accessible models of new learning environments where there is access to technology in every classroom . . . (to) share with others what is learned” (Pearson, 2003, p. 52). Despite visits to the exemplar school being “popular with teachers”, Pearson reported that “the impact of exemplar schools is not known as the experiences of teachers visiting these schools, and actual changes in classroom practice that may have resulted from these visits, have not been documented” (Pearson, 2003, p. 53). This remains the case, more than a decade later.

The boldest move by any recent Australian government to address the issue of equity of access was the Digital Education Revolution (DER), launched in 2008. “The DER is a five year \$1.2 billion Federal election commitment that will enable schools to better access the benefits of technology for their students” (Australian Institute for Teaching and School Leadership, 2008, p. 3). In 2011, this figure rose to \$2.4 billion, yet the commitment to training and resources component was less than \$60 million, a mere 5% of the total budget (Australian Government Department of Education, 2011). The DER provided hardware and software as well as professional support for teachers through its website. At a practical level, the DER facilitated the Laptops for Learning (L4L) program, in which laptops and other technologies were widely distributed to secondary school students across the country. This program has subsequently been abandoned by more recent federal governments. Whilst this is not unique to the Australian education sector, there are several warnings in the literature about the folly of provisioning funds for technology integration in education without a long term maintenance and reliability plan (Webster & Son, 2012). Effective

professional learning based around exemplary technology integration is, once again, an important consideration for schools, education sectors and professional development providers.

Both the intention to expand access to technology in the classroom and the subsequent entrance of such a large number of computers into secondary classrooms, spawned a series of studies into their potential and actual efficacy. In a review of ICT integration over a 16 year period, Baskin and Williams (2006) tracked changes in the views of computers in education. They mapped the progression in ICT integration from “an initial preoccupation with the teaching of computer skills, to focus more on issues of ICT access for all students (MCEETYA, 1999), the relevance of a ‘whole school’ approach to ICT teaching and learning (Curriculum Corporation, 2003), and more recently to issues of school based change management and teacher professional development” (Baskin & Williams, 2006, p. 456). In their review, they lament that for much of the time “pedagogy has been a silent space in the evolution of ICTs in schools” (Baskin & Williams, 2006, p. 456). In a longitudinal study evaluating the use of computers in the classroom, Newhouse (1997) opined the following; “in responding to the presence of the portable computers in a class, a teacher’s actions could be classified into three broad types: (1) actively facilitates the use of computers (*Active*), (2) permits the use of computers by those students choosing to do so (*Passive*), or (3) unconsciously or otherwise discourages the use of computers (*Negative*)” (p. 337). His research suggested only a small number of teachers fit into the active category “consistent with Becker’s (1994) finding that only 5% of computer-using teachers are exemplary” (p. 337). Despite these warnings, the mid-program review of the DER was promising. It highlighted the shift to a 1:1 student:computer ratio which had been achieved in schools and the subsequent rise in the use of technology in the classroom. However, the report did provide a number of warnings. There were concerns about ongoing hardware and infrastructure maintenance: “the sustainability of school-based technology infrastructure – including the enterprise-grade networks at the school level – is generally considered to be a potentially greater challenge than device sustainability” (Australian, 2013, p. 57) as a result of the devolving of financial

responsibility to the individual schools as a component of their budget, with the associated competition for priorities. There were also cautions regarding the effective use of the technology by classroom teachers: “A number of students reported that some of their teachers lacked the understanding and skills to use ICT, which resulted in those teachers developing mistrust for the devices” (Australian, 2013, p. 58). This too may have influenced the way future budgets are being spent in schools in terms of the proportion allocated to ICT maintenance and capital. Several specific inhibitors to effective ICT integration from Australia and New Zealand are presented below.

2.9.1.1 Lack of recognition of the pedagogical value of technology

Some recent studies have focused on the methods by which teachers can become more effective users of technology in the classroom. Richards (2005) suggests to “effectively integrate ICT in education teachers need to increasingly become designers rather than merely transmitters of learning” (Richards, 2005, p. 61). He seeks to try to shift the focus away from ICT to support a teacher-driven paradigm change towards the facilitation of a student-centred approach to learning. To achieve this he analysed three case studies and concluded that “teachers need (a) new design strategies for teaching and learning which promote the applied integration of ICTs, and (b) to avoid the kind of add-on tendencies associated with still dominant assumptions about formal lesson planning and syllabus design” (Richards, 2005, p. 75). His lament is that too many teachers do not value technology adequately as a vital learning tool.

The development of a technology curriculum for New Zealand schools began in 1992. This was the first stage in a broader plan to increase the use of technology in New Zealand classrooms. “Appropriate teacher development models that emphasise the importance of technology education and the structure of technology as a discipline are vital in the path to full implementation” (Jones, 2003, p. 97). “In New Zealand, the government spends over \$410 million every year on schools’ ICT infrastructure (Johnson, Calvert & Raggert 2009)” (Buabeng-Andoh, 2012, p. 136). This included a laptop program for teachers. “The provision of laptops to teachers

was one component of the New Zealand compulsory school sector ICT strategy: Learning through ICT and subsequently the Ministry of Education e-learning action plan for schools 2006–2010, Enabling the 21st century learner” (Jones & Cowie, 2011, p. 6). A 2011 study sought to quantify the impact of the Laptops for Teachers Program using questionnaires over subsequent years. They found “nearly three quarters of teachers overall (71%) had used their laptops to prepare student handouts or worksheets (83% of expert users and 74% of intermediate users). A third of teachers overall (31%) had accessed online resources for their lesson preparation (53% of expert users and 28% of intermediate users)” (Jones & Cowie, 2011, p. 10). Teachers self-rated their level of computer use in order to prepare these statistics, so such results must be contextualised within this framework, however the conclusions are worth consideration.

2.9.1.2 Equity of access to technology infrastructure

One significant publication appeared in the last few years which generated considerable debate and has had significant political implications. The review of funding for schooling final report (2011) which has subsequently become known as the ‘Gonski report’ after its Chairperson, identified several issues relating to the Australian education landscape. “Australia has a relatively high-performing schooling system when measured against international benchmarks, such as the Programme for International Student Assessment (PISA). However, over the last decade the performance of Australian students has declined at all levels of achievement, notably at the top end” (Gonski et al., 2011, p. xiii). One of its prime drivers was the importance of consistency of approach and equity for all students and based its recommendations around future funding on a fairer and more transparent system. All of this change should be set in the context of a quality future education system. “Classrooms should support innovative approaches to learning, not only through the curriculum, technologies and infrastructure, but also through the culture of the school. Principals and teachers should encourage a culture of high expectations, continuous learning, and independence and responsibility for all students” (Gonski et al., 2011, p. xix).

2.9.1.3 Inadequate professional learning around technology integration

A transition to a national curriculum, and a NSW version of this curriculum has also prompted some development and professional learning towards a favoured inquiry-based model for the teaching of science. While many publishers have been active preparing a suite of online and interactive resources, teacher associations, councils and research groups have also been exploring different technologies which may be implemented into the new curriculum. One group have been working on Virtua Singapura (VS) and Multi-level User Virtual Environment (MUVE) created for the purpose of teaching students about infectious disease through an inquiry model. “The practical significance of the project lies in the fact that there has been little research into how Australian students might learn in these newly available and innovative multi-user virtual environments and the sustainability of MUVES in the longer term. In addition, there has been little work into opportunities and challenges that in-service Australian teachers might face as they begin to learn about and to integrate technological and pedagogical innovations such as MUVES into their current and future classes” (Jacobson et al., 2010, pp. 51-52).

2.9.2 Enablers of ICT integration across Australia and New Zealand

The literature reveals both the attempts to address a major inhibitor of technology integration, namely equity of access, as well as how to describe and facilitate exemplary integration in the classroom. There seems to be a clear focus on the pedagogical shift to more student-centred learning on the part of Australian and New Zealand teachers who have a willingness to use technology in a range of different ways. One strategy involved the “employment of appropriate facilitators as well as teacher release” (Downes et al., 2001, p. 46) and while the mentoring approach proved popular, no formal evaluation of the impact of the professional learning program has been identified. Several programs have begun to emerge from the New Zealand education sector, such as Language Perfect/Education Perfect which focus on student autonomy and self-directed learning within a framework which allows the teacher to monitor student progress and provide feedback. Government attempts to increase student access to technology has resulted in some potential gains in terms of

student content creation. Two specific enablers which emerged from the literature are described in the following sections.

2.9.2.1 Increased student autonomy and differentiated learning

Government directives about the skills and goals of its education programs are not new, but the previously discussed digital education revolution in Australia crystallised those objectives as they pertain to teaching and learning in New South Wales secondary schools. Changes in access were designed to bring about equity across the public and private sectors and technology literacy for students. “The capacity to access data from multiple sources, to review it critically and to discriminate what is reliable and what is not reliable will be fundamental for many at work, and for all who hope to function as active and responsible citizens in the 21st century” (Downes et al., 2001, p. 25). This noble goal was to be partly achieved, and partly driven, by the government-established Australian Institute for Teaching and School Leadership (AITSL). “Students undertake challenging and stimulating learning activities supported by access to global information resources and powerful tools for information processing, communication and collaboration. Teachers devise student centric programs of learning that address agreed curriculum standards and employ contemporary learning resources and activities” (Australian Institute for Teaching and School Leadership, 2008, p. 4). These objectives needed to be set within the context of the intention that “Commonwealth, States and Territories commit to National ICT Infrastructure including access to broadband bandwidth, access to digital learning resources and activities, access to national curriculum and access to continual ICT PD for teaching staff” (Australian Institute for Teaching and School Leadership, 2008, p. 4).

2.9.2.2 Professional learning opportunities and methods

Governments and local teacher accreditation boards are now specifying the minimum requirements for teachers regarding ICT integration. This commitment to teaching standards and continuous professional development has resulted in frameworks which both prescribe minimum requirements and inform future professional

development opportunities. “Teachers and principals can use the new framework as a guide for planning enhanced professional learning with ICT” (Education Queensland, 2007, p. 65). State Departments of Education in Australia primarily draw from the Australian Professional Standards for Teachers (2011) document. This outlines specific expectations from teachers at graduate, proficient, highly accomplished and lead teacher levels. Graduate teachers are expected to “implement teaching strategies for using ICT to expand curriculum learning opportunities for students” (Leadership, 2011, p. 11), whilst within a couple of years they must progress to proficient teacher level and demonstrate their ability to “use effective teaching strategies to integrate ICT into learning and teaching programs to make selected content relevant and meaningful” (p. 11). Evidence of progress is assessed at the school executive level or through submission to one of the state teacher institutes. In New South Wales, this is NSWIT; the NSW Institute of Teachers; an organisation which sat within the larger BOSTES organisation. BOSTES, the Board of Studies Teaching and Educational Standards is the NSW entity responsible for the development, monitoring and management of quality teaching practice in all NSW schools. This includes the development of school curriculum, monitoring of schools for compliance and the management of teacher accreditation and student achievement in the external Higher School Certificate (HSC). In 2017, this organisation has been renamed NESA as mentioned above.

2.10 Exemplary Integrators of Technology

In seeking to generate a description of exemplary ICT integration, the literature reveals common problems and similar solutions. “The incorporation of ICT in all levels of education has increased dramatically and worldwide over the past 30 years” (Wiseman & Anderson, 2012, p. 608). Considerable resources have been invested in hardware and personnel to increase the efficacy of ICT integration in the secondary classroom. “In general, low-level technology uses tend to be associated with teacher-centred practices while high-level uses tend to be associated with student-centred, or constructivist, practices” (Ertmer, 2005, p. 26). High level technology integration can encourage constructivist pedagogies as they promote “a student-

centred, peer-learning approach, in which knowledge is created rather than transmitted” (Kolikant, 2012, p. 908). The literature search highlighted massive expenditure on the part of many governments to improve general internet access, increase the availability of specific educationally-located hardware and software and professional learning opportunities for teaching staff. Despite these efforts, many studies continue to lament the lack of increased technology availability, technology literacy, technology equity and/or uptake of technology by classroom teachers. “In 2012, 96% of 15-year-old students in OECD countries reported that they have a computer at home, but only 72% reported that they use a desktop, laptop or tablet computer at school, and in some countries fewer than one in two students reported doing so” (OECD, 2015, p. 3). Despite massive expense and the determination of government education departments around the world, the gulf between technology availability and technology application in education remains.

2.10.1 Defining the levels of technology integration

To contextualise the responses to the online survey and qualitative interviews, discussed in the next chapter, it was necessary to define the different levels of ICT integration for survey participants to make it easier to group the responses. In order to ensure the study retained a pragmatic approach, the literature identified the minimum ICT integration requirements for prospective teachers required by the New South Wales institute of teachers (Leadership, 2011; NSW Institute of Teachers, 2013). This provides a theoretical minimum in terms of ICT integration, however there needed to be a continuum of technology integrators from those who were reluctant to use technology at all to those for whom it was an indispensable part of their teaching practice.

A method of analysis which has been gaining some traction in seeking ways of separating the minimum adopters from the exemplary integrators is shown in Figure 3 on the following page. It may provide a useful means of auditing ICT integration practice across the learning communities. “According to the SAMR (*Substitution Augmentation Modification Redefinition*) model these two dimensions (substitution and augmentation) play an enhancement role in teaching and learning process. But

when ICTs are used to transform (modify and redefine) the teaching and learning processes we significantly realize a redesign of tasks” (Lubega, Annet, & Muyinda, 2014, p. 106) (*italics added*).

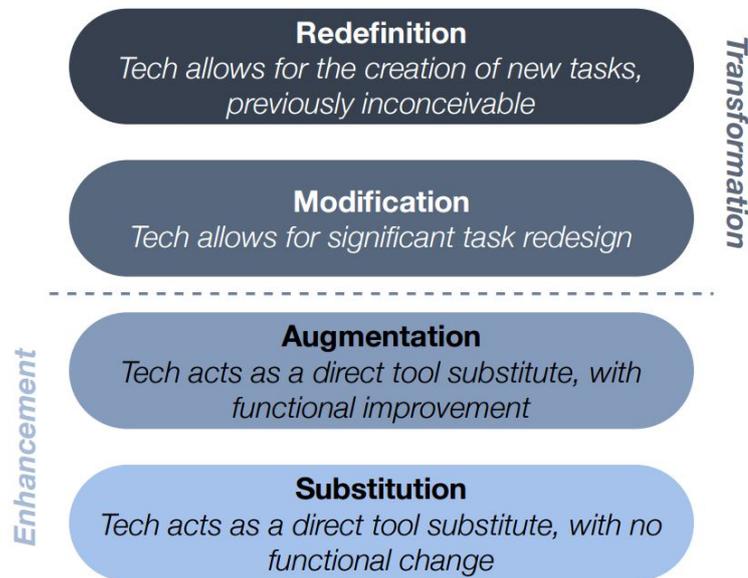


Figure 3 SAMR Model (Puentedura, 2010)

In broadest terms, technophobes¹ may only use substitution tasks as they seek to avoid or limit technology integration, while exemplary integrators are looking to redefine tasks and transform the learning with technology in ways that were not previously possible. There may be value in seeking to audit assessment, in all its forms, on the basis of where in this model, the current assessment would fit. Whilst personally interesting, this is beyond the scope of this study.

Lubega et al (2014) reported value in the use of this model in assessing the degree of ICT adoption by educators. “There is need to build capacity in both infrastructure and human that can fuel the pedagogical integration of ICTs” (Lubega et al., 2014, p. 109). They conclude with 4 areas they believed could help “institutions integrate the

¹ For the purpose of this study, teachers have been broadly classified as technophobes or technology avoiders, minimum adopters (those who only use technology when required to do so), competent users (those who are comfortable with technology and use it effectively in the classroom) and exemplary integrators (the most effective users of technology, confident teachers who use technology ubiquitously for high-order learning experiences).

SAMR Model in their pedagogical process” (Lubega et al., 2014, p. 113). Hew and Brush (2007) suggest that the dominance of enhancement over “transformative technology-supported-pedagogy” (Hew & Brush, 2007, p. 228), may be a consequence of the focus of most professional learning on operation rather than function. While a specific analysis of the role of the SAMR model in facilitating exemplary ICT integration practice is likewise beyond the scope of this study, the model provides a useful parallel for the evaluation of computer activities which are being delivered by teachers to their students. This study seeks to build on the SAMR model to help teachers identify the types of activities more common to competent users of technology and exemplary integrators; the transformation level of the SAMR model. It is the belief of the researcher that the raising of awareness of how exemplary integrators might use technology to redesign their learning tasks can encourage other teachers to try similar activities with their own students.

2.10.2 Common enablers and inhibitors from the literature

One goal of this study was to test the proposition that there is a set of skills or characteristics of teachers who demonstrate exemplary technology integration practice. The review of the literature supports the proposition, both in acknowledging common inhibitors and identifying common enablers of effective ICT integration. Much past research has examined the factors which inhibit or enable exemplary integration practice and many researchers came to similar conclusions. The research cited in the sections above supports the notion that “teachers’ lack of knowledge and skills is a serious obstacle to using ICT in primary and secondary education” (Bingimlas, 2009, p. 238). Despite the barriers, most teachers would have been likely to concede over a decade ago that they were not the “primary source of knowledge . . . [and are no longer sufficient] . . . in a world where knowledge doubles every seven years and 10,000 scientific articles are published every year” (Hargis, 2001, p. 480). Now the output rate for scientific publications has grown exponentially to be recently identified at between 1.5 and 2 million publications per year and it is still growing (Bornmann & Mutz, 2015). It is impossible for teachers to have knowledge and understanding of all of this research.

Yet to step away from the centre of the classroom, even with intent, requires a clear plan. “No other instructional tool has been at the centre of an educational revolution like the computer, nor has any other innovation been as invested in, supported, criticized, and researched as the computer” (Groff & Mouza, 2008, p. 22). However, rather than focus on the barriers, of greater significance is the methods used by exemplary integrators to recognise, embrace and overcome these common barriers or inhibitors.

Effectively, overcoming the inhibitors can now be summarised as addressing the three Ts:

- time;
- training; and
- tenacity.

Each of these are examined in detail below.

Time

Time is a constant theme in schools. Days are divided into sections or periods and almost everything is driven by time constraints. Technology is a tool which requires some investment of time to build familiarity and confidence and one of the major inhibitors identified is time (Downes et al., 2001). “Teachers are often not fluent in the technology themselves and have no time to develop their own plans for incorporating the use of online resources into their own curricula” (Perrone et al., 1996). Hence the time constraints placed upon teachers by bureaucratic demands, content-heavy curriculum and the importance of inclusive education are largely unresolvable. Amongst an aging population, particularly among science and mathematics teachers, “it takes longer to figure out integration strategies than use tried and true methods” (Solomon & Schrum, 2007). This was also identified by Becker (2000). “Developing expertise in using computers in teaching comes with time and experience – time spent using computers and time spent learning to teach well” (Becker, 2000).

The rapidly changing nature of technology creates another time pressure, articulated by Smith, Underwood, Fitzpatrick and Luckin (2009). “The fact that we as researchers need to spend some months planning and developing tools and setting up experiences points to the gap between what is potentially invaluable as a learning experience for children and what is practically deployable in repeatable, everyday ways” (Smith, Underwood, Fitzpatrick, & Luckin, 2009, p. 290). The time delay between the development of a technology or specific application of technology, its incorporation as a learning tool, the development of a valid evaluative measure of its efficacy and the subsequent publication of that research to champion its value to a wider audience can often be of sufficient length that a new application or version may have been developed to supersede the one that has just been researched.

An interesting aspect to the time conundrum relates to whether technology itself frees up time or absorbs it. Technology certainly doesn't appear to be time neutral and it may be mobile technologies that could arguably have the greatest impact. “Learners want to make best use of time, wherever they happen to be; yet educators are not used to thinking about time use and the realities of their learners' lives” (Kukulska-Hulme, 2010, p. 11). Anytime learning and anywhere learning have led to the development of teaching strategies such as Peer Instruction (Mazur, 1997) and the Flipped Classroom (Fulton, 2012); two ways in which educators are using technology to leverage time to their advantage. Mobile devices and personal digital assistants (PDA) are changing some of the teaching methodologies, increasing flexibility of learning, and can potentially “make learning ubiquitously possible” (Hung, Lin, & Hwang, 2010, p. 33). This can, of course, lead to another cycle of how to facilitate ubiquitous learning and even whether or not that is a desirable thing. The potential of mobile technologies is enormous and this potential is slowly being recognised as mobile devices “become increasingly useful in education settings as a means of integrating ICT with minimal financial outlay and a reduced need for IT or support staff” (Wilson & Boldeman, 2012, p. 663). As an incidental benefit, Wilson and Boldeman (2012) also suggested that mobile technology can also help students reluctant to ask for help in a traditional classroom setting to seek ‘socially acceptable’ assistance from their peers when handling technology (Wilson &

Boldeman, 2012).

Training

Past research, especially from Australia, North America, Asia and Europe, indicates that the more successful ICT integrators are part of a community of learners, connected physically through proximity, or electronically through technology. “Teachers can leverage the technology and collaborate with peers as members of a Community of Practice without investing intensive additional time” (Backhouse, 2003, p. 7). Such studies would suggest that it is hard to underestimate the value of teacher training and teacher support which is targeted and sustained. Much of the research has indicated that “support must be made available at various levels, such as professional development to increase teachers’ confidence and skills in choosing software and integrating ICT across the curriculum” (Schibeci et al., 2008). The line between technology knowledge and training is blurred and it is hard to address one area without overlapping the other. However, one approach that has support in the literature is the just-in-time training approach: “teachers need support specific to the technology they are planning to implement, and they need it when they are preparing to use the technology with their students” (Backhouse, 2003, p. 6).

Past research indicates that the most effective form of training centres around the creation of “school-wide teacher professional communities” as they “affect the levels of authentic classroom pedagogy, which in turn affects student performance” (Newhouse et al., 2002, p. 13). This view of a learning community is widely supported in the literature (Australian Government Department of Education, 2011; D. E. H. Ng, 2008; November, 2012). It is worth investigating the role talented peers may play in increasing the skill level of individual teachers in the area of ICT integration.

Tenacity

When the provision of time and training have been provided either by the school or by the education sector, they have still sometimes proven insufficient in facilitating systemic change. Progress is made by teachers with tenacity (Egea, 2014; Philomina

& Amutha, 2016). Philomina and Amutha (2016) suggest that “teachers’ tenacity also relates to their understanding of their ability to use computers in the classroom, especially in relation to their children’s perceived competence” (Philomina & Amutha, 2016, p. 604). This tenacity flows from their personal competence with technology, which feeds back into confidence and experience in using computer technology in the classroom. In this context, tenacity is the quality of persistence or determination to continue despite the barriers or challenges that may appear. A tenacious teacher who develops an activity for their students based around technology will not give up when the network crashes or when the WiFi fails. They will continue to persevere with technology despite these challenges. They will not allow a bad experience with technology to drive their decision-making when it comes to integrating technology.

This quality of tenacity can also be observed, and even taught, to students as demonstrated in the Harvard university physics context. Crouch and Mazur (2001) in evaluating the effect of changing their pedagogy to a Peer Instruction (PI) mode in university level physics courses observed that “with significant effort invested to motivate students, student reactions to PI are generally positive, though there are always some students resistant to being taught in a non-traditional manner” (Crouch & Mazur, 2001, p. 975). Resistance to change and lack of tenacity can apply to parents as well as students when teachers are trying something new. Students can be reluctant to do things differently and may express some negative emotion. Parents may involve themselves if the type of learning activities are very different to those they remember from their own learning and it may require a high level of resilience and a commitment to self-improvement for a teacher to persist in their desire to adapt new technologies to their specific classroom needs, especially in the face of scepticism or criticism. The challenges around technology use may also be personal challenges; either relating to the function of the technology or the way the teacher would like to use it in the classroom. “Teachers must progress through a series of stages to instigate real change in their teaching style to adopt ICT into their classrooms” (Newhouse et al., 2002, p. 43). At the rate of technological development, new hardware and software must be continually refined or relearned.

Even with superior training, much of this falls back on personal factors within individual teachers and their own measure of the cost-benefit analysis. Several studies have referred to, and measured, these qualities as personal self-efficacy (Abbitt & Klett, 2007; Enochs, Riggs, & Ellis, 1993; P.-S. Hsu, 2016; Mueller et al., 2008; Woodbridge, 2003), with the general conclusions that “teachers’ self-efficacy beliefs, or confidence regarding technology use, are a critical predictor of the teachers’ technology integration in the classroom” (P.-S. Hsu, 2016, p. 31).

Experimentation, trial-and-error, finding a shorter route after taking the longest route to solve a problem with technology are all part of the integration experience.

Teachers may need a significant investment of time in order to master a technology to a level at which they feel capable incorporating it into their lessons. This requires both time and tenacity as teachers may feel the desire to give up on something new prior to developing mastery.

Summary

Ultimately, for teachers to improve their level of ICT integration, they need to source activities which will blend all three of these potential inhibitors; time, training and tenacity. “Teachers who confidently use technologies in their classrooms understand the usefulness of ICT” (Bingimlas, 2009, p. 238). There is a counterculture created by developing a cycle of success. The more time invested in technology, the greater the understanding, the greater the application and the greater the influence in the classroom. “Effective professional development . . . needs to support teachers in developing and sustaining alternative pedagogies and teaching strategies” (Groff & Mouza, 2008, p. 29). In order to sustain alternate pedagogies, teachers must believe in their inherent value despite the obstacles which may, inevitably, arise. They must “experience a paradigm shift from the teacher-centred classroom to the student-centred classroom” (Groff & Mouza, 2008, p. 30). However when teachers embrace the change and incorporate the technology in a meaningful way, the results can be quite dramatic; “the use of technology positively influenced student learning and their (teachers’) use of student-centred practices” (Lowther et al., 2008, p. 205).

With sufficient time, targeted professional learning and a resilient attitude to persist

with technology to the point of competence or mastery, teachers may progress their level of technology integration from minimum adopters to exemplary integrators.

2.10.3 Indicators of exemplary practice

In his analysis of exemplary integration, Becker (2000) identified “four characteristics of the teaching environment (which) seem to make exemplary computer-users more likely to be present: a) the existence of a social network of computer-using teachers at the same school; b) sustained use of computers at the school for consequential activities; c) organised support for computer-using teachers in the form of staff-development activities and a full-time staff member in the role of computer coordinator and d) acknowledgement of the resource requirements for effectively using computers” (Becker, 2000, p. 279). These categories may be expanded after consideration of the emergent themes from the literature. Past research has indicated that there are several characteristics that are common to exemplary integrators. These include professional learning opportunities and methods, collaborative development and dissemination of technology integration strategies and increased student autonomy and differentiation. Additionally, implicit in the literature either through reversal of an inhibitor or through general discussion, several other factors may likely link to effective or exemplary technology integration in the classroom and also warrant further analysis. These include high personal self-efficacy, the frequency and types of activities which incorporate technology, the role of the teacher in the classroom, teaching experience, subject-specialisation, sex and age. Each of these areas will be examined briefly below and formed the basis of the study outlined in Chapter Three.

Professional learning opportunities and methods

Professional learning is the first key enabler of effective integration practice. Whether this involves a social network of collaborators, targeted professional learning from a local eLearning coordinator, or facilitated professional development, professional learning has been regularly discussed as an important factor. “At EDUsummIT 2013 the working group (TWG3) on Teacher Professional

Development (TPD) built on the work from EDUsummIT 2011 (Twining et al. 2013). Three foci were identified for initiating discussion: 1) engaging all stakeholders in developing a shared vision about the role of ICT in education, 2) engaging more teachers in school-based communities of practice and professional learning networks, which have been shown to be effective for building ICT integration capability, and 3) reducing the gap between educational research and the practice of teachers through research that is more closely connected to teachers' practice" (Albion, Tondeur, Forkosh-Baruch, & Peeraer, 2015b, p. 656). Local and regular access to professional learning networks has been made easier through technology, as global contacts can be part of local networks (November, 2012). It is the nature of the professional learning activities that are proving to be of greatest consequence in enabling improved technology integration. It should be informal, self-directed and relevant to the current student learning experiences and teacher needs (Wastiau et al., 2013).

Collaborative development and dissemination of technology integration strategies

The second key enabler builds on, and informs, professional learning opportunities and methods and involves the establishment, or strengthening, of social networks to ensure there is adequate support for teachers who want to use technology in their classrooms. The studies from Singapore (Gao et al., 2009) and Belgium (Gobbo & Girardi, 2006), discussed in previous sections, highlighted the importance of building a strong learning community. Jung and Latchem (2011) also identified several mutual benefits of technology use and one of those was in fostering a collaborative community. Local colleagues available for consultation can encourage greater technology usage as help is nearby if difficulties are experienced (Lim, 2007; D. E. H. Ng, 2008).

Increased student autonomy and differentiated learning

One theme which seems to recur continuously in the literature review was the desire of technology—using teachers to encourage student autonomy (Gabriel, Day, &

Allington, 2011). Previous international studies (Kozma, 2003; Webb, 2005) highlight the potential for technology to “promote innovative teaching and learning, constructivist activities among students and collaboration among teachers” (Jung & Latchem, 2011). Kozma (2003) concluded “technology-supported innovative classroom practices in many countries around the world have many qualities in common” (Kozma, 2003, p. 12). This was further emphasised in a study which focussed on the net generation of student-teachers in Korea and Singapore. In drawing the threads of several studies together, So, Choi, Lim and Xiong (2012) presented a generation of students who are “social and prefer interactive communication and collaboration as a mode of learning” (So, Choi, Lim, & Xiong, 2012, p. 1234). In their categorisation of schools on the basis of level of technology integration, Baskin and Williams (2006) found that “high integration schools expressed an interest in developing high end-user differentiation and capacity” (Baskin & Williams, 2006, p. 465). From these studies it would appear evident that high levels of technology integration are associated with pedagogies which focus on student directed learning, collaboration and content creation.

High personal self-efficacy regarding technology use in the classroom

One potential key enabler is high personal self-efficacy. In this context, high personal self-efficacy is a term used to describe the high recognition by an individual teacher in their ability to use technology to effectively accomplish tasks, namely to teach their students. Low personal self-efficacy can be a significant inhibitor, as noted from the literature from several Asian countries, where the belief in an autocratic pedagogue as the most effective teacher dominates the classroom (Morrone, 2012). However it has also been identified as a key enabler of technology integration (Abbitt & Klett, 2007; Hakverdi-Can & Dana, 2012). It seems axiomatic that teachers with the belief in their ability to effectively use technology in the classroom will be the ones who are most likely to be using it more effectively.

Other potential enablers

Research is less conclusive, but suggestive of a possible relationship between

effective ICT integration and other factors such as frequency and types of activities which incorporate technology, the role of the teacher in the classroom, and sex. Whilst these factors have not all emerged as dominant themes from the literature, they have been encountered with sufficient regularity by the researcher over a 30 year career in education, or are implicit in much of the literature, to suggest they merit further investigation. As a result they have been included in the analysis of data from the online survey in Chapters Four and Five of this study.

High frequency and innovative types of activities involving ICT

A fifth potential enabler of technology integration is the frequency and type of activities undertaken by students. Whilst the type of learning can be student-centred, the types of tasks set by the teacher, the degree of autonomy and the frequency of such tasks can also be an indicator of an exemplary technology integrator. In analysing the importance of teacher scaffolding for primary school students in the context of exemplary practice, Masters and Yelland (2002) concluded that “an experienced teacher constantly monitors children’s progress and contributes in a number of different ways during a task. The teacher must also know when to withdraw support in order to allow children to explore and construct new understandings” (Masters & Yelland, 2002, pp. 320-321). This seems to apply equally to the application of technology integration in the secondary classroom. The cost and availability of hand-held and portable devices is likewise providing teachers with a much greater capacity to incorporate technology more easily and more often (Hung et al., 2010; Klopfer, 2008). The various uses, and relative frequencies, of technology facilitated activities would appear to warrant further investigation and hence they form a component of both the online survey and the qualitative interviews in Chapters Three and Four.

Shift in the role of the teacher in the classroom to facilitator

The previous point, along with the shift to a more student-centred pedagogy, is linked to a significant, almost paradigmatic, shift in the role of the teacher. Teachers are in the process of evolving with the technology into facilitators of learning rather

than the more traditional transmitters of knowledge (Fullan & Longworthy, 2014). In many ways, this links to a previous enabler; high personal self-efficacy. The more likely a teacher is to believe in the need to adapt their pedagogy to the new technologies, the more successful they are likely to be (Fullan, 2013). “Teacher openness to change influences teachers’ willingness to integrate technology into the classroom” (Baylor & Ritchie, 2002, p. 399). The energy and enthusiasm of teachers who are inspired by technology and its potential to revolutionise teaching are traits that are hard to transfer from one individual to another. However despite these intrinsic traits which are hard to quantify, they are “closely tied to external factors such as professional development and a supportive climate” (Baylor & Ritchie, 2002, p. 399). Professional learning needs to better model the facilitator-learner relationship which characterises more effective technology integration.

As a result of the data emerging from the literature review, it was felt necessary to expand research question two to focus on specific factors or enablers emerging from the research and believed to positively impact on technology integration. As a result, research question two now has six subsets in order to focus more specifically on these factors.

Research question 2: What are the sets of skills, outcomes and personal motivators which separates a minimum adopter of technology, a competent user of technology and an exemplary integrator of technology in the context of teaching practice?

Research question 2a: How do the exemplary integrators' preferred training methods differ from other integrators of technology?

Research question 2b: How do exemplary integrators' patterns of technology usage, both inside and outside the classroom, differ from other integrators of technology?

Research question 2c: What is the preferred pedagogy for teachers who view themselves as exemplary integrators?

Research question 2d: Do exemplary integrators have a higher personal self-efficacy than other integrators of technology?

Research question 2e: Do the differences between teachers, in terms of their degree of technology integration, persist between male and female teachers?

Research question 2f: Do the differences between teachers, in terms of their degree of technology integration, persist across different subject-specific (maths and science) groupings?

One underlying principle in this study is to address research question three, namely how to use future professional learning experiences to close the gap between research and teaching practice. This assumes that the qualities or characteristics of teachers who demonstrate exemplary ICT integration practice can be configured into a skill set which could be delivered to new and experienced teachers using an effective professional learning model. This may follow the three-fold approach advocated by Hew and Brush (2007) with a focus on “content”, “opportunities for hands-on work” and professional learning which is “highly consistent with teachers’ needs” (Hew & Brush, 2007, p. 238). Sufficient data has already emerged to suggest that there is support for this assumption and it, too, can be marked as a driver of this study. In evaluating research question three, each of the enablers listed above has been considered in the development of a set of tools to be administered to teachers as both an online survey and through a one-on-one qualitative interview process, in order to assess the degree to which each of these key enablers are actually indicators of exemplary ICT integration. The methods and results of these surveys will be described in subsequent chapters.

2.11 Summary

In this chapter, research questions one and two were initiated through a search of the international literature regarding ICT integration. Consistencies identified in both enablers and inhibitors of exemplary ICT integration practice provided some common enablers and inhibitors for investigation in the local context. Evidence from different nations support the proposition that there is a set of skills or characteristics of teachers who demonstrate effective or exemplary technology integration practice and that they are relatively common across national and international boundaries.

The common inhibitors of exemplary technology integration identified in the literature were:

- Equity of access to technology infrastructure
- Inadequate professional learning around technology integration
- Lack of recognition of the pedagogical value of technology
- Low personal self-efficacy relating to computer use
- Lack of practical support from the network of learners
- Lack of time to effectively explore the technology

The common enablers of exemplary technology integration identified in the literature were:

- Professional learning opportunities and methods
- Increased student autonomy and differentiated learning
- Collaborative development and dissemination of technology integration strategies
- High personal self-efficacy regarding the use of technology in the classroom

As a result of the gaps in the literature and the emergent patterns of enablers, a study of local and state-wide teachers of secondary science, mathematics and technology has been undertaken to seek clarification of these factors in the local context to try and highlight which of the factors identified from the literature contribute most significantly to effective ICT integration. From these results the study aims to develop strategies which may assist teachers to improve their integration of technology into the classroom. The study was organised in two components; an initial online survey and a follow up qualitative interview seeking rich data on which to base conclusions relating to future professional development. The format of the study and the methods used to collect the data will be presented in the next chapter.

Chapter 3 Research Design and Method

3.1 Introduction

The literature review revealed a set of inhibitors and enablers that were common to effective and exemplary ICT integrators and that many of these factors were common across cultural and international boundaries. The literature review identified several features of exemplary teaching practice relating to the integration of technology which required further examination. Specifically, the means by which exemplary ICT integrators overcome the challenges of time, target appropriate training and remain tenacious in the face of infrastructure and pedagogical or systemic challenges form the focus of the subsequent chapters of this thesis.

This chapter provides a rationale for the study (section 3.2), the research design (section 3.3), the study sample (section 3.4), the methods used to address the research objectives (sections 3.5 and 3.6), analysis of the data (section 3.7) and ethical considerations (section 3.8). All data collection instruments and procedures are detailed. In this final section (section 3.8), the resources chosen to administer the data gathering component of the study as well as the data storage methods are also identified.

3.2 Rationale for the study

In this section the rationale for the study will be provided and the conceptual framework will be outlined. This will include the philosophical context and epistemological assumptions. This section also includes the restating of the research questions.

In selecting the most appropriate method to critically evaluate the research questions, a conceptual framing based on an underlying philosophical position was necessary. The pragmatic goal of the study was to determine whether a set of factors common to exemplary ICT integrators could be shared through professional learning experiences. This suggested an ontological view that includes universals as well as particulars and is hence a realist rather than nominalist approach towards exemplary

integration of ICT in the classroom. In practice, many factors impact on how individual teachers view technology and why they use it (Baek et al., 2008; Hakverdi-Can & Dana, 2012; Mumtaz, 2000; Proctor & Marks, 2013). As a consequence, this study is based on a social constructivist epistemology that fundamentally incorporates the building of knowledge on the basis of a series of experiences and hence includes aspects of positivism and post-positivism (Cohen et al., 2011). As teachers use technology their views about its effectiveness as a teaching and learning tool may be reinforced or challenged and consequently constructs that individuals have developed change and are modified as a result of experience. Hence experience is a powerful influencer of knowledge construction in the context of ICT integration. Within this social constructivist framework, an interpretive methodology has been chosen as the most appropriate theoretical perspective for the study.

The methodology must, necessarily sit within the conceptual framework outlined above. It should encompass an understanding of how individual teachers create experiences, modify the learning and interpret the ways in which ICT can enhance their pedagogy. The duality of thinking around how to gather information about ICT integration and how to configure the information into an effective set of professional learning experiences implied a multi-faceted research design. This led to a need for a survey which provided frequency statistics to test assumptions about common factors as well as open-ended questions designed to avoid prompting teachers, but rather to permit them to provide their own ideas around what ICT integration looked like in their classrooms. From these open-ended questions, sprang a need to delve more deeply into the specific responses of a representative sample of ICT integrators to understand the driving factors behind why certain strategies or behaviours were favoured by particular groups. The need to gather both qualitative and quantitative data to build a strong case for common enablers and inhibitors of effective ICT integration in the New South Wales context led to the obvious choice of a mixed methods approach; an approach within an interpretivism methodology which will be described in more detail in the next section.

The methods described in this chapter are based on the research questions outlined in Chapter One and expanded in Chapter Two as a consequence of the literature search. These questions have been reproduced below.

1. What are the enablers and inhibitors of exemplary ICT integration?
2. What are the sets of skills, outcomes or personal motivators which separate the minimum adopter, the competent user and the exemplary integrator in the context of ICT integration practice?
 - 2a. How do the exemplary integrators' preferred training methods differ from other integrators of technology?
 - 2b. How do exemplary integrators' patterns of technology usage, both inside and outside the classroom, differ from other integrators of technology?
 - 2c. What is the preferred pedagogy of teachers who view themselves as exemplary integrators?
 - 2d. Do exemplary integrators have a higher personal self-efficacy than other integrators of technology?
 - 2e. Do the differences between teachers, in terms of their degree of technology integration, persist between male and female teachers?
 - 2f. Do the differences between teachers, in terms of their degree of technology integration, persist across different subject-specific (mathematics and science) groupings?
3. What are the key competencies required as a component of targeted professional development for effective and exemplary ICT integration in the Australian Curriculum context?

The literature review confirmed the suggestion that teachers in different education systems in different countries experience similar frustrations in regard to the

integration of technology into their classrooms. It also suggests that the ways in which these teachers solve their problems, overcome the barriers and demonstrate proficiency have some commonality across different educational contexts. As a consequence, an online survey was developed to test these literature based assertions through both their frequency of occurrence based on a series of common statements and through open-ended questions designed to allow teachers to provide their own view of exemplary ICT integration issues.

3.3 Research Design

In this section the research design has been expanded to situate the mixed methods approach within a social constructivist conceptual framework, based on an interpretive methodology as described in the previous section. Each of the key components of a mixed methods approach has been identified and examples from the study used to demonstrate how each of these key components has been addressed in the study. This section concludes with an outline of the two separate phases of the study.

The research design chosen for this study is a mixed methods research approach based on an interpretive methodology within a social constructivist framework. “Mixed methods research is currently defined as research in which the researcher collects, analyzes, and integrates qualitative research and quantitative research to study a problem” (sic) (Plano Clark, 2010, p. 428). The key features of a mixed methods model as they apply to this research include a focus on real-life context and multi-level perspectives, rigorous quantitative data, qualitative interviews, triangulation between quantitative data and qualitative observations in a multi-modal model and the importance of synthesising the data into a coherent rich set which provides both theoretical and pragmatic frameworks. A mixed methods approach was chosen as a result of the need to draw together multiple perspectives from teachers at different management levels into a logical sequence of enablers of exemplary ICT integration. Without the benefit of actual observations of teachers in their classrooms using the technology, additional information was necessary to facilitate a deeper understanding of how and why teachers were using technology.

Drawing out deep levels of understanding about ICT use requires a significant investment of time from interested teachers and it is necessary to ensure all data is validated through tests for consistency of responses within the data set (Plano Clark, 2010) or expanded through qualitative interviews to minimise the possibilities of misunderstanding or misconception in reading or interpreting a response.

In order to propose a change in teacher professional learning around ICT integration, it is important that the research design considered the following components: *”real-life contextual understandings, multi-level perspectives, and cultural influences”*, *“employing rigorous quantitative research assessing magnitude and frequency of constructs and rigorous qualitative research exploring the meaning and understanding of constructs”*, *“utilizing multiple methods”*, *“intentionally integrating or combining these methods to draw on the strengths of each”* and *“framing the investigation within philosophical and theoretical positions.”* (Creswell, Klassen, Plano Clark, & Smith, 2011, p. 4). Each of these points has been addressed in the following paragraphs.

3.3.1 Interpretivism methodology

In locating the study within a social constructivist framework under an interpretivism methodology, the key components of a mixed methods approach, identified above, which needed further consideration and justification were as follows.

1. Clarification of real-life contextual understandings has been addressed through the inclusion of practicing teachers and their current use of technology, the inclusion of classroom teachers, heads of faculty, heads of teaching and learning or e-learning and principals in the sample groups. The literature review sought to inform the questions for New South Wales science and mathematics teachers undertaking the surveys and locate their responses within a wider, global context, taking account of different cultural and religious differences.
2. Rigorous quantitative and qualitative research has been addressed through the inclusion in the online survey of components from several studies in the

literature including the Level of Computer Use scale (LCU) (Marcinkiewicz & Welliver, 1993) and the Microcomputer Utilisation in Teaching Efficacy Beliefs Instrument (MUTEBI) (Enochs et al., 1993). These tools have been validated in subsequent studies (Hakverdi, 2005) and contain numerical scales and calculations which can convert participant views into numerical values for statistical analysis. Open-ended questions in the online survey gave participants a chance to expand their responses providing additional qualitative rigour in seeking to understand the patterns identified in the quantitative data. This was further integrated through the additional qualitative follow-up interviews enriching the depth of understanding about ICT integration practice.

3. Utilizing multiple methods has been addressed through the inclusion of both quantitative and qualitative components in the online survey and through the use of follow-up qualitative interviews with self-nominated participants from within the online survey. This allowed triangulation of data and helped contextualise the response of participants regarding what was happening in their own schools and classrooms.
4. The intentional integration of these methods has been addressed through the inclusion of five separate sections in the initial survey. Within the online survey, demographic and computer usage questions were compared with questions relating to exemplary practice and activities relating to types of computer-based activities in the classroom. This provided a wealth of data around what teachers were doing with technology and how successful they felt they were in integrating technology into their teaching and learning. In seeking to centre the study in a pragmatic philosophy it was deemed vital to incorporate understandings from practicing teachers.
5. Framing the investigation within philosophical and theoretical positions has been achieved by centring the research study within a social constructivism conceptual framework as discussed in the rationale. The purpose of this research is to provide practical guidance to teachers who are seeking ways to more effectively integrate technology into their pedagogy. Understanding teachers' views when it comes to using technology in the classroom, what

facilitates effective inclusion of technology and what frustrates teachers about technology must be gained from different teachers in different ways. This has led to the selection of an interpretive methodology (Cohen et al., 2011). The framing of the research questions and development of a mixed method approach enabled the researcher to probe practices and metacognitive understandings around why teachers are using technology in different ways in different classrooms. It also provided the impetus for framing future professional learning into a more effective vehicle for skilling teachers in exemplary ICT integration practices.

The benefits of a mixed method research design are two-fold. Firstly, it provides the opportunity for meaningful statistical analyses of correlation between different variables. Secondly, it proposes a degree of predictive power of a series of independent variables on a second series of dependent variables, specifically level of computer usage and self-assessed ICT integration capacity in this study. This allows for the evaluation and testing of hypotheses. The triangulation design allowed multiple sets of data to be used to validate emerging patterns, such as the links between self-assessed technology integration and level and type of computer usage. The data sets were collected both concurrently and sequentially, with phase one occurring around six weeks prior to phase two. Each phase is described in the following paragraphs.

Phase One

The online survey, regarded as phase one of the data collection process, contained both qualitative and quantitative data used for the purposes of triangulation and correlation. All sections of this survey were completed concurrently. From within this survey, an opportunity was offered to participants to self-select for a second phase of interview questions. In order to identify the source of open-ended quotations which appear in this study, two keys were developed; one for the online survey and a second for the qualitative interviews. These keys are reproduced in Appendix A on page 312. The online survey contained six sections, each representing a separate tool. These included:

- 1) demographic information, described in section 3.4.1 on page 113
- 2) personal and professional computer usage data, described in section 3.5.2 on page 118
- 3) reflection on computer use through a series of open text questions, including a self-assessment of technology integration, described in section 3.5.3 on page 119
- 4) level of computer usage in the classroom (the LCU), described in section 3.5.4 on page 119
- 5) specific applications for instruction, a reflection on technology applications used by the teacher and their students, described in section 3.5.5 on page 122
- 6) a series statements using a Likert scale which focussed on teacher efficacy beliefs (MUTEBI), described in section 3.5.6 on page 124.

Phase Two

The qualitative interviews, regarded as phase two of the data collection process, were conducted six weeks after the collection of the online survey data. The latter were triangulated against the individual respondents from the online survey and hence these responses expanded on those from the online survey providing additional depth and breadth of response, hence much of this data has been reported in this thesis.

The data transformation model (Creswell et al., 2011) was also employed to evaluate potential enablers of exemplary technology integration practice. The transformation of qualitative data into quantitative data allowed for the evaluation and testing of the types of professional learning preferred by exemplary integrators as well as the relative importance which they placed on student autonomy in their classrooms. Data transformation extends the mathematical models into the pragmatic realm of classroom practice, helping to build a picture of what is actually happening in the science and mathematics classrooms in New South Wales, albeit in only a sample of these classrooms. Hence, the primary purpose of both the online survey and qualitative interviews was to identify the patterns of thinking and practices common to exemplary integrators of ICT and to draw from willing participants a deeper analysis of what was happening in their classrooms and their rationale for these

actions.

Phase one, the online survey, was lengthy and required a 20 minute commitment. The online survey was delivered to schools during the third calendar term of 2015. The gathering of qualitative data began within one month of the closing date for the first survey. In phase two, school executives as well as classroom teachers were involved in qualitative interviews either by phone or through Skype.

3.4 Study Sample

The richness of the data sought in this study required a significant investment of time from participants. In order to ensure the integrity of the data and a large enough sample to provide levels of statistical significance, several sources were chosen to invite potential participants for the study. Whilst the initial offers were distributed nationally, the sample was heavily skewed to teachers and principals from Australian institutions and New South Wales schools in particular. Hence further canvassing for participants was later focussed solely on teachers in New South Wales secondary schools and those teaching secondary science, mathematics and technology in particular. The following sub-sections describe the characteristics of the participants in the online survey, the self-selection process and characteristics of the participants in the phase two qualitative interviews as well as the process used to determine the exemplary integrators within the sample.

3.4.1 Initial sources of participants for the online survey

Preliminary notifications of the online survey were sent through the national associations of science and mathematics teachers via their database of contacts or within social media presences such as Facebook. Additional approaches were made directly (Appendix B on page 314) to the Australian Science Teachers Association (ASTA), Australian Association of Mathematics Teachers (AAMT) and the Australian Council for Computers in Education (ACCE) seeking support and promotion of the survey (by provision of a link to the Survey Monkey URL), through their professional network connections which was acceded to by both science and mathematics teachers associations.

The first group of participants which made up the study sample were generated from the various open invitations through online forums (eg ASTARIX – the Australian Science Teachers Association forum), social media posts (Facebook page of the Science Teachers Association of New South Wales and LinkedIn), emails specifically addressed to the Principals of schools in New South Wales public and private secondary or kindergarten to Year 12 schools and via the researcher's personal networks (eg Northern Sydney Science Heads of Faculty Network Group and Association of Independent Schools (AIS) Science Professional Learning Advisory Council). A few respondents to these initial contacts were from outside of New South Wales, or from international schools, however, due to their small representation, their responses were eliminated from the final data set. Data from these sources may have strengthened the conclusions regarding the universality of applications if the number of participants from different geographical regions was larger. Unfortunately the number of participants from outside of New South Wales was too small and not statistically significant to include in separate analyses. All subsequent correspondence was sent directly to New South Wales secondary schools as outlined below.

Over a period of four weeks, once the survey was opened, the total number of participants was monitored as well as the spread of responses from different types of schools (eg government schools, catholic schools and independent schools), the mix of teachers (males and females, classroom teachers, department heads, directors of eLearning and principals) as well as religious affiliations (eg Christian schools, Jewish schools, Islamic schools, Aboriginal and Torres Strait Islander schools, etc). Where low numbers of teacher representatives were identified in any of the categories listed above, follow up emails were sent to the schools to try and encourage a greater participation and hence representation from these particular groups. This was not successful for all of the desired groupings and hence some of these groups have not been analysed in subsequent chapters as a result of their small sample size.

Direct emails (Appendix C on page 317) were sent to 947 New South Wales school

principals or administrators on at least two occasions; consisting of 295 AIS schools, 490 NSW Department of Education and Community schools and 162 catholic schools. Follow-up emails were sent to subsets of these schools during the subsequent four weeks to attract additional participants. Principals were asked to forward the survey on to a member of their staff who may be interested in a study of exemplary ICT integrators within the science, technology or mathematics faculties. Individual schools were not identified, so there may have been multiple respondents from the same school in the online survey, e.g. two science teachers, or one science and one mathematics teacher. Participant response rates from these 947 schools, all of which may be presumed to have at least one mathematics and/or science teacher, was 140. As the online survey did not require participants to identify their schools, there was no way of determining whether all 140 participants came from 140 individual schools.

3.4.2 The sample for Phase One: Respondents to the online survey

It was important to include a section on demography in the online survey in order to contextualise responses relating to ICT integration. This also informed discussions about the degree to which the enablers and inhibitors of exemplary technology integration practice in secondary education are common across sex and secondary science and mathematics subject boundaries. Hence, the demographic component of the online survey included a description of school type; school affiliation; school culture and heritage links; participant's role in the school; main subjects taught; main year levels taught; birth year; sex; highest academic qualification and teaching experience. This demographic data set the context in which participant information was assessed and to address the first two research questions.

A broad representation of teachers was sought for the online survey, including the largest sample size available in order to test a range of variables including sex, culture, subject taught, self-assessment of technology integration and so on. Many of the parameters provided sufficient individuals within the different categories to enable a meaningful analysis, eg 53% of the online survey participants were female, 47% were male. Schools in both the public and private sector were contacted as

described above. 140 secondary school teachers volunteered to be involved in phase one of the study which involved responding to the online survey. Of these teachers, 96 completed all, or at least most (>95%), of the questions. This represents a response rate of 15% of schools contacted with a 67% completion rate for those who started the survey.

3.4.3 Participants involved in Phase Two: qualitative interviews

Teachers and middle and upper managers who participated in the online survey (Phase One) were able to self-select (as part of the survey) to participate in the qualitative interviews. Participants were asked to provide their name and email address if they were willing to participate in this phase. Participants who had indicated a willingness to participate in the qualitative follow up interviews were contacted by email and provided with a link to a google sheet and calendar. 53 participants indicated their willingness to be involved and all were sent an email (See Appendix K on page 336) offering them the opportunity to participate in the qualitative component. One of these emails was undeliverable. Of the remaining 52 volunteers, 11 participants consented to take part in the qualitative follow up and were asked to book in a suitable time for a 30 minute interview. Six teachers booked an interview and were subsequently interviewed, however, this sample was not considered to be sufficiently diverse to be representative of the participants in the online survey. A second email was sent to participants, primarily those who had identified as exemplary integrators and were female, as this was an under-represented group, and this drew an additional seven respondents, not all of whom were female. Only two of these failed to book a suitable time for the one-on-one interview. As a result, there were 11 participants, of whom six were males and five were females. Of these participants, five were from government schools and six were from the private sector, three were mathematics teachers and five were science teachers, with one interviewee identifying as teaching both mathematics and science. The sample included eight teachers as well as one head of faculty and two directors of eLearning, duplicating the hierarchical organisation in a school and providing a sample of different levels of teachers and middle managers. As such, this subgroup

was representative of the larger sample (in Phase One) and, therefore, considered more suitable in the timeframe.

3.4.4 Identifying Exemplary Integrators

One of the necessities built into the survey was the need for teachers to self-assess their level of technology integration in the classroom. This required several tools in order to affirm that teachers were displaying the attributes of exemplary integrators, competent users or minimum adopters according to their personal assessment. The literature was used to inform the degree of consistency of self-assessed technology integration through the inclusion of components of the survey which targeted the characteristics of exemplary integrators, eg MUTEBI and LCU. Several components of the online survey were designed to gather data regarding the level of teaching experience, the amount of time spent with technology, the types of tasks carried out using technology and the types of activities carried out by students in classrooms. However the LCU component of the online survey was used to moderate the responses of participants and a high level of correlation indicated a high level of confidence in teachers' ability to self-assess as competent technology users or exemplary integrators. 30 participants or 31% of the total sample self-assessed as exemplary integrators of technology. Of these 30 exemplary integrators:

- 14 identified as female
- 12 identified their highest academic achievement as a Master degree or Doctor of Philosophy
- 11 primarily taught mathematics and 14 primarily taught science
- 12 identified as a head of faculty, 11 as classroom teachers and the remainder as director of eLearning or equivalent or higher, eg principal.

3.5 Online Survey

From the common factors emerging from the literature review, a survey was developed (see Appendices D-J) to gather data from current secondary principals, middle managers and teachers regarding the critical factors they felt impacted on

successful ICT integration in their schools. This survey was used to determine the universality of exemplary technology integration practice across New South Wales secondary science and mathematics teachers and the common factors which may be shared by these educators.

3.5.1 Pilot survey

The survey was first developed in 2014 and contained five pages with the same tools as in the final online survey. It was pilot tested during the final academic term of the 2014 school year, (specifically November and December). A small sample of seven participants completed the pilot survey. They were primarily used to test the organisation and timings for the survey, any ambiguity in the structure or content of the survey questions and to evaluate the chosen tools regarding their ability to discriminate between the levels of ICT integration. Some minor changes were made to the structure of the online survey as a result of the pilot, including the separation of demographic data and personal and professional computer usage data as well as the addition of clearer statements around participant consent and purpose of the study.

Following the analysis of the pilot survey, Phase One took the form of an online survey using Survey Monkey and a link was generated and shared for participation. It was delivered to schools during the third calendar term of 2015. The gathering of qualitative data began within one month of the closing date for the survey. Each of the tools that make up sections two to six of the online survey are outlined in greater detail in the following paragraphs.

3.5.2 Demographic data

The broad range of potential factors affecting ICT integration present in the literature necessitated a range of demographic identifiers and these formed the first component of the online survey. This data focussed on the identifiers for the school; education level (primary, secondary or both) and sector (government, catholic or independent), any school affiliation, dominant school culture or heritage. It also focussed on the participant; their role within the school, main subject and levels taught, year of birth,

sex, highest academic qualification and years of teaching experience. These factors were used to situate the patterns of ICT usage and degree of ICT integration in order to test for correlation and identify any patterns around common enablers or inhibitors of ICT integration. The questions have been reproduced in Appendix E on page 322.

3.5.3 Personal and professional computer usage

In consideration of the fact that this study did not include a component of classroom observations, it was difficult to draw a direct link between an individual response to the survey and their level of computer use and/or ability to integrate technology effectively in the classroom. One way of addressing this deficiency is to gather a range of different types of data about computer usage patterns, both personal and professional (See Appendix F on page 325). This data could be analysed and triangulated to ensure there was alignment between how a participant assessed their level of computer usage and the specific usage they identified in another part of the survey. Hence this component of the online survey provides some background data for comparison.

Personal and professional computer usage data assessed the teachers' personal computer use; professional computer use; types of applications used; sources of learning about technology integration; hours of professional development relating to the use of ICT in the classroom; computer activity patterns; computer activity locations and preferred devices for internet access, (adapted from the Technology Use in Science Education Scale (TUSES) (Hakverdi, 2005).

The survey included three additional components: the personal reflection on ICT integration tool (developed specifically for this study), the level of computer use scale (LCU), the specific applications of technology and the microcomputer utilisation in teaching efficacy beliefs instrument (MUTEBI) (Enochs et al., 1993). Each of these will be described in the subsequent paragraphs.

3.5.4 Personal Reflection on ICT Integration Tool

The collection of data obtained from these surveys was designed to include

recommendations for the key competencies required in targeted professional learning for effective and exemplary ICT integration in the New South Wales context, as interpreted by the teachers actually working within this system. In order to clarify the key competencies, participants were asked to discuss the sets of skills, outcomes or personal motivators which they felt separated the technophobes and the minimum adopters from the competent users and exemplary teachers in the context of ICT integration practice. Providing participants with the opportunity for some qualitative reflection was considered vital to the online survey and an attempt was made to seek the factors which either enable or inhibit ICT integration in the classroom within this context.

The personal reflection on ICT integration tool was developed specifically for this study (See Appendix G on page 329). It consists of eight items, seven of which were open-ended or involved open numbering. The final item required a self-assessment of ICT integration level; categorised from technophobe to exemplary integrator and was contextualised after participants had the opportunity to discriminate personally between these different categories. The category of technophobe was later discarded as no participants in the survey identified themselves lower than minimum adopter, so only three categories were used in the analyses in Chapter Four.

The questions in the online survey were designed specifically to identify minimum requirements relating to technology and to consolidate the patterns regarding inhibitors and enablers as well as the preferred learning methodologies of different teachers when it came to ICT integration. For some of the questions, an open numbering form was used, eg preferred training method. In this question participants were given a series of potential sources of training and asked to rank them in order of personal preference. This included options such as 'learned on my own' or 'learning from my peers'. Participants selected a '1' for their most preferred option, a '2' for their second choice and so on from a drop down menu. However this question did not require participants to number every option as it was assumed some participants may not have experienced each type of learning. As a result, modes and means for each category are a better predictor of most preferred learning method.

The section on personal reflection of computer use culminated in two questions asking participants to identify what distinguishes between a technophobe, a minimum adopter, a competent user of technology and an exemplary integrator and then to self-assess their own level of technology integration. This self-assessment question is critical to the study as it has been tested against several independent variables for causality and is also used as a grouping tool for strategies and behaviours which encourage exemplary technology integration. It also provides a context for each of the other questions to provide potential patterns of responses for the self-assessed exemplary integrators.

Participants were required to self-assess on the basis of their prior experience. Given that “most of the adoption models depict five adopter categories – innovators, early adopters, early majority, late majority and laggards – with relatively consistent characteristics among the derivative models” (Gillard, Bailey, & Nolan, 2008, p. 23), it was considered useful to identify how teachers might view themselves in terms of these categories. To do this, teachers were given the opportunity to reflect on the sorts of activities which might categorise technophobes (TP), minimum adopters (MA), technologically competent users (TC) and exemplary integrators (EI) in terms of classroom practice. Participants were also given the opportunity to self-assess in terms of how they viewed their own practice (Appendix G on page 329). It was felt important to avoid researcher bias, hence no examples were given to direct participants. However, the continuum of technology usage which emerged from participant responses to the survey questions broadly flowed as follows:

- TP – no technology usage in the classroom and only reporting systems, roll marking or emails as mandated by the school or department
- MA – some use of technology in the classroom, but of a very utilitarian manner, eg powerpoint to replace whiteboard or electronic notebook to replace written notebook
- TC – some evidence of transformative or creative uses of technology including collaborative projects or student learning choices
- EI – seamless integration of technology into all aspects of the teaching

program with technology used as the learning and presentation medium and as a vehicle for the creation of products which could not exist without it

The purpose of this tool was to provide opportunities for teachers to freely respond to the issue of ICT integration and identify minimum standards, inhibitors and enablers of good or best practice for themselves.

3.5.5 Level of Computer Use (LCU)

The level of computer use was chosen to moderate the responses to the self-assessment of technology integration category (See Appendix H on page 331). It is expected that there should be a high degree of correlation between the level of computer use and the self-assessed level of technology integration. The higher the score on the LCU, the more likely the teacher will identify technology as indispensable to their teaching and the more likely they will self-assess as a competent to exemplary integrator of technology. The Level of Computer Use tool was developed by Marcinkiewicz and Welliver (1993) to provide a means of discriminating between utilisation and integration levels of technology usage, where the “distinction between the Utilization and Integration levels lies in the expendability of the computer technology” (Marcinkiewicz & Welliver, 1993, p. 4). This scale has been used as a dependent variable in several studies which focus on ICT integration (Hakverdi-Can & Dana, 2012; Kerr, 2013; Schoepp, 2004), particularly with previously identified exemplary teachers. The LCU is based on teacher dependency on computers in their instruction. It contains four items and has a reliability coefficient of 0.96 (Hakverdi, 2005, p. 50).

A single digit LCU statistic was created by allocating the numbers ‘1’ and ‘2’ to each of four paired statements. For paired statements one and two, each A scored a ‘1’ and each B scored a ‘2’. For paired statements three and four, each A scored a ‘2’ and each B scored a ‘1’. The single LCU statistic ranges from ‘4’ (each statement scoring a ‘1’) to ‘8’ (each statement scoring a ‘2’), with ‘4’ indicating lower reliance on computer technology for teaching and instruction and ‘8’ indicating the highest reliance on computer technology for teaching and instruction. While technology in

education has progressed significantly since this statistic first emerged, its reliability and relevance has been tested in more recent research (Hakverdi, 2005) and found to remain applicable today. It is therefore important to the self-assessment component of this research to triangulate against a reliable instrument hence justifying its inclusion in this study. Its primary significance to the study is at the integration level; at this level, the computer becomes an indispensable part of the learning process (Newhouse et al., 2002) and this is where exemplary integrators of technology are most likely to reside.

The LCU scale, was “derived from the model of Instructional Transformation . . . First, a teacher becomes familiar with computers (*familiarization*); then, the teacher uses computers in teaching (*utilization*). A higher level of use is observed when the computers have become critical to the teaching (*integration*).” (Marcinkiewicz & Welliver, 1993, p. 1). According to Marcinkiewicz & Welliver (1993), “A CR (*coefficient of reproducibility*) of .90 is the criterion for demonstrating that items form an ordered scale of allowable response patterns” (Marcinkiewicz & Welliver, 1993, p. 2) (*italics added*). To maintain consistency with previous uses of this tool (Hakverdi et al., 2011), the coefficient of reproducibility was preferred as the analytical tool for internal correlation. Calculation of the CR from the results in this study produced a value of 0.96, consistent with the value calculated in the Hakverdi (2005) study. This correlates to a high level of reliability and provides clarity between the utility of technology and the regular integration of technology. Hence there is confidence about using LCU as a dependent or predictive variable in subsequent analyses, particularly regarding the self-assessment of technology integration category.

The main purpose of the LCU component of the online survey is to triangulate against the self-assessed category of computer usage, primarily to ensure teachers who identified as exemplary integrators had a high level of computer usage. This increases confidence in the reliability and validity of the conclusions being drawn as there was no other way to validate self-assessed computer competence other than in the previous section which focussed on computer usage patterns. Lesson

observations were not a component of this study. Hence the LCU statistic generated an additional level of confidence in the findings.

3.5.6 Specific applications for instruction

The fifth section is an adapted table of technology applications used by both the teacher and their students, sourced from the TUSES tool (Hakverdi, 2005). A search of the literature suggested that the types of activities preferred by minimum adopters of technology may differ from the types of activities adopted by exemplary integrators. For example, data collection and analysis or publishing on a daily basis, may present more opportunities for student autonomy and higher level thinking than information retrieval and drill and practice activities. Any identified differences in the frequencies of activities facilitated with their students may reflect a teacher's confidence and competence to integrate technology and hence this informs research questions two and three. The tool required participants to evaluate the following computer applications or activities:

- Simulation and Educational Games
- Imaging
- Communication
- Publishing
- Drill and Practice
- Information Retrieval and
- Datalog and Analysis.

Each category requires teachers to reflect on the relative frequencies with which each technology application was used by both the teacher themselves and by their students. The choice of frequencies included daily, more than once a week, weekly, every two weeks, once or twice a month or less often. The format is shown in Appendix I on page 332. Percentages were then calculated for each category for both teacher use and student use and comparisons made to identify any differences in the frequencies of applications chosen generally, and by exemplary integrators specifically.

3.5.7 Microcomputer Utilisation in Teaching Efficacy Beliefs Instrument (MUTEBI)

The final component of the online survey was the microcomputer utilisation in teaching efficacy beliefs instrument (MUTEBI) developed by Enochs et al (1993). This tool contained a total of 21 items (See Appendix J on page 333) which were subdivided into two groups; outcome expectancy (seven items with a Cronbach's alpha reliability coefficient of 0.78) and personal self-efficacy (remaining 14 items with a Cronbach's alpha reliability coefficient of 0.91, Hakverdi, 2005). Outcome expectancy has been previously defined as "teachers' beliefs regarding their responsibility for students' ability or inability to use computer technology in the classroom" (Abbitt & Klett, 2007, p. 30). Personal self-efficacy has likewise been defined as "teachers' beliefs in their own ability to utilize the microcomputer for effective instruction" (Enochs et al., 1993, p. 2). Several researchers attest to the efficacy of the MUTEBI scale to provide "a valid and reliable measure of computer self-efficacy that can be used in a variety of research settings" (Hakverdi, 2005, p. 54). The literature review pointed to the importance of high personal self-efficacy or confidence in using computers to achieve educational outcomes. This scale could be used to analyse the generalisability of personal self-efficacy and outcome expectancy when measured against the level of computer use and hence add to the discussion about the importance of a teacher's attitude towards technology when they are developing lesson activities for their students. Several of these components were chosen for inclusion in this research study as a result of the overlap in some of the research goals with an unpublished PhD thesis entitled: "The factors influencing exemplary Science teachers' level of computer use" (Hakverdi, 2005). The Hakverdi study validated several of the tools which have been chosen for this study and permission was sought and granted to use these tools where relevant and with acknowledgement.

Data for each of the above components was collected online through Survey Monkey and analysed using SPSS v.23 software. A number was allocated based on a Likert scale for each statement, which ranged from one for strongly disagree through to five

for strongly agree. Some of the allocated values were reversed as some questions were written from a negative perspective, as described in Enochs et al (1993). This was to ensure that a higher total score would indicate a higher outcome expectancy (OE) or a higher personal self-efficacy (SE). The MUTEBI data were then combined in SPSS to produce two separate scores; one for outcome expectancy (calculated using the sum of items 1 to 7) and one for personal self-efficacy (calculated using the sum of items 8 to 21). The Cronbach's alpha reliability score for OE is 0.77 for the 7 items. There were 95 valid responses with one response excluded. This value demonstrates a high level of internal consistency within the OE scale, with each statement providing a consistent measure of teacher outcome expectancy regarding technology usage in the classroom. The Cronbach's Alpha reliability score for SE is 0.86 for the 14 items. This is a high value and indicative of the level of internal consistency of responses, allowing this variable to be used as a potentially predictive variable for exemplary ICT integration practice. There were 91 valid responses with five responses excluded. The Cronbach's Alpha reliability score demonstrates a very high level of reliability in the personal self-efficacy scale, with each statement providing a consistent measure of teacher personal self-efficacy regarding technology usage in the classroom. This tool was used to address specific components of research question two, namely research question 2d, regarding the importance of personal self-efficacy on level of ICT integration.

The purpose of the six separate tools, identifiable as six separate pages in the survey, was to gather rich data from individual principals and/or their delegates to produce a comprehensive picture of exemplary ICT integrators in secondary education. The survey endeavoured to identify the most common qualities, characteristics and practices of exemplary ICT integrators. As a component of this process, volunteers were sought to participate in a second phase of telephone or Skype interviews. These interviews sought clarification on issues arising from the preliminary survey to provide an opportunity for expansion on the traits most desired in exemplary integrators of technology.

3.6 Qualitative Interviews

Qualitative interviews were conducted with a selection of participants who responded to the initial survey. Participants were asked in item 20: “Please provide your contact information; (name, email address) if you would be willing to participate in further studies involving the use of computers in education and/or receive a copy of the findings from this research. If you would prefer not to participate, nor receive a copy of the results, please leave the question blank.” All participants who responded to this question were contacted by email (Appendix K on page 336) and given a chance to book a time for a qualitative follow-up interview.

Interviews with participants took place over a three week period following the online survey. Each interviewee was asked a series of questions with additional prompts used to seek further clarification. Interviews took place either through Skype or over the phone and each was recorded using the Voice Record Pro application on an iPad or iPhone. Following the conclusion of each interview, the researcher created a transcript of each interview as a written record both for use in this study and for storage purposes.

The interview group included two eLearning coordinators, one head of the mathematics faculty and eight classroom teachers. This diversity in interviewees was deliberate in order to duplicate the hierarchical organisation in a school and provide different levels of teachers and middle managers with an opportunity to provide their personal insights into ICT integration practice. Vertical integration of data was chosen to try and avoid potential bias which may arise from the survey of just one level of organisation within a school environment. Of the 11 participants interviewed as part of this process, six were science specialists, one of whom also taught maths, while there were three other mathematics teachers and two technology teachers. One participant identified as a minimum adopter, seven as competent users and three as exemplary integrators. This data has been summarised in Table 23 on page 180 in the following chapter.

Each of the interviewees was sent a link to a google sheet to book in a suitable 30

minute timeslot and was provided with an additional statement of consent as well as seven additional questions for discussion (see Appendix L on page 338). Questions were chosen on a preliminary analysis of the quantitative data and the need for expansion in certain areas relating to student autonomy, and personal and professional learning practices. The questions were as follows:

1. How would you describe your preferred teaching style? Please discuss one example.
2. How would you describe your use of technology in your classroom? Please provide one example.
3. What do you think is your greatest need in terms of improving your integration of technology in your classroom? Why have you identified this particular need?
4. How would you describe yourself in terms of technology integration and specifically the use of computers in your classroom? Why?
5. What level of student autonomy exists within your classrooms generally? Please provide an example.
6. If it was critical that you learned how to use a new piece of hardware and software for educational purposes, how would you prefer to learn?
7. How do you see your classes operating in five years time? Will they be much as they are now or will they change? If so, can you describe how they might change?

Most participants took between 20 and 40 minutes to complete the interview and as a result provided some broad indicators, as well as very specific examples, of professional behaviour around the use of technology in the secondary classrooms in New South Wales schools.

3.7 Data Analysis

Data was downloaded from Survey Monkey and imported into SPSS v.23 software for analysis. Open-ended responses were printed in full and manually analysed for recurring themes. Where possible, similar responses were grouped so they could be quantified for the purpose of reporting on trends or percentages of common responses. The specific data used to analyse each research question is summarised in Table 1 on page 130. A more detailed description of the data used to analyse each research question may be found below Table 1.

Correlation and regression analyses were used to determine which factors could be used as predictors of computer usage and exemplary integration practices. A series of one way and multiple analyses of variance were performed to determine to what extent dependent variables were affected by changes in the independent variables and what, if any, interactions were occurring between the independent variables.

3.7.1 Research question 1: enablers and inhibitors of exemplary ICT integration

The first research question sought to identify the enablers and inhibitors of technology integration in the classroom, and specifically the enablers of exemplary integration. Personal and professional usage, part two of the online survey, and personal reflection on ICT integration, part three of the online survey, reinforced some of the enablers and inhibitors of effective ICT integration in the classroom identified in the literature review. The former were analysed by percentage of self-assessed time spent on different types of activities involving technology for both personal and professional use to identify any differences in general usage patterns between exemplary integrators and other participants. The latter were analysed by reviewing the responses to open-ended questions in part three of the online survey and determining the number of times in which each of the different responses occurred for similar self-assessed users of technology. The LCU score was used to triangulate against the self-assessed category of technology integration through a correlation analysis.

Table 1

Relationship between research questions, data collected and analysis

Research Question	Data Collected	Data Analysis Method
Enablers and inhibitors of exemplary ICT integration	Online survey, parts 2, 3, 4 and 6	<ul style="list-style-type: none"> • Correlation between LCU and self-assessed technology integration • Common open-ended responses converted to a percentage • MANOVA based on school culture between self-assessed integration level and OE and SE from MUTEBI, student activity, teacher activity, experience, formal and informal professional learning
Exemplary integrators' preferred training methods	Online survey, parts 2 and 3 Qualitative interviews	<ul style="list-style-type: none"> • ANOVA between self-assessed integration level and formal and informal learning • Descriptive statistics, including mean, mode and median for categories of learning from online survey, part 2
Exemplary integrators' pattern of technology usage	Online survey, parts 2, 3 and 5 Qualitative interviews	<ul style="list-style-type: none"> • Common open-ended responses converted to a percentage • Pearson correlation coefficient for self-assessed integration level and types of learning activities
Exemplary integrators' preferred teaching style	Online survey, part 3 Qualitative interviews	<ul style="list-style-type: none"> • Common open-ended responses converted to a percentage • Direct quotations used to support arguments

Research Question	Data Collected	Data Analysis Method
Exemplary integrators' personal self-efficacy	Online survey, part 6	<ul style="list-style-type: none"> • ANOVA between self-assessed integration level and OE and SE from MUTEBI
Effect of sex of technology integration	Online survey, parts 1, 2, 3, 5 and 6	<ul style="list-style-type: none"> • MANOVA based on sex between self-assessed integration level and OE and SE from MUTEBI, student activity, teacher activity, experience, formal and informal professional learning
Differences between science and mathematics teachers	Online survey, parts 1, 2, 3, 5 and 6 Qualitative interviews	<ul style="list-style-type: none"> • MANOVA based on subject between self-assessed integration level and OE and SE from MUTEBI, student activity, teacher activity, experience, formal and informal professional learning
Implications for professional learning	Online survey, qualitative interviews	<ul style="list-style-type: none"> • Emergent trends, or factors of significance which emerged from the above tests

The MUTEBI scales, derived from the responses to the statements in part six of the online survey, provided two scores to measure the effect of outcome expectancy and personal self-efficacy relating to computer usage. These scores were correlated against both the level of computer use and self-assessed integration categories to identify whether either outcome expectancy, personal self-efficacy or both were indicators of exemplary technology integration and hence enablers of exemplary integration. In addition to the quantitative data, the open-ended responses in the online survey and review of transcripts from the qualitative interviews also provided information about the enablers and inhibitors of exemplary ICT integration. All data from the qualitative interviews was transcribed and has been used directly to support arguments about preferred teaching style, preferred learning style or examples of activities involving high student autonomy. In addition, where participant responses could be reasonably regarded as common in either the personal reflections on ICT integration tool, part three of the online survey, or during the qualitative survey, these were counted and converted to a percentage as an indicator of how regularly a particular concept was identified by different participants. These findings were tested against the self-assessed technology integration category in part three of the online survey.

An analysis of variance (ANOVA) test was carried out to determine whether there were any differences in potential predictors of exemplary practice as identified from research question one on the basis of exemplary practice for different cultural groups. Each of several variables were separately analysed for variance by testing a null hypothesis for the three categories of self-assessed technology integration. These null hypotheses were assuming no significant differences between the mean values of the minimum adopters, competent users and exemplary integrators, for a range of variables including personal self-efficacy, student activity, teacher activity, outcome expectancy, teaching experience, formal professional development and informal professional development. The variables chosen were sourced as follows; outcome expectancy and personal self-efficacy (based on the MUTEBI data from part six of the online survey), student activities with computers (part five of the online survey), teacher activity with computers (part five of the online survey), teaching experience

(from the demographic data in part one of the online survey) and formal and informal professional learning preferences (part two of the online survey). This data was used to report on any differences observed between different school cultures.

3.7.2 Research question 2: what separates the minimum adopters from the exemplary integrators?

The literature review was used to identify enablers and inhibitors of ICT integration across a range of contexts. The study sought to duplicate some of the cultural and community groups which are found scattered across the New South Wales education sector. Demographic information in the online survey gathered data about school location and type and the predominant cultural or religious affiliations. These were used to filter the responses for other sections. An ANOVA was carried out to determine whether there were any differences in potential predictors of exemplary practice as identified from research question one on the basis of exemplary practice for different cultural groups. Each statistically large cultural sample, eg Aboriginal and Torres Strait Islander culture, was analysed for group differences on the basis of outcome expectancy and personal self-efficacy (based on the MUTEBI data), student activities with computers, teacher activity with computers, teaching experience and formal and informal professional learning preferences from the personal and professional usage component of the online survey. Other variables analysed in this way included differences based on sex and based on primary subject taught (eg mathematics or science). The emergence of several factors from the research suggested some specific enablers of exemplary technology integration and each of these was assessed separately as part of this research question.

3.7.2.1 Research question 2a: How do the exemplary integrators' preferred training methods differ from other integrators of technology?

This question focussed on whether there were differences between exemplary integrators of technology and other technology integrators on the basis of their preferred training method. Data relating to this question was gathered in part two of the online survey, in the open-ended questions in part three of the online survey and

during the qualitative interviews. Patterns of responses were identified for the open-ended questions and qualitative interviews to determine the percentages of different methods. However, part two of the online survey required participants to identify the amount of time spent on formal and informal professional learning and the types of activities they felt were most effective as a learning style. An ANOVA was carried out to determine whether there were any differences between exemplary integrators and other self-assessed integrators on the basis of time spent pursuing formal and informal professional learning. Data from the various categories of learning were analysed using descriptive statistics including mean, mode and median. These were then separated for the three categories of responses and reanalysed to identify any patterns.

3.7.2.2 Research question 2b: How do exemplary integrators' patterns of technology usage, both inside and outside the classroom, differ from other integrators of technology?

This question focussed on whether there were differences between exemplary integrators of technology and other technology integrators on their patterns of technology usage. Data relating to this question was gathered in part two of the online survey, in the open-ended questions in part three of the online survey, in part five of the online survey and during the qualitative interviews. Patterns of responses were identified for the open-ended questions and qualitative interviews to determine the percentages of different activities. However, part five of the online survey required participants to identify the amount of time spent on learning activities as part of their own practice and the types of activities they required of their students. A Pearson correlation coefficient was calculated for the relationship between the self-assessed integration category and the types of tasks involving technology undertaken by the teacher and the student. An ANOVA was also undertaken to determine whether there were any differences between exemplary integrators and other self-assessed integrators on the basis of the types of learning activities undertaken personally and by their students.

3.7.2.3 Research question 2c: What is the preferred pedagogy for teachers who view themselves as exemplary integrators?

This question focussed on whether there were differences between exemplary integrators of technology and other technology integrators on the basis of their preferred teaching style. Data relating to this question was gathered in the open-ended questions in part three of the online survey and during the qualitative interviews. Patterns of responses were identified for the open-ended questions and qualitative interviews to determine the percentages of different methods. This question did not have a quantitative component and hence was not analysed statistically. However issues which emerged from both the open-ended questions and qualitative interviews were reported and direct quotations used to reinforce differences between the self-assessed groups of technology integration.

3.7.2.4 Research question 2d: Do exemplary integrators have a higher personal self-efficacy than other integrators of technology?

This question focussed on whether there were differences between exemplary integrators of technology and other technology integrators on the basis of their outcome expectancy or self-efficacy. Data relating to this question was gathered in part six of the online survey. An ANOVA was carried out to determine whether there were any differences between exemplary integrators and other self-assessed integrators on the basis of outcome expectancy or personal self-efficacy. The high statistical significance of personal self-efficacy when evaluated against self-assessed technology integration justified the inclusion of this statistic in the analyses described above and in the following sub-section.

3.7.2.5 Research question 2e: Do the differences between teachers, in terms of their degree of technology integration, persist between male and female teachers?

The literature review was used, in part, to identify the degree of commonality across different cultures and communities of both the enablers and inhibitors of ICT integration. Demographic information in the online survey gathered data about school location and type and the predominant cultural or religious affiliations. It

included data about the sex of the participants. These were used to filter the responses in other sections. An ANOVA test was carried out to determine whether there were any differences in potential predictors of exemplary practice as identified from research question one on the basis of exemplary practice for different cultural groups, sex, types of computer-based activities and professional learning. Each of these variables was separately analysed for variance by assuming a null hypothesis for the three categories of self-assessed technology integration using the variables; outcome expectancy and personal self-efficacy (based on the MUTEBI data from part six of the online survey), student activities with computers (part five of the online survey), teacher activity with computers (part five of the online survey), teaching experience (from the demographic data in part one of the online survey) and formal and informal professional learning preferences (part two of the online survey). This data was used to report on any differences observed between males and females.

3.7.2.6 Research question 2f: Do the differences between teachers, in terms of their degree of technology integration, persist across different subject-specific (maths and science) groupings?

As a subset of the ANOVA described above, exemplary ICT integration was tested against the main subject taught by the teacher, ie science or mathematics. This variable was separately analysed by assuming a null hypothesis for the three categories of self-assessed technology integration using the variables; outcome expectancy and personal self-efficacy (based on the MUTEBI data from part six of the online survey), student activities with computers (part five of the online survey), teacher activity with computers (part five of the online survey), teaching experience (from the demographic data in part one of the online survey) and formal and informal professional learning preferences (from part two of the online survey).

3.7.3 Research question 3: focus on exemplary practitioners to inform future professional learning

The same tools described above were used to focus on any differences identified

between teachers who self-assessed as exemplary integrators and those in other categories. Once again, factors such as professional learning preferences, types of ICT-based activities, personal qualities and pedagogical approaches from the online survey were used along with the qualitative interviews where participants had the opportunity to expand on their self-assessed exemplary use of technology and how it fitted into their teaching philosophy. Patterns which emerged as a consequence of the online survey were specifically targeted as part of the qualitative interviews in order to focus on what made an exemplary integrator of ICT different from other, competent users of technology in the classroom and hence which factors may justify inclusion in future professional learning experiences.

3.8 Ethical Issues

The researcher was aware of the ethical issues relating to data collection. Ethics approval for the purpose of this study was sought and gained from the Human Research Ethics Committee, (SMEC-30-13). The conditions of Human Ethics Clearance approval, which was granted on 10 April 2014 for the purpose of the study, included the following statements: “All potential participants in the survey, whether teachers or students, will be given the opportunity to participate or to decline without consequence. Recommendations from Principals regarding exemplary practice, or subjects for further interviews will all be given the right to contribute to the study or decline the invitation. No participant in the study will be specifically identified to avoid potential repercussions based on their responses or decision to decline the invitation to participate. The researcher will contact previous employers and colleagues to invite participation in the study, however all contacts will be treated with respect and given the opportunity to decline or accept the invitation. No participant in the survey will be identified without prior consent and where the potential for an unequal relationship exists, this invitation will be made by a third party, such as the researcher’s supervisor.”

As required under section 5.5.5 of the National Statement on Ethical Conduct in Human Research, annual reports have been submitted to the Ethics Committee. The researcher ensured concerns were addressed in relation to informed consent,

voluntary participation, ability to withdraw and confidentiality of responses. A cover letter was provided to principals or their nominees, with the invitation to participate outlining the researcher's role and the purpose of the study, see Appendix C on page 317. Material collected from schools is very sensitive and any data collected from persons requires a respect for their welfare, rights, dignity, beliefs, culture and custom.

Informed consent

Participants needed to indicate their consent to the use of personal information for the purposes outlined prior to entering the survey. This was done by selecting 'I agree' to a series of statements on the first page of the online survey, see Appendix D on page 320. Where consent was not given, the survey went straight to the end and did not give the participant a chance to complete any of the survey.

During the qualitative interviews, participants were read a series of statements of consent and asked to verbally provide consent prior to the asking of the first interview question, see Appendix L on page 338. All participants in the qualitative interviews gave their consent.

Voluntary participation

No direct approaches were made by the researcher or supervisors to any educator other than via general invitations, group discussions or online forums or social media. All vehicles used to publicise the study emphasised the voluntary nature of participation and no rewards were offered for participation or successful completion of either the online survey or the qualitative interviews. Participants were offered the opportunity to receive a copy of the report from this research once it was complete but there was no minimum effort required to do so, other than to reach this option in the online survey. All emails were sent to principals or their delegates and distribution was left to the individual schools as to whether to participate and whom to nominate.

Ability to withdraw

The ability to withdraw participation in either the online survey or qualitative interviews was included as a component of both consent statements. The statement of consent at the start of the online survey identified the ability of participants to withdraw at any time without penalty. This was understood and exercised by many participants. Whilst all participants in the qualitative interviews gave their verbal consent and understood the choice of withdrawal or refusal to answer any of the questions, none exercised their right to do so.

Confidentiality

Confidentiality was addressed by limiting access to all data to only the primary researcher and his supervisors. All participants were guaranteed privacy and confidentiality and may remain anonymous if they wish as outlined on the first page of the online survey (see Appendix D on page 320) and through a standard introduction at the start of each qualitative interview as outlined in the participant consent statements (see Appendix L on page 338). This was sent as an email attachment to each participant prior to the actual interview. Schools will not need to be matched to individual participants unless they wished to identify their school as part of the second phase of the data collection. Demographic data was collected from all responding educators.

All data collected will be stored by the researcher and at Curtin University for a period of five years and participating educators will receive feedback as desired. An electronic report will be produced and distributed to interested parties, as nominated within the online survey, when the study is completed and after the thesis is submitted. It is not expected that this study will make a significant impact on teaching time within schools as participation is voluntary and most participants will likely choose a time which is personally convenient. No complaints were received by the researcher from any individual or school regarding the style, length or specific questions in the surveys. Some participants made a comment about specific questions in the space provided in the online survey.

3.9 Summary

In this chapter, the mixed methods research design was discussed and justified for this particular study. The purpose of the online survey and qualitative interviews was to identify the thinking patterns and common practices of exemplary integrators of ICT in the classroom. The research aimed to draw from willing participants a deeper analysis of what is happening in their classrooms and their rationale for these actions. The method conforms to the statutory requirements relating to the ethical use of humans in research. Data collection and storage processes were outlined and followed.

The participant sample was drawn through several contacts, including professional associations and via direct emails to school principals. It included a sample of 96 participants who successfully completed the online survey out of 140 who began the survey. The online survey was developed to encourage a range of participants from different teaching areas, eg science and mathematics, as well as different cultural backgrounds and types of schools, eg government, catholic and independent sectors. The online survey consisted of six parts; a demographic collection, a review of personal and professional computer usage, an open-ended component focussing on personal ICT integration, a level of computer usage tool, an application of technology usage tool focussing on the types of activities which utilised technology by both the participants and their students and a series of statements designed to indicate participants' outcome expectancies and personal self-efficacies in the context of technology use. A series of qualitative interviews were conducted with 11 of the original participants who indicated their willingness to be interviewed and who provided a suitable time for contact. These interviews were conducted over a three week period and took between 20 and 40 minutes. There was a structured series of seven questions which were provided to each participant prior to each interview, however additional questions were asked by the researcher based on each individual participant's response to the set questions.

Data analysis techniques were linked to each of the research questions. As this study collected both qualitative and quantitative data, several different analytical tools were

described, which included descriptive statistics, regression analyses, calculation of Pearson correlation coefficients and the testing of null hypotheses through a series of analyses of variance. Qualitative data was either compiled on the basis of common responses into a single percentage characteristic, or quoted directly to enhance a stated position or conclusion.

In the next chapter, the analyses described above will be presented. The results of both the qualitative and quantitative components of this study are reported with the data trends identified and analysed in the context of each of the three research questions.

Chapter 4 Results

4.1 Introduction

The previous chapter outlined the methods chosen for the gathering of data to address the research questions. A number of factors were suggested by the literature review in Chapter Two. In Chapter Three, tools previously evaluated for their efficacy, as well as several additional qualitative components were described and their relevance to this study identified. The selection of a mixed methods approach ensured the broad data collected in the online survey could be supplemented with explanatory notes to increase the depth and rigour of the interpretations placed on participant responses. The data presented has been analysed in the context of the following research questions:

1. What are the common enablers and inhibitors of exemplary ICT integration?
2. What are the sets of skills, outcomes or personal motivators which separate the minimum adopter, the competent user and the exemplary integrator in the context of ICT integration practice?
 - 2a. How do the exemplary integrators' preferred training methods differ from other integrators of technology?
 - 2b. How do exemplary integrators' patterns of technology usage, both inside and outside the classroom, differ from other integrators of technology?
 - 2c. What is the preferred pedagogy of teachers who view themselves as exemplary integrators?
 - 2d. Do exemplary integrators have a higher personal self-efficacy than other integrators of technology?
 - 2e. Do the differences between teachers, in terms of their degree of technology integration, persist between male and female teachers?

- 2f. Do the differences between teachers, in terms of their degree of technology integration, persist across different subject-specific (mathematics and science) groupings?
3. Which of the key competencies could be delivered as elements of targeted professional development for effective and exemplary ICT integration in the Australian Curriculum context?

In this chapter, all of the data is analysed and organised into a format consistent with the structure of the online survey and qualitative interviews. It links participants' personal reflections, their computer usage and attitudes, potential inhibitors to ICT integration, professional learning and skill acquisition preferences to their self-assessed discrimination between minimum adopters, competent users and exemplary integrators of technology. Results of the LCU and MUTEBI scales will be presented and analysed as will each of the questions from the interviews. Pearson correlation coefficients and regression analyses were undertaken to triangulate the data and all emergent patterns are reported. Following this is a series of one way and multivariate analyses of variance to test null hypotheses regarding between group differences for minimum adopters, competent users and exemplary integrators for several of the factors identified in the study. To confirm the data from the literature search regarding research question one and to specifically address each component of research question two, where the sample size is large enough, different factors have been analysed to determine whether the patterns observed for all schools were consistent when applied to the different characteristics, including sex, dominant subject, personal self-efficacy, cultural groupings and so on. This provides some conclusions regarding the enablers and inhibitors of exemplary ICT integration in the secondary classrooms of New South Wales and also the degree of generalisability based on each component of research question two.

4.2 The Online Survey

An online survey containing both quantitative and qualitative components was designed to draw from different teachers in different schools their computer

experience inside and outside the classroom. It sought data on their views on student use of technology and additional statements included were designed to test their teaching efficacy beliefs in the context of technology integration. Not all participants completed the survey. Of the 140 participants to start the survey, 96 completed it in full. This represents a 69% completion rate. Their results are presented in sections 4.3 to 4.7 of this chapter.

Participants were also offered the opportunity within this survey to participate in a qualitative follow up interview to expand on some of the points they had previously raised. Eleven participants took part in these interviews and some interesting patterns emerged. These have been outlined in section 4.8 of this chapter and will be expanded upon in Chapter Five.

4.2.1 Self-assessment of current ICT integration

The most critical component of the online survey was the final question in section two. It asked participants to rank themselves on a technology integration scale from technophobic, through minimum adopter, competent user to exemplary integrator. This was set in the context of a previous question regarding their perceived differences between the four categories of technology integration. This was a critical step as it was the basis upon which all of the conclusions for research questions one and two have been made. The reported self-assessment of technology integration levels are shown in Table 2 on page 145.

4.2.2 Demographic data

The demographic data gathered provided a number of variables which could be tested, however not all cultural and religiously-affiliated schools were equally represented in the survey and this has limited some of the conclusions which can be made regarding the commonality of exemplars and inhibitors across different cultural groups. Analyses were undertaken for groups in which participant numbers were high enough for statistical confidence. This including teachers from schools identifying as Aboriginal and Torres Strait Islander culture and heritage, Australian culture and heritage and equal representation of all cultures. It also included tests of

significance for preferred training methods, patterns of technology usage, preferred teaching style, personal self-efficacy, sex and dominant subject taught.

Table 2

Self-assessed ICT Integration level

I would describe myself as	Responses	Percentage
a) Technophobic	0	0.0%
b) A minimum adopter	5	5.2%
c) Technologically competent	61	63.5%
d) An exemplary integrator of ICT in the classroom	30	31.3%

The majority of participants came from high schools or K-12 schools with over 50% of these schools being independent schools, as shown in Table 3 below.

Table 3

Type of School

School Type	Responses	Percentage
High school	57	60.0%
Combined Primary and High School	31	32.6%
Senior School	3	3.2%
Government School	17	30.9%
Independent School	28	50.9%
Catholic School	10	18.2%

While the largest groups in school affiliation data were from non-religious (21.7%) and non-denominational schools (33.7%), there was representation in the sample from Catholic schools (20.7%), Christian schools (19.6%), Jewish schools (3.3%) and Islamic schools (1.1%), as shown in Table 4 on page 146. When analysing exemplary patterns across different cultural groups, some of the small sample sizes, eg participants from Jewish schools and Islamic schools, will provide only general guidelines, and cannot be included in the statistical or factor analyses.

Almost half of the schools surveyed identified all cultures and heritage as being equally represented (46.8%), see Table 5 on page 146. However once again, there

are only three dominant cultural groups; all cultures equally represented, Aboriginal and Torres Strait Islander culture and heritage (22.3%) and Australian culture and heritage (19.1%) with statistically significant representation, which limits the validity of the study in terms of its generalisability. Despite this, some consistent patterns emerged which will be discussed later in this chapter.

Table 4

School Affiliation

School Affiliation	Responses	Percentage
Non-denominational	31	33.7%
Catholic	19	20.7%
Christian	18	19.6%
Jewish	3	3.3%
Islamic	1	1.1%
Non-religious	20	21.7%

Table 5

School culture and heritage

School Culture and Heritage	Responses	Percentage
Aboriginal and Torres Strait Islander culture/heritage	21	22.3%
Jewish culture and heritage	4	4.3%
Islamic culture and heritage	2	2.1%
Australian culture and heritage	18	19.1%
All cultures and heritage are equally represented	44	46.8%
Other (please specify)	5	5.3%

The majority of participants were either teachers (42%) or heads of department (42%), whilst several directors of eLearning and three principals also contributed to the study. Of the 96 participants in the study, 52% identified science as their major teaching subject, 31% identified mathematics as their major teaching subject and 17% identified technology as their major teaching subject. Two of the participants were instructors of teachers. This breakdown is summarised in Table 6 on page 147.

The online survey was dominated by science and mathematics teachers, with the largest representation from teachers of Year 9-10 science (51.1%) and Years 7-8

science (42.4%) as shown in Table 7 below.

Table 6

Current Role

Current Role	Responses	Percentage
Classroom teacher	40	42.1%
Head of department	40	42.1%
Head of administration	1	1.1%
Director of Teaching and Learning	2	2.1%
Principal	3	3.2%
Other (please specify)	9	9.5%

Table 7

Main Subjects and Years Taught

Main Subjects and Years Taught	Responses	Percentage
Year 7-8 Mathematics	29	31.5%
Year 7-8 Science	39	42.4%
Year 7-8 Technology or Applied Studies	6	6.5%
Year 9-10 Mathematics	28	30.4%
Year 9-10 Science	47	51.1%
Year 9-10 Technology or Applied Studies	6	6.5%
Year 11 Maths	31	33.7%
Year 11 Science	5	5.4%
Year 11 Biology	15	16.3%
Year 11 Chemistry	18	19.6%
Year 11 Earth Science	8	8.7%
Year 11 Physics	27	29.3%
Year 11 Technology and Applied Studies	2	2.2%
Year 11 Software Design	4	4.3%
Year 11 Information Processing	4	4.3%
Year 12 Maths	27	29.3%
Year 12 Science	6	6.5%
Year 12 Biology	15	16.3%
Year 12 Chemistry	18	19.6%
Year 12 Earth Science	6	6.5%
Year 12 Physics	25	27.2%
Year 12 Software Design	4	4.3%
Year 12 Information Processing	4	4.3%

The next highest percentages are for Years 7-12 mathematics teachers. The nature of

these subjects and the needs of schools possibly accounts for the fact that teachers will have indicated teaching more than one category of year group (eg 7-8 and 9-10) and some teachers have indicated more than one subject (eg 7-8 science and 7-8 mathematics) and were included in the data for both.

The representation from design and technology teachers was smaller and hence, statistically less relevant to this study. As a result, they were excluded as a separate subject grouping, but included for general trend data around exemplary enablers. Consequently, the conclusions of the study relating to subject taught were focussed on teaching practices in secondary science and mathematics classrooms.

Academic qualifications were varied as shown in Table 8 below, although just less than 50% of respondents indicated that they held a higher learning qualification above Bachelor Degree with over 10% of these holding a Master Degree with Honours or a Doctor of Philosophy.

Table 8

Academic Qualifications

Academic Qualifications	Responses	Percentage
Diploma	2	2.1%
Bachelor Degree	21	21.9%
Graduate Diploma	26	27.1%
Bachelor Degree with Honours	9	9.4%
Masters Degree	25	26.0%
Masters Degree with Honours	5	5.2%
Doctor of Philosophy	5	5.2%
Other (please specify)	3	3.1%

Analysis of birth year suggested that 7% of participants were between 21 and 30, 16% between 31 and 40, 39% between 41 and 50, 34% between 51 and 60 and 6 participants were over 60. This correlated well with teaching experience, shown in Table 9 on the following page, as would be expected and hence provided a degree of confidence in the validity of using teaching experience data for later analyses.

Table 9

Teaching Experience

Teaching Experience	Responses	Percentage
1-2 years	4	4.2%
3-5 years	7	7.3%
6-10 years	13	13.5%
11-15 years	17	17.7%
16-20 years	16	16.7%
21-25 years	13	13.5%
26-30 years	9	9.4%
Over 30 years	17	17.7%

4.3 Personal and Professional Computer Use

The data in this component of the online survey has been gathered for the purpose of determining whether exemplary teachers are more likely to be experienced computer users and also what types of activities, locations and training are undertaken and/or preferred by exemplary ICT integrators. These factors may have an empowering effect on teachers with respect to their ability or willingness to integrate technology in their classrooms, and hence may be recommended for less competent technology-using teachers in order to increase their experience and level of comfort with technology.

4.3.1 Number of years of computer use

The first question asked participants to indicate the number of years they had been using computers for personal purposes, see Table 10 on the following page. Given that most teachers would be at least 21 years old, the sample was dominated by teachers who had been using computers personally (62%) for more than 20 years. These values may reflect an older teaching population who have been exposed to computers for much or most of their careers and have embraced them for personal use, or younger teachers who have been likely to have grown up using computer technology in a personal, entertainment capacity.

Table 10

Self-assessed Personal Use of Computers vs Age

Personal use of Computers	Mean Age (Range)	Responses	Percentage
6-10 years	48 (31-55)	4	4.2%
11-15 years	46 (28-58)	12	12.6%
16-20 years	42 (25-55)	20	21.1%
21-25 years	48 (30-69)	24	25.3%
26-30 years	51 (33-71)	17	17.9%
Over 30 years	52 (35-72)	18	18.9%

Table 10 reinforces this notion as the average age of participants in each group is relatively consistent, with a slight drop in mean age for the 16-20 years of experience category. The pattern observed in Table 10 above may also be explained by the fact that teachers who feel comfortable with technology may be more likely to respond positively to a survey about technology usage in teaching. These two factors may also explain the finding that no teachers indicated using computers personally for less than six years.

4.3.2 Types of applications used

The second question asked participants to indicate the number of years they had been using computers for professional purposes (see Table 11 on the following page). The sample was dominated by teachers who had been using computers professionally (55%) for more than 15 years. The average age of participants in each group is less consistent than for personal use, with a mostly incremental increase in mean age for each increase in professional experience with computers.

The smaller values for professional use, compared to personal use, may reflect younger teachers who only recently began using technology in a professional capacity as well as in a personal capacity. This may also explain the finding that no teachers indicated using computers professionally for less than three years. This provides some argument for the ubiquitous nature of modern technology and specifically technology in an education setting.

Table 11

Self-assessed Professional Use of Computers

Professional use of Computers	Mean Age (Range)	Responses	Percentage
3-5 years	39 (25-48)	3	3.2%
6-10 years	46 (31-57)	17	17.9%
11-15 years	45 (29-57)	23	24.2%
16-20 years	47 (35-58)	21	22.1%
21-25 years	53 (43-69)	16	16.8%
26-30 years	59 (51-72)	10	10.5%
Over 30 years	60 (58-63)*	5	5.3%

In seeking to expand on what sorts of applications were being used professionally by teachers, participants were asked to identify the applications they primarily use for professional purposes. In assessing these applications, participants reported primarily Microsoft applications (eg Word, Excel, OneNote and Powerpoint). At least one Microsoft Office application, but generally more than one, was identified by 78% of participants. Adobe's suite of resources were identified by 14% of participants with 7% specifically referring to Apple applications such as iMovie, or iPad applications such as nearpod. 48% of participants reported using a range of online tools and applications, other than Microsoft, Apple or Adobe products, including Prezi, Kahoot, Geogebra, YouTube, etc. 38% of participants identified specific administration roles they were carrying out with technology. Minimum adopters were more likely to identify admin applications such as "word" (MT08), "internet research" (MT11) or "lesson preparation" (FT24), whereas many exemplary integrators listed a wide range of applications such as "office, camtasia, adobe, geogebra, geometers sketchpad, quick graph, wolfram alpha, web browser, moodle, media player, mathletics, kahoot it" (sic) (FH16).

4.3.3 Preferred training methods for technology integration

The participants were also asked to indicate their preferred training methods using an open numbering form. Participants did not have to number all of the options, only those that were relevant to them. The range of numbers for each method was scored from '1' (first preference) to '12' (last preference), with the most popular choice

(mode) providing an indication of relative importance of that method. The mean and standard deviations were also calculated to determine whether the scores were closer to '1', indicative of a high preference, or closer to '12', indicative of a very low preference. A large standard deviation indicates a method selected by many of the participants in various positions of preference, whereas a low standard deviation suggested either a small number of participants selecting that method or a large number of participants selecting the method in a similar position, ie very high preference, mid-scale, or a very low preference. The results are summarised in Tables 12 and 13 below and on the following page.

Table 12

Preferred Training Methods Part 1

		Educator conf.	Uni course work	School level w'shop	Non- school w'shop	Private vendors	Learned on my own
N	Valid	69	56	65	41	40	89
	Missing	27	40	31	55	56	7
	Mean	4.23	5.07	5.02	5.22	6.63	2.16
	Mode	2.00	2.00	5.00	3.00	6.00	1.00
	Std. Dev.	2.86	3.35	2.50	2.76	3.14	2.05
	Minimum	1	1	1	0	1	1
	Maximum	11	12	12	11	12	12

In order to identify the pattern of preferred training more clearly, the mean and mode were converted into a graph, shown in Figure 4 on page 154. A description of the patterns evident in this data and their implications can be highlighted by the juxtaposition of the results for the categories 'learned on my own' and learned through using 'list servers'. The former category was ranked by all but seven of the 96 participants. The mean for 'learned on my own' was 2.16 and the standard deviation was 2.05 for this method with a mode of 1. This indicates that although some of the participants allocated a lower preference to this category, most had a number close to 1, 2 or 3, indicating it was a major training or learning preference for them, when it came to learning about ICT integration.

Table 13

Preferred Training Methods Part 2

		Learning from my peers	Learning from students	Web- based	Software Help Files	List Server	User Forum
N	Valid	88	71	65	47	30	40
	Missing	8	25	31	49	66	56
Mean		2.83	4.72	4.22	5.64	7.43	6.40
Mode		2.00	4.00	4.00	4.00	11.00	7.00
Std. Dev.		1.90	2.23	2.25	3.36	4.04	3.13
Minimum		1	1	1	0	0	0
Maximum		10	11	12	12	12	12

By contrast, the category; ‘List Servers’ was ranked by only 30 participants, and their responses ranged from ‘0’ or ‘Not Applicable’ to ‘12’ (least preferred method). For ‘list servers’, the most popular choice (mode) was 11, the mean score was 7.43 and standard deviation was 4.04. This indicates that for the 30 participants who were familiar with this form of learning, they generally did not prefer this method of training as an effective method for ICT integration.

A consideration of the data in Tables 12 and 13 and Figure 4 suggests there are several ways of interpreting the data. Firstly the most frequent methods chosen, irrespective of their preference scores were ‘learned on my own (reading, trial and error, video)’, selected by 93% of participants and ‘learning from my peers’ nominated by 92% of participants. Secondly, the mean and mode may be examined as measures of preference for training methods for different participants. When the calculation of mode and mean were considered, ‘learned on my own’ was the most preferred method; scoring a mode of 1 (equivalent to the most preferred option) and a mean of 2.16. This was the lowest means of all the methods listed and indicated that most respondents thought ‘learned on my own’ was the most preferred form of professional learning for them. ‘Learning from my peers’ had the second lowest mean and hence was likewise highly regarded as a preferred form of professional learning for the effective use of technology.

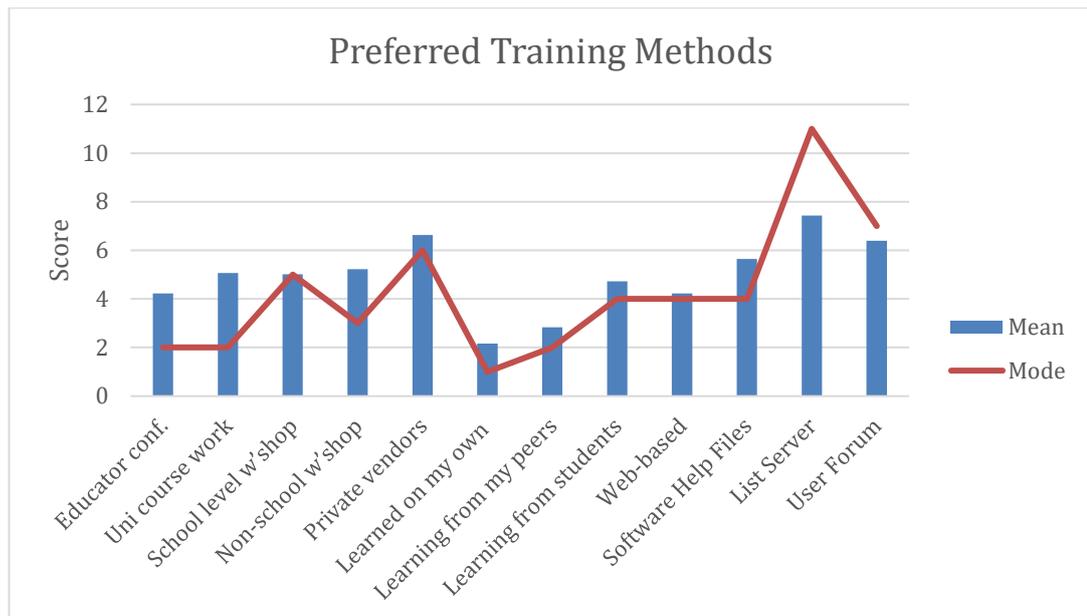


Figure 4: Mean and mode for different training methods

The lowest 5 mean scores, and hence the highest preferences for preferred training methods, in order of preference from the most preferred were: 'learned on my own', 'learning from my peers', web-based instruction', 'educator conference' and 'learning from my students'. This is an interesting finding and overlaps with the literature stating that many competent and exemplary users of technology, which covers the majority of participants in this survey, prefer independent or peer learning as an effective means of professional development when it relates to ICT integration. The extent to which this data is representative of teachers generally, or whether it is truer of exemplary integrators will be analysed in section 4.8.1 on page 180, where the degree of correlation between preferred learning method and the self-assessed category of integration has been calculated. 'State/district/school level workshops', 'non-school sponsored workshops' and 'private vendors' are all rated as a lower preference than 'web-based instruction', 'educator conferences' and 'learning from my students'.

Differences were also noted in the types of training undertaken by participants with informal training larger by a factor of three, compared with formal training. The average number of hours spent on formal professional development activities was

44.3 hours, whilst the average investment in informal professional development was 130.8 hours. While these figures fluctuated over a large range, the pattern for most participants was consistent and supports the preferences identified in Tables 12 and 13, where the more formal methods of professional learning, such as ‘educator conferences’, ‘state/district/school level workshops’, ‘non-school sponsored workshops’ and ‘private vendors’ were ranked lower on the preferences scale than the informal ones, such as ‘learned on my own’, or ‘learning from my peers’.

4.3.4 Purpose of computer use

The next question asked participants to indicate the purposes for which they used computers and how much time they had spent on the activity in a typical week. Ninety six participants completed this question and the percentages are reported in Table 14 below.

Table 14

Self-assessed Computer-based Activity

Answer Options	Average hours spent on this activity in a typical week (n=96)				
	> 1 hour per day	1-2 hours per day	3-4 hours per day	5-6 hours per day	>6 hours per day
Teaching/Instruction (%)	16	32	32	14	6
Personal use (%)	43	39	12	2	4
Communication (%)	31	50	11	4	3
Administration (%)	28	52	16	1	3
Facilitating student work/activities (%)	22	51	21	4	2

When analysed by self-assessed technology integration category, some interesting patterns emerged. In analysing Table 14, there appears an anomaly in the patterns of usage for ‘teaching/instruction’. When looked at by categories, 0% of the self-assessed minimum adopters indicated using computers for teaching/instruction for more than five hours per day, whilst 18% of competent users and 27% of exemplary integrators indicated using computers in their teaching/instruction for greater than five hours per day.

In terms of facilitating student work and activities, only one minimum adopter identified spending three or more hours per day on this type of activity, however 25% of competent users and 33% of exemplary integrators identified spending three or more hours facilitating student learning with computer technology. These are shown in Table 15 below.

Table 15

Use of computers for different activities by integration category

Use of computer for specific activity	Minimum adopters	Competent users	Exemplary integrators
Teaching/instruction for >5 hr/day (%)	0	18	27
Facilitating student work for >3 hr/day (%)	20	25	33

The locations most frequently identified for accessing the internet was school and home, see Table 16 on the following page. Given that this sample consists almost exclusively of school teachers and management, it can be assumed that many participants may have interpreted ‘school’ and ‘work’ to be equivalent.

Table 16

Internet Access

Hours per week using internet in this location					
Answer Options	N/A	1-2	3-4	5-6	>6
School (%)	4	8	11	11	65
Bookstore (%)	100	0	0	0	0
Cafe or coffee shop (%)	82	18	0	0	0
Friend's home (%)	86	11	2	0	0
Home (%)	1	12	15	11	61
Library (%)	95	5	0	0	0
Outside (%)	51	34	4	0	11
Work (%)	12	6	13	7	61

In question 19 of the survey, which asked participants to rank computer-related devices, eg laptops, tablets, etc which they used either for personal or work related

uses in order of preference of use, laptops dominated the ‘choice of device’ category.

Laptops were the preferred device for personal admin, educational admin and teaching and learning. Smart phones and iPads were chosen more often for gaming and entertainment purposes with iPad or iPad minis dominating PC tablets by factors of up to 7:1, except for the teaching and learning category. No patterns emerged which were significant to this study, hence no table has been provided for this data.

4.4 Reflection on Computer Usage

Reflection on computer usage was assessed with a series of open-ended questions in an attempt to encourage participants to express their own views about enablers and inhibitors of ICT integration in the classroom in their own words. In order to focus on the enablers and inhibitors of exemplary ICT integration, as required by research question one, responses have been categorised on the basis of self-assessed category; ie minimum adopter, competent users or exemplary integrator. For convenience, as each of the questions relates to ICT integration in the classroom, respondents have been referred to as the relevant role of ‘teachers’, even though the sample included middle and senior managers.

4.4.1 Effective Technology Use

The first open-ended question asked: How could teachers’ use of computers in the classroom be more effective? The most regular themes emerging from responses to this question were time (20% of respondents), connectivity, and training, consistent with the patterns identified in the literature in Chapter Two. This question was answered by 92 participants; 5% identified as minimum adopters, 62% as competent users and 33% as exemplary integrators.

Time

Eight out of the 29 (28%) teachers who self-identified as exemplary integrators specifically mentioned time in their response to this question. This was in contrast to 11 out of 55 (20%) competent technology users who likewise lamented the lack of

time. Perhaps of greater significance were the different reasons exemplary integrators gave for the use of this time. “*I had more preparation time . . . time to choose/invent relevant activities for students*” (MH11) or “*I had more time to develop lessons that more effectively developed deep thinking strategies with the technology*” (FT14). Yet there was consistency about the desire to have the required time to explore the technology they specifically sought to implement within their classrooms. To the question: I feel my use of computers in the classroom would be more effective if, some of the exemplary integrators desired “*time to learn effective engaging applications for my students*” (MH16) or “*the time to develop effective and interesting lessons using ICT*” (FT20).

Connectivity

Connectivity issues related to reliable internet, reliable technology (computers, laptops, iPads, etc), access to programs and/or IT support staff. This was a major issue for all teachers in all schools, with 60% of minimum adopters, 58% of competent users and 59% of exemplary integrators all mentioning issues relating to getting students connected in the classroom. However, some interesting patterns emerged when analysing the different responses for exemplary integrators. Whilst some were lamenting the unreliable nature of the hardware; “*more reliable technology and internet, greater access to ipads or tablets*” (FT25), the desire to be more effective integrators was evident amongst this group who already self-assessed at exemplary level. To the question: I feel my use of computers in the classroom would be more effective if, some of the exemplary integrators desired “*more evidenced-based research into best practice for integrating technology into K-12 learning*” (MC01).

Training

Exemplary integrators mentioned training less often (14%) than either competent users (22%) or minimum adopters (40%). Exemplary integrators appear to have a desire to continue to improve and develop new and/or better resources specifically

for their own students' use. They also appear to recognise the importance of personal responsibility in skill-development with one respondent suggesting “*more teachers took responsibility for developing their skill sets independently*” (MH17) and another “*other staff supported the use of computers better throughout the school*” (MT14). Beyond these responses were those who had thought more deeply about the magnitude of the technology integration issues to include more purposeful training, such as “*more courses available that help directly link the use of IT to the Stage 6 syllabus*” (MT15), how to promote collaboration within the school community; “*teachers passed on tips in their classrooms and how they use them*” (MT02) and beyond the school community “*there was a way to share resources between teachers of the same subject/year levels in the same state*” (MT06). This theme was developed more fully in the later qualitative interviews.

4.4.2 Potential Inhibitors

The second open-ended item asked participants to complete the following sentence: I feel my use of computers in the classroom is less effective than it could be because Four overarching themes related to the teachers' views of the inhibitors to effective technology integration were time, systemic connectivity, type of learning technologies and collaboration. The results related to each of these factors are reported below.

Time

Irrespective of the self-assessed category of technology integration, all of the participants were feeling the pressure of time when seeking to extend their technological influence. For example, one participant wrote: “*I know there are more effective and engaging tools but I just don't have the time to locate and organise my lessons using them*” (MH16). Another wrote: “*more time to develop lessons that better utilise the technology*” (FT14). This was particularly true for competent users (27%) and exemplary integrators (34%). Some of the time pressures have been exacerbated by an increase in bureaucratic loads, “*overcrowded curriculum*” (MT15), the need for greater differentiation and modification of tasks “*differing*

levels of student ability with tech” (FT24), the increasing sophistication of assessment and reporting systems; *“lack of time to spend learning or integrating new software/hardware into teaching programs”* (MT01) and the sheer volume of educationally relevant applications; *“I am not familiar with a wide variety of applications”* (MP02). As a practicing teacher, the researcher can concur with these sentiments from his own experiences in the classroom.

Systemic connectivity

Systemic connectivity issues identified by the participants revolved around reliability, numbers of students per computer and speed of connection. In thinking about the issues associated with reliability for example, one participant summarised her frustrations with technology through *“internet connection instability, slow computers, students not having devices fully charged and inadequate battery life”* (FT19). Connectivity is a major issue for the minimum adopters (80%), less so for competent users (55%) and exemplary integrators (45%).

Types of learning technologies

There were interesting issues raised in relation to the type of learning technology or device programs selected by the school. Many schools have a Bring Your Own Device (BYOD) program, but this too can create different kinds of systemic challenges: *“systems are not really as integrated, so students have multiple (and often complex) systems and steps to follow which can slow learning (or indeed stop it if students miss one step in the pathway to a lesson)”* (ME02). Such frustrations are magnified when students rely on different operating systems, different word processing, spreadsheet or presentation applications and so on. However, even within a BYOD environment, there were differences regarding the numbers of students per computer. Some teachers reported student-related rather than systemic failures in their BYOD program; *“very few of our students have devices to bring (BYOD policy)”* (MH14). Other participants identified problems with existent technologies; *“computers are so old and slow”* (FH10) whilst still others don't have the luxury of a 1:1 program or policy in place. One teacher wrote *“I need to book*

computer rooms to ensure that all students have access. Computer rooms may be unavailable” (FT06). Such frustrations were identified as significant inhibitors to effective computer use.

Some schools appear much better connected in terms of infrastructure than others, although sometimes it can be difficult to separate the cost factor from the many human factors. This was particularly relevant for teachers in New South Wales Department of Education schools: *“the DER laptop I am forced to use is unreliable, slow and often will just stop working. I do not have a SmartBoard and still have to use a blackboard and chalk. The wireless connection is unreliable and I cannot trust that I will even be able to connect to the internet for a whole lesson so I rarely plan a lesson where this is necessary. When I do connect, it is slow and takes a very long time to connect – or websites that I have researched at home are blocked by the DET”* (FT20). There may also be issues of systemic control: *“some of my preferred programs (emacs &c.) are barred”* (MT05) or, as one exemplary integrator observed *“our LMS (learning management system) is not good”* (FH04).

Collaboration

The final group of inhibitors were collaboration issues, which also referenced training directly or obliquely. Only one minimum adopter commented on this issue, however it was raised by 9% of competent users and 10% of exemplary integrators. Such issues include those which relate to accessing colleagues: *“it is hard to collaborate at the moment”* (FL01), and systemic pressures: *“staff not willing to explore options open to them and support students who have made the change”* (MT14), *“no systemic integration of ICT across the school”* (MH14), or *“not all the teachers in my school have a common practice in the effective use of ICT in teaching and learning”* (ME01). However there were also inhibitors based on access to expert peers *“I need a little more PD”* (MT13), *“I need more up to date training”* (MH03), *“I can’t share resources”* (MT06) and even the challenge of being the expert peer *“I have limited time for preparation at school due to support I offer to others”* (FH19).

4.4.3 Minimal Technology Usage

The third open-ended item asked participants to complete the following sentence: In order to do my job efficiently in the current age of technology, I think the minimal amount of technology use I can get away with is . . . This question sought to address the minimum standard expected in different schools and systems and was probably best summarised by the observation “*I do not agree with this statement. Education department mandates the specific use of ICT and software in science. I must use ICT in every class!*” (FH10).

There were no clear patterns in the responses to this question. Most of the issues relating to minimum standards are now being specified by Teacher Accreditation Boards in the various Australian states. Both teachers and educational leaders are largely deferring to these elements or standards to progress the efficacy of technology integration within their teaching staff. This occurs both at a national and international level. The successful completion of an accreditation report by the researcher in 2015 for the New South Wales Institute of Teachers, as well as fulfilling a role as a supervising teacher for a practicum student in 2016 and providing meaningful lesson observation feedback to the student, has provided personal experience of these mandatory requirements.

Where participants responded at face value to this question, most of the minimum activities related to research or administration issues: “*use it for research only*” (FT25), “*preparation, planning and communication*” (MH19), “*marking rolls*” (MT12) or “*demonstrations, communication and administration*” (FH14). Over one-quarter of participants (27%) were either upset by the question or couldn’t understand the reasoning behind it: “*silly question, technology is ubiquitous*” (MT07), or “*there is no minimum amount*” (FL01). Still others took this as a measure of time and provided their answer in terms of hours spend in front of technology. Values ranged from “*2 hours per day*” (MP03) to “*7 hours a day*” (FH05).

Participants who identified themselves as exemplary integrators often demonstrated a

different way of thinking when confronted with these sorts of questions. *“I use it all the time – indispensable”* (MH10), *“I don’t think like this”* (MH11), *“I believe the use of technology is ubiquitous in a science classroom”* (ME02), *“I would like to be paperless and have my students paperless. I would rather facilitate independent learning than teach”* (MH16). *“No minimum use. Staff should always be looking to improve skills”* (MT14).

In contrast, self-identified minimum adopters responded with *“once a cycle per mainstream class”* (FT24), *“chalkboard”* (MT08), or *“nothing as I am from the pre-electronic era and know the old ways”* (MH09). Clearly some participants are responding out of their frustration to incorporate technology into their teaching either reluctantly or under specific directives, whereas the exemplary integrators have just assimilated technology into their practice so seamlessly that there is now no value in asking questions about limiting or minimising its impact. These sorts of diversity in thinking and consequent translation into classroom action partially explain a technology divide which has little to do with school infrastructure.

4.4.4 Knowledge and Skill Development

The fourth open-ended question asked participants to complete the following sentence: In order to do my job more efficiently in the current age of technology, I would like to be able to improve my knowledge and/or skills in . . . Participant responses to this question were very diverse with many specific programs being identified. These have been listed in Table 17 on page 164.

Responses were grouped against the self-assessed technology integration categories; five responses from the MA (minimum adopters), 54 responses from the TC (technologically competent) and 29 responses from the EI (Exemplary Integrators). It would appear from the higher frequency of specific programs mentioned, especially by the exemplary integrators, and the apparent technological skill required for their use in a classroom, that the more technologically competent participants; TC and particularly EI, were better able to analyse their specific educational needs in terms of applications and identify how to meet these needs.

Table 17

List of programs identified by category

Minimum Adopters (MA)	Technologically Competent (TC)	Exemplary Integrators (EI)
No specific programs mentioned	SENTRAL and Edval OneNote Excel HTML 5 Google apps/docs Classdojo/three-ring Word Powerpoint CAS Calculator TI-nspire Prezi Photoshop	Newer programming languages such as Python Excel Geogebra Adobe software range GAPE Google apps/docs Shader coding HTML 5 VR tech Sectar/Connect SENTRAL

Minimum adopters remain sceptical about technology and its potential benefits. They wanted to improve their knowledge in “*instruction in use of technology and improve the speed in which I can plan ICT lessons*” (FT24) or broadly in “*software and hardware use*” (MT08). They wanted information about “*appropriate apps for learning*” (FH05) and “*uses others have for the technology*” (MH09). One individual “*wouldn’t waste my time, there is still no empirical evidence for benefits in the classroom*” (MT11). Such responses reveal a negative or overwhelmed emotion regarding technology. These comments reinforce the earlier stated inhibitors of low personal self-efficacy regarding technology use in the classroom and the lack of recognition of the pedagogical value of technology.

Several participant responses to this question were suggestive that teachers were not just providing a wish list of programs; they were after techniques, strategies or contacts to share information and learnings about technology use in the classroom, ie

“seeing what other schools are doing” (MT14). In contrast to the self-assessed minimum adopters, exemplary integrators knew what they wanted and how they could extend their already considerable knowledge base. In addition to the specific programs listed in Table 14 on page 155, exemplary integrators focussed on innovation and the ways in which student learning can be enhanced or differentiated better in responding to this question. Participant responses included; *“creating online learning environments for students”* (FT25), *“integrating smartphone use into lessons”* (MT15), *“script entry apps for numbers and algebra”* (FH16), *“video editing to store useful class demos for future classes or for students who miss that class”* (MH10), *“need to be more adaptive to new emergent ideas and become more creative in their use”* (MH05), *“coding”* (FH04), *“videoconferencing, collaborative teacher research projects and student collaborative projects”* (MD01) and *“designing and developing interactive flash animations App/game development Ebook publishing”* (MT01).

These educators are ahead of the learning curve in ICT integration according to the literature. They are seeking to create new pedagogies or resources or to take the best and most relevant techniques that already exist and mould them for the student cohorts they teach, eg *“flipped classrooms and emerging apps and programs that promote deep thinking”* and *“individualised assessment”* (FT14).

Technologically competent users likewise have a range of specific strategies or techniques they are interested in extending and their responses span the continuum between the two other groups, eg *“how to design more creative, challenging and higher order thinking tasks using technology”* (FT17). As can be seen from Table 14, many of the programs specifically identified by competent users are based on the most common applications available in schools, including the Microsoft Office suite, the Adobe Creative suite and Google.

The technologically competent users and exemplary integrators seem to be aware of their current level of expertise in relation to technology and on reflection are seeking the next step in their own progression, eg *“determining the next best tools and software that will support student and teacher learning. Data visualisation and the*

connected analytics is an area of interest to me” (ME02). The list in Table 14 suggests that exemplary integrators are selecting applications which foster student autonomy and creativity, particularly in comparison to the list produced by the technologically competent users. This has significant implications for teacher professional learning. Even such a small sample of teachers reveals a large diversity of professional development needs and this has to be accounted for when teacher training activities are being planned. This will be explored in greater depth in Chapter Five.

4.4.5 Professional Learning Activities

The fifth open-ended item asked participants to complete the following sentence: In relation to the use of technology in the classroom, I think I would personally benefit most from professional development activities which . . . Professional development is another area which elicits a variety of responses from educators. The time factor continues to impact on educators, however training also involves financial cost and some level of personal commitment. Many participants in the survey have completed tertiary qualifications beyond the minimum required for teaching (almost 50%) and many continue to do so. However there are also formal and informal opportunities for teachers to develop and refine their knowledge of effective ICT integration, eg *“involved me in working with similarly skilled peers”*(sic) (ME01).

Minimum adopters have tended to identify general activities such as *“help me locate quality resources”* (FT24), *“support the administration I am required to do”* (FH05) or *“show how others use it effectively”* (MH09). The lack of specificity is characteristic of teachers who are still a little reluctant to incorporate technology more consistently into their practice.

By contrast exemplary integrators are seeking knowledge and skills which will extend student learning, have high utility value and increase student engagement. Some of this professional learning is content specific; *“targeted at Stage 6 in mathematics”* (MT15), some is application specific; *“develop digital learning objects and applications based on evidence of how people learn”* (FT07) whilst still others

are pedagogically driven; *“how to use collaborative space apps, where students access and contribute to the same ‘document’”* (FH16).

The time pressures have forced many teachers to be very protective of their professional learning time and many are seeking proven strategies. Activities such as *“peer sharing”* (MH13), *“teachers outlining the technology they are using”* (ME02) and *“are practical and complete – where participants come away with a unit of work”* (FE01) are favoured. Consistency is also a critical factor; *“being able to dedicate consistent time with meetings and staff development days to technology and see what other schools are doing”* (MT14).

However there are also a number of participants who want the opportunity to learn on an ongoing basis, to have differentiated instruction, provide time for personal exploration and follow-up (12% of competent users and 40% of exemplary integrators). They like *“to do practical activities which I can then modify for the students in my class”* (FT26), to *“work at my own pace and choose from a variety of options that interest me”* (FT19), with *“the facilitator as a guide rather than a teacher”* (FT20). Many expressed the desire that professional development activities adhered to the differentiated learning model, when more often, the most capable educators have *“to wait for the rest of the staff to catch up before I get presented with the next activity”* (FT20). Many exemplary educators like to try something out for themselves in order to know what questions they need to have answered. Training should be *“very hands-on with activities to complete myself at my own pace”* (FT20). Some would like time in lieu of formal professional development to *“connect tools and abilities with the curriculum and pedagogy. The best professional development I’ve ever had is an hour to myself”* (MC01). One participant also suggested that professional learning *“include students”* (MH17).

The need for relevant activities which can be readily translated into the classroom was identified by 52% of participants which may indicate the general nature of professional learning relating to technology use. The fact that 15% identified the importance of working at their own pace and that 56% of these were exemplary integrators shows a distinct preference by the exemplary integrators for learning by

doing. This corresponds well with the preferred training method question in section 4.3.3 on page 151, especially when considered concurrently with the identified need of 6% of participants for a peer or local school-based group network. As one participant wrote; “*learn beside someone, or, with a buddy or in a small group say 5 of us*” (FH20).

4.4.6 School-based Professional Learning

The sixth open-ended question asked participants to complete the following sentence: In relation to the use of technology in the classroom, I think the teaching staff in my school would personally benefit most from professional development activities which . . . Themes arising from respondents to this question generally mirrored those of the previous question, although many responses involved a greater depth. However the responses were very diverse and hence difficult to group into particular categories.

Whilst most minimal adopters of technology once again looked for “*practical, hands on and provided more individualised support*” (MT08), or wanted whole school professional development to focus on “*how to teach students to research*” (FT24), or “*resources that line up directly with the national curriculum*” (FH05), one suggested training which does not “*show a dependence on computers in every situation*” (MH09).

Some respondents (26% of competent users and 33% of exemplary integrators) were again looking for a consistency of approach and the allocation of time for collaboration and exploration. Professional development at the school level should not be “*instruction and regulated but give time for play and personal development for individual teaching styles*” (FT14). Many respondents identified the need for smaller groups rather than whole school groups when it came to technology integration strategies. Teachers need “*time to look at the resources that are available and organise them for student access*” (MH19). They want the leadership to avoid demonstrating “*how something could be done, but show them step by step through activities to set up resources and materials for teaching*” (MH05). Many

exemplary users are technology advocates, not surprisingly, and desire whole school approaches which *“improve confidence and skill with technology, show them that technology is a tool that is used to enhance teaching not replace good quality teaching”* (MT14), *“show that technology can be used to enhance learning, not just for Word Processing. This includes, for example, development of learning games, student-paced learning opportunities, and providing instant feedback”* (MT06). This approach can *“empower them by sharing successes”* (ME02), particularly when they *“are related to their KLA – teaching area. We have done many general professional development (sessions) but they need concrete examples for their own area”* (FE01). These sort of responses support the views of Ottenbreit-Leftwich, Glazewski, Newby and Ertmer (2010) whose observations included the exhortation to trust exemplary integrating *“teachers to make good pedagogical decisions about how and why to use technology in order to enhance teaching and learning”* (Ottenbreit-Leftwich et al., 2010, p. 1323).

Logically the teaching staff in any school tend to be mixed ability when it comes to technology integration learning. Unless delivery of training is differentiated, the majority of participants will come away feeling disappointed or frustrated. For some teachers, there will need to be a *“focus on building basic ICT skills to enable better integration of existing ICT resources”* (MT01) if only with the goal of enabling all teachers to *“become more efficient at their jobs. The non tech-heads are so bombarded with new things that they are mostly overwhelmed and don’t bother with the new things. I have IT training from TAFE and teachers are somehow expected to just learn all the things I know in brief sessions of information, rather than systematic activities at a computer learning and exploring”* (FT20). For most, there is simply a benefit in *“teachers teaching teachers”* (MH13).

4.4.7 Discriminators in Technology Usage

The seventh open-ended item asked: In thinking about the use of technology in the classroom, in your opinion, what sorts of activities best identify the following types of teachers in terms of technology use in the classroom . . . The analysis for this question was based on evaluating the specific responses of participants who self-

identified in a particular category. None of the participants identified as technophobes.

Five participants self-assessed as minimal adopters of technology. They listed identifying activities as: *“laptop research for a paper task”* (FT24), *“establishing a case for their exclusion from the classroom”* (MT11), *“use of YouTube educational videos and sites”*, *“adapts some electronic teaching into lessons”* (MT08) and *“only using it for roll marking and basic applications”* (FH05).

Sixty one participants (64%) self-assessed as technologically competent. Many of these demonstrated a utilitarian view of technology integration. They listed identifying activities as: *“wide range of technological aids”* (MD02), *“learns new programs”* (FH19), *“internet searches done before lesson, lesson spent with quality images/videos and links embedded into whatever software both the teacher and student uses”* (FH18), *“integrates online activities and explicitly teaches ICT skills”* (FT22), *“use of technology to engage students in making and communication”* (ME01), *“blends their teaching with the use of technology for good learning outcomes”* (MT13), *“a range of tech activities used, eg data loggers, data analysis and graphing, simulation activities”* (MH14), *“student directed ICT lessons”* (FH14), *“use regularly and effectively for a variety of purposes and is willing to try new things as they emerge”* (FH12), *“higher order thinking required in technology setting”* (MH08), *“use of projectors/whiteboards to provide more stimulating and interactive material for teaching purposes”* (FH08), *“uses ppt & YouTube & spreadsheets & animation”* (FT11), *“one who integrated projected notes with interactive computer demonstrations”* (FT10), *“would be comfortable using technology in the classroom, but also knows when not to use it”* (MT04), *“designs and develops self-made Science curriculum interactive pdfs”* (MH02) and *“a variety of use(s) from passive to interactive, differentiated activities”* (FH01).

Thirty participants (31%) self-assessed as exemplary integrators of ICT. They tended to focus more on pedagogy rather than utility when evaluating exemplary integration. They listed a broad range of activities which could be grouped under the headings: self-paced lessons; *“using moodle to allow students to work through*

activities at their own pace and act as a facilitator to assist their learning when it is necessary” (FT26), promoting student autonomy; “use digital resources to provide engaging, student-centred activities. Is proficient in the use of technology in the classroom for presenting course material. Monitors student progress in real time using digital platforms” (MH19), contemporary blended or flipped strategies; “competent teacher using a range of contemporary pedagogies (PBL, flipped, etc) and digital tools (communication, collaboration and productivity software, learning management systems, etc) to create a hybrid or blended learning environment which leverages the best of both digital and physical learning spaces in a systematic and sustained manner” (MC01), “incorporates apps as part of the everyday learning process rather than add-ons for student engagement, use video and slide show for flipped classroom, use interactive docs such as Google docs, Google classroom, wikispaces that enable student collaboration” (FT14), collaborative learning; “these teachers plan rich learning experiences that incorporate the use of collaborative activities involving technology, integrating a variety of apps in the activity to foster deep learning of the outcomes being addressed” (FH16), student input into the learning; “often these teachers will discuss their plans and successes as well as hearing what students are talking about at school” (ME02), and individually designed lessons and learning plans; “develops interactive learning applications for specific needs. Doesn’t use technology if it would hinder (instead of enhance) learning” (MT06), “one who is technically competent and designs the integration of technology for a specific pedagogical purpose” (FT07), “guides student creation of content, very good understanding of various tools students can use, teaches others to use these tools” (MH01).

Educators who self-assess as exemplary integrators of technology clearly have several characteristics in common that discriminate them from other users of technology, as has been summarise for comparative purpose in Table 18 on the following page. Exemplary integrators are driven to learn more about technology and do so independently, online or via their students or peers. They develop and use specific practices, matching the technology to the purpose or outcome. By placing technology in the hands of students, exemplary ICT integrators, according to this

survey, use multiple devices and link the technology to the task.

Table 18

Discriminators of Computer-using Educators

Minimal Adopters	Competent Users	Exemplary Integrators
Administration	Administration	Multiple devices
Content delivery	Information gathering and processing	Multiple applications
Technology supports didactic pedagogy	Presentation of learning	Driven by pedagogy not application
	Passive and active strategies	Student-centred
	Augments tasks with technology	Content creation
		Collaborative with students and peers

Many respondents shared specific student activities that typify exemplary practice, most of which involve student autonomy and/or content creation. There seems to be a difference in the characteristics and attitudes to technology between the categories of minimum adopters, competent users and exemplary integrators. One participant in the survey did not feel comfortable evaluating themselves or their colleagues under these general headings, noting that “*I don’t like to categorise people in these terms. Learning is more fluid than this*” (MH17).

4.5 Level of Computer Use

To examine whether teachers were utilising or integrating technology in their classrooms, the LCU scale was administered (Marcinkiewicz & Welliver, 1993). The purpose of this section was to use a tool which had already been validated in previous studies (Hakverdi, 2005; Hakverdi et al., 2011) to triangulate against the self-assessed integration categories discussed in 4.2.1. Participants were asked to select one of a pair of statements regarding the importance of computers in their teaching. One of each pair represented a utilisation level statement while the other represented an integration level. The order for these was altered and repeated with a

different partner statement to increase reliability and confidence in the responses. Participant responses for the four paired statements were separated and re-grouped together under the relevant headings of utilisation (converted to a score of one for each chosen statement selected) and integration (converted to a score of two for each chosen statement) as shown in Table 19 below. This produced a single statistic for each participant out of eight, with a range of four.

Table 19

Level of Computer Use

<i>Paired Statements</i>	Total	Percent
Utilisation level statements (score 1 for each)		
1A. in my instruction, the use of the computer is supplemental	41	43
2A. the use of the computer is not essential in my instruction	32	33
3B. the use of the computer is not essential in my instruction	43	45
4B. in my instruction, the use of the computer is supplemental	31	32
All four utilisation options selected scored an LCU = 4	27	28
Integration level statements (score 2 for each)		
1B. the computer is critical to my instruction	55	57
2B. for my teaching, the use of the computer is indispensable	64	67
3A. the computer is critical to my instruction	52	55
4A. for my teaching, the use of the computer is indispensable	65	68
All four integration options selected scored an LCU = 8	47	50

As this study sought to make recommendations about the key skills or qualities of exemplary integrators, it was important to establish a mechanism by which self-assessed exemplary integrators could be validated. This tool was chosen to provide support for the self-assessment category and hence increase the level of confidence in the conclusions drawn from their responses. Participants who were minimal adopters scored closer to four on this scale, while exemplary integrators were more likely to score eight on this scale.

Data was combined into a single statistic according to Marcinkiewicz & Welliver (1993) within the SPSS software platform as described in section 3.5.5. The percentages for scores of four and eight are also shown in Table 19. The data revealed a bimodal distribution with limited values between five and seven; 5% scored a five, 8% scored a six and 8% scored a seven. This is expected as minimum

adopters would be more likely to identify with the utilisation of technology (a score of four) whereas exemplary integrators would be expected to identify with the integration of technology (with a score of eight).

Almost half of the sample of participants have been identified as integrators of technology and while this statistic does not exactly match the ratio of minimum adopters to exemplary integrators from section 4.4.8, the labels chosen are arbitrary and convenient for the purpose of this study. The results from the level of computer use scale suggest that technology integration is a continuum from those who use technology very little in the classroom to those for whom it is an indispensable part of how they teach. Hence these percentages are not unexpected, and the level of computer use statistic has been used to validate the self-assessed technology integration categories as described previously.

4.6 Specific Applications for Instruction

In this component of the online survey, participants were presented with a table to make a direct comparison between the frequency of different technology assisted activities which were carried out either by the teacher or by the students, as reported by their teacher. A range of applications were chosen, most of which had utility value for teachers and students, with several stretching student capacity and providing opportunities for student autonomy. Frequency tables were produced corresponding to how often an activity, such as communication, involved the use of technology. These frequencies were self-reported by the participant for both themselves and their students and have been converted to a percentages table (Table 20 on page 175).

4.6.1 Teacher frequencies of activities involving technology use

The data in Table 20 suggests that most participants are using technology regularly (more than once a week) for communication (93%) and information retrieval (81%). Participants are using technology for other activities less often, however the results suggest that the following activities are carried out using technology on at least a weekly basis; publishing (71% of participants), imaging (66% of participants), data

logging and analysis (46% of participants), simulations and educational games (40% of participants) and drill and practice activities (34% of participants).

Table 20

Comparison between teacher use and student use of technology

My students' use of technology for this purpose (%)						
Activity	daily	more than once a week	weekly	every 2 weeks	Once/twice a month	less often
Simulation & Ed Games	25	16	15	14	14	15
Imaging	31	13	11	10	9	26
Communication	63	16	5	3	7	7
Publishing	12	18	15	14	16	25
Drill & Practice	14	20	23	6	13	24
Information Retrieval	62	17	7	2	7	5
DataLog and Analysis	0	9	7	9	26	50

My use of technology for this purpose (%)						
Activity	daily	more than once a week	weekly	every 2 weeks	Once/twice a month	less often
Simulation & Ed Games	7	20	13	12	13	34
Imaging	32	21	13	4	9	21
Communication	93	5	1	0	1	0
Publishing	33	24	17	5	5	17
Drill & Practice	13	11	10	3	8	56
Information Retrieval	81	12	4	1	1	1
DataLog and Analysis	11	20	15	4	17	33

Of the 96 participants in the survey, 56% indicated they carry out drill and practice activities less than once or twice a month. This is an expected result as a teacher may be most likely to carry out such an activity only as an evaluation exercise prior to presenting it in the classroom, hence it will not be a regular activity.

4.6.2 Student frequencies of activities involving technology use

The data in Table 20 above suggests that most participants are requiring their students to use technology regularly (more than once a week) for communication (63%) and information retrieval (62%). Participants are requiring their students to use technology for other activities less often, however the results suggest that the following activities are carried out using technology on at least a weekly basis; drill and practice activities (57% of participants), simulations and educational games (56% of participants), imaging (55% of participants), publishing (45% of participants) and data logging and analysis (16% of participants). Of the 96 participants in the survey, 50% indicated they require students to use data logging technologies less than once or twice a month. This is a surprising result given the mandatory use of technology by students required as a component of the science curriculum. However, given that more than 10% of the participants reported using data loggers on a daily basis this seems a large disconnect between teacher use and student use. One possible explanation is that students may more regularly observe a teacher using this type of technology, rather than having access to it themselves.

4.6.3 Comparison of teacher and student use of technology

Teachers are using technology for publishing (33% to 12%) and data logging and analysis (11% to 0%) on a daily basis more often than they report requiring their students to do so, however they report student usage of simulations and educational games (56% to 40%) and drill and practice activities (57% to 34%) on at least a weekly basis, more often than their teachers based on teacher reporting. Teachers wishing to “augment higher-order thinking skills” will be seeking to extend their students well “beyond simple drill and practice or tutorial software” (Baylor & Ritchie, 2002, p. 410). Differences in frequency between different activities were used to correlate against competent and exemplary ICT integrators to identify any patterns of usage for teachers and/or students. To determine whether exemplary teachers use technology for these purposes more or less often than others, the teacher usage was converted into a single statistic. Each category was given a numerical value as follows: daily = 6, more than once a week = 5, weekly = 4, every two weeks

= 3, once or twice a month = 2 and less often = 1. The scores were then summed to produce a statistic called ‘frequency of teacher activities involving technology’ or just ‘teacher activities’ (TA). A similar process was carried out for the responses to the same variables as they related to student activities. These scores were likewise summed to provide a new statistic called ‘frequency of student activities involving technology’ or just ‘student activities’ (SA). The scores and their relationship to the self-assessed technology integration category have been reported on later in this chapter in the section 4.9.

4.7 Teaching with Technology – the MUTEBI scale

The literature suggested that one of the key enablers of exemplary integration practice was high personal self-efficacy. To determine whether this was true for the New South Wales educator cohort, the MUTEBI tool was used. Participant’s responses to the MUTEBI were combined to produce the two subscales; outcome expectancy and personal self-efficacy as previously defined and described in section 3.5.7. Descriptive statistics calculated from responses to the MUTEBI statements are shown in Table 21 below.

Table 21

Descriptive statistics for MUTEBI Scale

Scale	N	Min	Max	Mean	Adj. Mean	St. Dev	Adj. St. Dev.
Outcome Expectancy	95	9	34	20.96	2.99	4.58	0.65
Personal Self-efficacy	91	42	70	59.52	4.25	6.93	0.49

An adjustment was made to several statements as not all statements were phrased in a similar manner. The grouped statements were then tallied to produce a mean score for each scale and then each mean adjusted by dividing the mean score for each subscale by the total number of statements in that section (7 for outcome expectancy and 14 for personal self-efficacy). An adjusted mean score of three would indicate a mid-range on each scale; adjusted mean scores below three would indicate a low level of outcome expectancy or personal self-efficacy, whilst an adjusted mean score

greater than three would indicate a high outcome expectancy or personal self-efficacy. Outcome expectancy and personal self-efficacy have both been used in correlation coefficient calculations as potential measures of predictability and the results of these tests appear later in this chapter.

The purpose of this data was to determine whether outcome expectancy or personal self-efficacy could be used as predictors of the level of computer use and/or self-assessed technology integration category and hence whether or not they could be regarded as enablers of exemplary ICT integration. The first test required was to identify any differences in means and variance within the groups. This is shown in Table 22 below.

Table 22

Comparison of means for outcome expectancy and personal self-efficacy

Scale and group	N	Min	Max	Mean	Adj. Mean	St. Dev	Adj. St. Dev.
Outcome Expectancy							
Minimum Adopter	5	15	25	18.40	2.63	4.16	0.59
Competent User	60	11	30	20.91	2.99	4.30	0.61
Exemplary Integrator	30	9	34	21.47	3.07	5.14	0.73
Personal Self-efficacy							
Minimum Adopter	5	42	50	45.00	3.21	3.16	0.23
Competent User	56	46	70	58.77	4.20	6.00	0.43
Exemplary Integrator	30	48	70	63.33	4.52	5.16	0.37

In order to test the similarities in the means, two null hypotheses were proposed.

H_0 (Outcome Expectancy): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$ and

H_0 (Personal Self-Efficacy): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$

An examination of the means using a one way ANOVA demonstrated no significant differences between the group means for the variable outcome expectancy. However there was a high degree of significance between the group means for the variable personal self-efficacy; $F(2,88) = 23.96, p < 0.001$. This indicated that the higher the score in the variable personal self-efficacy, the more likely the participant was to be an exemplary integrator of technology.

Personal self-efficacy is a variable which has been referred to regularly in the literature and this study provides additional evidence for the importance of high personal self-efficacy regarding technology and the ability or likelihood of technology being used effectively in the classroom.

4.8 Qualitative Component of the Study

The results reported in the previous section provided some broad indicators relating to the enablers and inhibitors of the use of technology in selected secondary classrooms in New South Wales schools. However, the patterns which emerged during the analysis demanded deeper investigation and led to the inclusion of the qualitative interview component of the research. The data reveals several predictors of exemplary ICT integration along with some confirmation of commonalities of practice.

A major source of data for this study, the in-depth interviews, were recorded personal interviews with 11 educators who self-nominated and were interviewed as described in section 3.6 on page 127. The data was used to provide a rich collection of the perceptions and practice of a selection of educators within New South Wales. The participants involved at Phase Two, like Phase One, provided a broad representation of different levels of users. As shown in Table 23 on the following page, the participants included three teachers who self-assessed as exemplary integrators, seven who self-assessed as competent users of technology and one who identified as a minimum adopter.

The interview questions were structured to triangulate responses from the initial online survey regarding preferred teaching style and technology use and then to probe for deeper understandings of the professional and educational needs of each educator, their students and peers. One question focussed specifically on student autonomy as this emerged as a significant characteristic of exemplary ICT integrators. Participants were also asked to speculate on future directions in technology with the desire to gather information about the degree of forward planning which might characterise different participants.

Table 23

Characteristics of Qualitative Interview Participants

Subject Taught	Role	Self-assessment	Code
Science	Head of eLearning	Exemplary	EIH01
Mathematics	Head of Faculty	Exemplary	EIH02
Science/Mathematics	Classroom Teacher	Exemplary	EIT01
Science	eLearning Coordinator	Competent user	CUH01
Science	Classroom Teacher	Competent user	CUT01
Mathematics	Classroom Teacher	Competent user	CUT02
Technology	Classroom Teacher	Competent user	CUT03
Technology	Classroom Teacher	Competent user	CUT04
Science	Classroom Teacher	Competent user	CUT05
Mathematics	Classroom Teacher	Competent user	CUT06
Science	Classroom Teacher	Minimum Adopter	MAT01

A summary of the responses to each of the questions follows.

4.8.1 Preferred Teaching Style

The first interview question asked participants: How would you describe your preferred teaching style? Please discuss one example. This question was used to confirm specific response data gathered from the online survey which related to the preferred teaching style of exemplary technology integrators and whether any extrapolations could be made in terms of pedagogy from this small sample of interviewees. The use of any strategy of technology in the classroom feeds into the primary tenets held by different teachers (Lloyd, 2005). Hence this question was seeking to contextualise the subsequent responses and also inform research questions one and three. Unsurprisingly, exemplary integrators and competent technology users had a preference for student-centred pedagogy (45%), with a qualifier based on lower ability or younger students (27%). Interviewees identified the utility of technology to help provide more student self-direction and choice in learning (36%); a point which was later developed in a question relating to student autonomy. 27%

of interviewees inferred their role had changed to more of a facilitator and one competent user discussed the use of Socratic questioning in the context of preferred teaching style. “In order to understand why technology is integrated differently among teachers, their *fundamental* beliefs about what is important in student learning and thus teaching (regardless of technology use) should be understood” (C. Kim, Kim, Lee, Spector, & DeMeester, 2013, p. 77). Teachers who self-identified as competent or exemplary were more likely to describe their preferred style as student-centred with varying degrees of structure and control. “*I prefer to teach as a facilitator, rather than as an instructor*” (EIH02).

Issues were identified at this early stage of the interviews around the ability levels of the students and how this related to the design and depth of self-directed and open tasks. “*Often with lower ability, there does seem to be a lot more direction that’s required in the scope of . . . the openness of the task is actually much narrower*” (EIH01). The challenges associated with preferred or desired teaching style compared to actual style were picked up by one interviewee. “*My preferred teaching style would definitely be a little bit more student-centred than what actually happens*” (CUT06). This may suggest an anomaly between how participants self-assess; some interviewees self-assessed as competent, yet discussed quite high level strategies more consistent with an exemplary integrator; “*a lot more student-focussed, there’s more differentiation . . . use socratic questioning . . . need to differentiate*” (CUH01).

In the context of increasing student autonomy and creating a predominantly student-centred classroom environment, 72% of interviewees, independent of their self-assessed status, linked technology to student self-regulation. In prefacing her response with “*I prefer to teach as a facilitator*”, one exemplary integrator commented; “*I would group the students, mostly in pairs, and they would be given questions of their ability level, but they would work through together in pairs, and then what I would do is I would work my way around the room providing support for those as they work through the problems*” (EIH02). They recognised the inherent possibilities in using technology to help students identify and solve problems of

interest. Strategies included open-ended research, project based learning, real world applications, inquiry and experimental models with varying degrees of scaffolding discussed. Another exemplary integrator commented; *“I’d like to think I give opportunities for students to determine what they want to find out within the parameters of what they need to find out”* (EIH01). However several teachers commented on the challenges, particularly at the senior level (Years 11 and 12 in New South Wales) of provisioning time for student direction and the pressure to complete content-heavy courses. This was expressed by both science and, particularly, mathematics teachers. *“The lessons are very content-based and I think that’s a factor of doing HSC content-heavy courses. It would be nice to run off on a tangent but it’s really, you really need to keep focus on syllabus points and make sure we get through it. Class time is sacred”* (CUT04). This trade-off between time and learning outcomes was also articulated by another interviewee; *“I’ve definitely been able to create opportunities where kids are starting to get information more self-directed, but still sort of do go lock-step a bit through some of the critical concepts, and then we break away and start differentiating”* (CUT06).

Teachers discussed a range of examples where student choice was important and presentation media was either specified or left open, more so for exemplary integrators. This helped teachers deal with the important consideration of differentiation, where technology was used to facilitate both the means of data gathering and the mode of presentation. Yet with younger students or lower ability students, teachers also identified the importance of routines, *“I usually have to have a routine, otherwise they kind of go a bit crazy”* (EIH02).

From this question it appears that exemplary integrators favour a student-centred approach and act as facilitators in the classroom. Where technology is mentioned, it provides the opportunity for student choice and project-based learning, allowing the teacher to add depth of understanding and student autonomy in their approach to learning.

4.8.2 Technology Usage

The second qualitative interview question was: How would you describe your use of technology in your classroom? Please provide one example. This question sought to confirm the preferred ways in which exemplary users incorporate technology in a manner which may be different to those of minimal adopters or even competent users. Interviewees identified research (36%) as a use of technology fairly evenly across the categories, however competent and exemplary users used, or implied, terms like ubiquitous (72%), collaborative (9%) or skill development (27%). 18% of competent users focussed on note-taking, with one exemplary integrator discussing simulations. The creative use of technology, combined with the facility to encourage creative use by the students were identified by 27% of interviewees.

The specific responses to this question ranged from the frustrated “*some days it works, some days it doesn’t*” (MAT01) to the ubiquitous; “*I use technology whenever I can*” (CUT02) and “*it’s not part of my teaching, it’s not just a tool, it is fully integrated*” (CUT06). Three of the interviewees linked their comments to the discarded L4L program (Australian Government Department of Education, 2011) which provided laptops to government high school students. “*When they had laptops you could send them off hunting on different questions or you could even differentiate it on the fly pretty easily for different ability kids*” (MAT01). The comments suggested a much higher degree of technology usage when students each had a reliable, connected device. Subsequent governments have not renewed the program and as a result many of the laptops either remained in schools becoming increasingly slow and superseded or were discarded. This has had an impact on the attitude of some teachers to technology; evident in the online survey and confirmed in the interviews. However, recent developments suggest that this too may be changing; “*New South Wales is going down the track called ET4L . . .so the technology barrier in New South Wales public schools is being overcome*” (CUT02). While deficiencies in the hardware or network were also present in some of the independent schools many students, depending on the school and the socioeconomic background of the families, may have access to several devices. This prompted some deeper thoughts

by the teachers about how the technology could be used and the ways in which the learning could be transformed. For example, one exemplary integrator commented on the various presentation modes with different tools which he was observing from his students; *“multiple ways in which they can present information . . . It’s not multi-tasking but it’s giving multi-perspectives on being able to do a particular task”* (EIH01).

The teachers’ list of their uses of technology included e-readers, quiz-based apps like Kahoot, collaborative google docs, excel and google sheets, data logging and processing, simulations, computer-aided design and photographs of experimental results, or worked solutions to mathematical problems, which reflects a breadth of programmes and applications as well as an attempt to provide technology integration for purposes other than information gathering, most commonly chosen by minimum adopters as an integration strategy. One competent user reflected that *“I in 4 lessons generally I would have technology being used for something other than information gathering”* (CUH01). To complement the above variety of uses of technology, some of the parameters set regarding technology integration were deliberately opened by the competent users and exemplary integrators, particularly those parameters relating to the format in which students presented their work. *“I don’t really care what they use. So long as they get to the nub of the questions or key concepts we are trying to get at, that’s fine. My emphasis more and more, is on skills of how they make use of the knowledge, how they use technology to process things or to analyse things”* (CUH01).

Seven of the 11 interviewees, 70% of the competent users and 66% of the exemplary integrators, spoke of using video sharing and/or video creation as an adjunct to learning. It is being used by teachers and their students. The teachers explained that they used videos for a range of reasons, eg information dissemination or motivation, or as part of a blended or flipped classroom approach. For example, one teacher commented, *“you develop tutorials on how to use a program”* (CUT03), and another said *“I write software they can use to practice questions, randomly generated and I make videos and all kinds of things like that”* (CUT05). Teachers also talked about

using the creation of videos with their students as a means of assessing student understanding. One exemplary integrator said, *“there’s a growing reliance on technology as a tool to be able to do things that you couldn’t do in a standard classroom. Movie and story-telling are huge ways in which students are able to demonstrate their understanding”* (EIH01). For many teachers, the challenge associated with technology is not incorporating its use, it’s teaching the students how to select the most appropriate tool for the specific job they are doing. This was identified as a challenge for teachers too, and one more likely to be solved by an exemplary integrator, with one saying, *“I know I actually walk around with multiple devices and depending on what needs to happen, I’ll pick one up and I’ll have multiple ones going at the same time often, just because they all have their own particular use”* (EIH01).

Research was the primary activity identified by the minimal adopter, however this may equally have reflected his frustration with inadequate technology and the loss of funding from the previous laptops for learning initiative as mentioned above.

Technologically competent and exemplary users were more likely to identify the ubiquitous nature of technology use and, in the case of exemplary integrators, the creative ways in which it was being used, although the competent users were also identifying uses such as note-taking and skill development.

4.8.3 Personal Technology Needs

The third interview question is: What do you think is your greatest need in terms of improving your integration of technology in your classroom? Why have you identified this particular need? This question sought to identify the types of professional learning experiences most desired by different teachers with a view to addressing research question three. The minimum adopter identified the need for time and training as general categories which would provide some benefit. The competent users also wanted more time (14%) but were more specific with their requirements: better systems integration across the school (28%), practical applications which translate directly into the classroom (42%), immersion (14%) and video tutorials (28%) either self-developed or prepared by professional learning

providers. Exemplary integrators were looking for a more holistic approach, through better systems integration (33%), increased access (33%), development of video lesson expertise (33%) and increased support for more adventurous use of technology, such as the flipped classroom model (33%).

Reflecting on the online survey results, reported in sections 4.3 to 4.7 above, time was identified in several components and by many teachers as a major inhibitor or specific need. All teachers who participated in the qualitative interviews were identifying time pressures or challenges, either due to a perceived lack of knowledge and expertise and hence the time needed to develop that knowledge or out of a desire to extend their students' learning through the linking of a particular tool to an identified student need. As with any differentiated strategy, in my experience and in those of the interviewees, developing specific strategies or tools for a particular cohort of students takes time. *"Time and Training"* (MAT01), *"Just time basically. My dreams are bigger than the time I have. Although there are a load of resources available on the web and I use those when I can, ultimately it's better if I can make the stuff myself based on what my students need"* (CUT05).

Time pressures also impact on teacher's ability to learn new strategies and techniques. Preferred learning styles and the nature of technology mean most educators like to have some time to play with new software or hardware before they use it with their students. *"All software requires what I call the . . . around hours to go up blind alleys and make your mistakes"* (MAT01). Another interviewee identified training with specific technology as one of her learning needs; *"data loggers to carry out experiments"* (CUT01). However, she also realised that she needed *"experiments written up for new technologies and then time for me to implement it in class"* (CUT01) as needs which coexisted. The dual pressure of a teacher incorporating a new technology is greatly magnified by a factor of 20 or 30 times when the teacher provides the technology to his or her students. The importance of time for *"immersion in the technologies that are available"* (CUT02) was shared by one teacher who knew that if he was to select relevant resources for his students he needed to be familiar enough with them to critically evaluate their

utility and relevance.

The second area of need focused on the systemic level. One exemplary integrator identified “*systems integration*” (EIH01) as a critical component from someone who has a leadership role in eLearning in his school. “*We have a lot of subscriptions to things like brain pop and skwirk and tweek and lots of those other online resources which don’t get used very well just because they don’t actually integrate these*” (EIH01). This reference to accessing a huge variety of applications, either within an individual school or more broadly online, was raised as a concern by another exemplary integrator, however for a different reason. She cites “*access to IT support*” (EIH02) as one of the critical inhibiting factors. As an exemplary integrator of technology, she finds that her “*ability to use the computer is often better than other teachers and so the security measures that are in place . . . actually hamper your own capacity to do the trouble-shooting*” (EIH02). Security system requirements and administrator level access can stifle the creative and problem solving processes. “*I understand they’ve got security measures for a reason, but it also then hampers your capacity to keep up to date quickly, looking for the changes*” (EIH02). Whilst some problems may relate to connectivity and broadband speeds, there are potential quick fix solutions to problems which may still be beyond the security level of a competent teacher to solve. “*I wanted to do videos like a flipped classroom . . . and mine weren’t working and I couldn’t understand why. And, of course, I didn’t have, you know, basic things like java script running*” (EIH02). Such problems could be easily addressed by similar teachers who have the skills and ability to troubleshoot issues, but not the required permission to make changes on their system nor those of their students. This also applies to other simple acts like accessing applications. One interviewee described his reliance on this factor in his analysis of the success of the iPad, iPhone and other Apple products. “*That’s also a big driver as to why the iDevices and in particular the iPad, is so fantastic. Because you know, you put your credentials in once and then you just do what you want to do*” (EIH01). It is again a question of security; one which is based on the number of user name and password combinations your average 12-18 year old (and some older members of the school community) can remember. Several schools have sought

ways of minimising the number of different combinations required and where possible reduced this to a single username/password combination for all school-based applications. This seems to be working, at least at some schools. As one exemplary integrator suggested; *“keep it simple is probably a good solution”* (EIH01). Frustrations such as those articulated above can create barriers within a lesson, across a unit and perhaps in the future planning of teachers without the technological resilience or tenacity of exemplary integrators.

At a systemic level, several educators identified inhibitors at the school or departmental level. As previously mentioned, the L4L program provided a massive injection of one-to-one technology in the form of laptops to each secondary student in Year 9 and 10 in the late 2000s. Poor decision making, changes in government and lack of sufficient infrastructure and long-term vision consigned the laptops to museum pieces, according to several public school teachers who were interviewed. However, for some government schools in particular, they remain the major electronic device available en masse to many students. *“We do have a bank of the old laptops that the government stopped looking after that are falling apart, but they are way too slow to use. . . I’ve got a lot of resources for electronic whiteboards and I can’t even use them”* (EIT01).

There are also challenges associated with consistency across the school community. As the Head of eLearning in his school, one interviewee coordinated several rollouts of technology hardware and learning management systems. He also team teaches with staff, identifying strengths and weaknesses in the system and seeks ways of maximising his impact through his role. *“You are trying to manage and keep things in house and that’s what I was saying about systems as well is that I think there are plenty of great individual teachers that are really great adopters of technology . . . but they often do that outside of the school system and independent of all the technology and the integration and the e-learning facilities in the school”* (EIH01).

Another interviewee also has a role as eLearning director in his school and he shares some of the same concerns. *“If we are going to integrate technology, it’s got to be something that works across a whole school because you need some degree of*

consistency as kids move from one classroom to another” (CUH01). He emphasises the critical importance of *“staff on a common page with use of technology and how technology gets used”* (CUH01). Whilst there are many teachers working in isolation to solve problems whether they do so using the features of the internal LMS or via some external application, to move the whole school community forward requires a committed community of learners and collaborators. He felt that *“sharing that information across the school, creating that sense of culture within the school is probably what I would see as the greatest need for improving integration”* (CUH01). The community of learners and educators is a common theme amongst exemplary ICT integrators. *“More exposure to the methods that other people are using that gives you a better way of differentiating with kids in the classroom”* (EIH01). One teacher demonstrated a desire for growth and refinement in his teaching craft throughout the interview and highlighted the need for regular collaboration. *“There’s so much scope for improvement always. You think you are on the cutting edge and you are integrating it as much as you possibly can and then someone just blows you out of the water with how they are using it”* (CUT06). His proactive approach to ICT integration was highlighted through a discussion of his studies. *“I’m doing an online course at the moment in relation to a flipped classroom, so that results in us having discussions on forums and skype, communication at home which I’m completely fine with”* (CUT06). He is a strong advocate for the collaborative nature of technology use and the need to keep open communication channels to other experts to maintain currency of practice.

The shift to a flipped model has also been part of another teacher’s reflection on ways to increase his ICT integration efficacy, exacerbated by the fact that he finds demonstration lessons a challenge with a large group. *“Being able to demonstrate how to do something is fraught with a lot of problems. When you actually try to show students as a group how something is done. The only way that I can figure is to actually do video tutorials”* (CUT03). His frustrations are commonly held in practical subjects, particularly when a big group is gathered around a central position in a technology room or laboratory.

One mathematics teacher uses a dual display to keep work side by side in the classroom, so students have more than one way to visualise and solve mathematical problems. He currently uses an overhead projector (OHP) to achieve this, but knows this sort of technology is being phased out. By assigning one student per lesson to operate a wireless keyboard and mouse, he can create a diverse visual effect.

“Hopefully there will be a time soon where there’ll be two computers, like they have in University lecture theatres . . . I’ll be starting to write and explain the solution, the kid with the keyboard and mouse will be grabbing it in Geogebra, so at the same time the students are seeing side by side the calculus, algebraic approach to a problem and also seeing an interactive Geogebra thing” (CUT04).

For most educators, it is the plethora of resources that can be overwhelming. Whether time, professional collaboration or systemic organisation is the limiting factor, ultimately most teachers recognise; *“you have to have a range of tools and you have to know how to use them to their best purpose and to use them effectively”* (CUH01). The difference between minimal adopters and exemplary integrators has less to do with the common needs of time, training and better connections, it is based on a pragmatic analysis of the technology. Exemplary integrators know how technology is being used more widely, including globally, such as the flipped classroom, and their major needs are focussed on how to bring these global initiatives into the local setting.

4.8.4 Self-Assessment of ICT Integration Practice

The fourth interview question was: How would you describe yourself in terms of technology integration and specifically the use of computers in your classroom? Why? This question was primarily used to confirm the self-assessed level of technology integration from the online survey, however it also allowed exploration of some of the reasons why interviewees had used particular labels. In the absence of classroom observation, this allowed the researcher to catch a glimpse of what sorts of activities were happening and what sorts of frustrations were being experienced, providing additional data around research questions one and two. The minimum adopter described himself as low to middle in terms of technology integration,

whereas competent and exemplary integrators described themselves as adventurous (56% and 33%), improving (competent 28%) or collaborative (competent 28%) and their use of technology as ubiquitous (competent 28%, exemplary 33%).

As this question sought to clarify the degree of correlation between how teachers self-evaluate their practice in terms of ICT integration and what strategies are used to justify this criterion, the researcher sought to explore some of the reasons behind the choice of technology integration in the classrooms. Rather than seeking to justify a single position, most teachers discussed their perceived or real inhibitors to extending their use of technology in the classroom. Whilst this group was very diverse in both its original self-assessment and in actual strategies being used, they were united in their desire to think through how they could be more effective in their craft. Some of the inhibitors identified included the rapid rate of change associated with technology. *“You can’t keep up with technology, it’s really quick and I look at some of the other teachers and what they do and I teach with a lot of personality rather than technology”* (MAT01). This also manifests itself when school systems don’t keep pace with upgrades in software, including operating systems. *“When they use a program that the network doesn’t recognise, it comes out all disjointed”* (CUT03). *“Sometimes the executive at the school like the principal, if they’re on board with all the technology, they expect you to try to keep up with the current technologies before you’ve actually really gotten a handle on the ones that were thrown at you before”* (CUT03). One exemplary integrator demonstrated both her broad reliance on technology as well as some of the inhibitors to its effective implementation; *“electronic copy of the textbook, simulations on Geogebra, I used technology in my lessons, no matter what. But the technology has to be there and it has to be reliable for effective learning”* (EIT01).

Some interesting discussions took place around the perceived value of a dedicated computer room. For departmental schools, many still use this model. However in many of the independent schools, the computer room has been superseded by a 1:1 laptop program and/or BYOD program. Reactions were mixed to this type of model, with some educators very strong advocates, as reflected in the literature (Zucker &

Hug, 2008). *“It never makes sense for me to actually go and do an experiment and then book in to a computer to go and get the kids to write up on the excel sheet what their experiments were and then do a graph of it”* (EIH01). *“Access and mobility and just getting that 1:1 to actually have ownership of the device. That’s really how you learn”* (EIH01). *“I’m very hands off in the classroom, students open the google doc, a student opens Geogebra”* (CUT04).

Purpose-designed applications like Geogebra were mentioned regularly as a key tool. However, the user-support systems for such programs must be strong and relevant for competent and exemplary ICT integrators or else they soon move on to something more user-friendly. One strength of Geogebra was its community of users, many of whom were willing to share their experiences, successes and words of caution with other users. *“The (Geogebra) website appears to facilitate this instructional dialogue and ongoing user support relatively effectively”* (Grandgenett, 2007, p. 277). Self-evaluation often accompanied specific discussion around how that was made manifest in the classroom. *“I use Minecraft, a range of tools . . . I’ve had to go and self-teach myself the applications that I might use”* (CUT02). *“I experiment with technologies or I learn new things, because I really am somebody who tries to refine what I do from year to year, or week to week even”* (CUH01). *“I think I would be on the high end (of the spectrum). I get involved in any pilots or anything new”* (EIH02). *“I’m not bad, particularly with the google products, Geogebra and Excel”* (CUT04). *“I’d call myself a developer. I see it as an ongoing process. When students have needs, I write software to fit that need. Or I find the resources online to fit that need”* (CUT05). *“Although we can use Apps and programs on (the iPad) to replicate a book, you actually use a program that is specifically designed to be used with something like that then, it just makes the integration so much stronger”* (CUT06).

Some educators talked about their approach and how they solved the problems they encountered with technology. *“I get excited about technologies like VR goggles and stuff. I have these idealistic visions of the future, but for now I use it as a tool to help me teach”* (CUT05). *“The model that I’m using is a learning together approach”*

(CUH01). *“So I, at times, give support to colleagues in those areas. I have a real desire that every student could leave the school with advanced spreadsheet skills”* (CUT04).

There were also some issues raised regarding the utility and relevance of professional development, particularly for the more capable integrators. *“I have no formal training, basically picked it up as I went”* (CUT05). *“So PD really, it doesn’t go far enough to enhance what I can do”* (CUT02).

The ability to reflect on their practice and identify where they were situated currently in terms of ICT integration, where they wanted to be and what may have been inhibiting that progression was generously shared by all participants, although it was articulated more clearly by the exemplary integrators. Their understanding of what they wanted to use and how they wanted to use it shaped their views and focussed their attention onto those factors which inhibited their effective use of the technology.

4.8.5 Student Autonomy

The fifth interview question was: What level of student autonomy exists within your classrooms generally? Please provide an example. One of the key points which emerged from both the literature review and the online survey was the importance of student autonomy in exemplary practice. Akcay and Yager (2010) in their study of student-centred vs teacher-directed approaches to science, technology and society instruction found “significant differences between the students experiencing student-centred approaches for all grade levels with respect to their understanding and use of science process skills. . . . The greatest success of students in the student-centred STS (Science Technology and Society) sections occurred in the use of the concepts and skills in completely new situations” (Akcay & Yager, 2010, pp. 606-607, 609). As schools become more accountable for their learning support and gifted and talented strategies, differentiated learning has become even more critical. In Nancy Sulla’s latest edition of *Students Taking Charge Inside the Learner-Active, Technology-Infused Classroom* (2013) she describes a classroom where technology is used to

facilitate this sort of high-end differentiation through student autonomy. “Teachers in this classroom masterfully craft learning experiences that emanate from authentic problem situations; they facilitate learning, ensuring that each student achieves at the highest level” (Sulla, 2013, p. 1). Egea (2014) suggested that the “new pedagogy” will be “based on the autonomous and self-regulated learner as an active knowledge producer” (Egea, 2014, p. 275). The move away from a didactic pedagogy to a more student-centred approach can be facilitated by technology. It may also be an indicator of how the technology is being used. In the qualitative interviews, teachers discussed the ways in which student autonomy was facilitated in their classroom and what inhibitors they found.

In this study the minimal adopter and 42% of the competent users identified “minimal student autonomy”. This was either because they were not confident of being able to facilitate it or because they felt their students were unable to cope with too much choice in the classroom. In juxtaposition were other competent users (56%) and exemplary integrators (66%) who identified the importance of students posing questions and working in a self-paced, supportive environment to seek answers to those questions. One exemplary integrator and one competent user discussed the importance of cultures of thinking (Ritchhart, 2015) in their classroom, and/or the adoption of Socratic questioning (Paul & Elder, 2007) to probe deeper understandings and up the ante for student learning. Perhaps reflective of a growth mindset (Dweck, 2006), both a competent user (14%) and two exemplary integrators (33%) identified that their use of student autonomy was increasing. Most of the discussion relating to student autonomy can be divided into the inhibitors of student autonomy and the enablers of student autonomy. These have been expanded in the sections below.

Inhibitors to student autonomy:

- “*Not a lot of autonomy because there is a syllabus to plough through*” (MAT01).
- “*Depending on what the activity is, is how autonomous they are. Things that are more engaging, they will work on a lot more*” (EIT01).

- *“Some students cope well with that and some students do not” (EIH02).*
- *“I allow students to give me feedback when it comes to how they would like things delivered to them” (CUT03).*
- *“Our brightest students cover more work when they’re allowed to work at their own pace and choose what they are doing. . . in terms of our top end getting to there, the more autonomy they have, in fact, the more work they cover. My main issue with giving autonomy is with students who don’t have the maturity to progress at their level” (EIH02).*
- *“Fairly structured maths lessons. There’ll be some autonomy about what topics we will revise” (CUT04).*
- *“There are technological limitations even now and I’m hoping to overcome these challenges in the next few years, because ultimately the classroom still has to be a unit and move together through learning” (CUT05).*
- *“Top performing kids really weren’t pushing on and accelerating and attempting much more harder, challenging questions. I’m now setting tasks but the tasks that I set are very differentiated in relation to the abilities that I perceive that the student has. The workload that is coming out of the top performers is significantly greater and the happiness of the lower performing students in the class is much more because they’re able to succeed at quite a smaller task” (CUT06).*

Teachers identified the major inhibitors as a content-laden curriculum, pressure from a high stakes external examination, issues with the technology infrastructure or the students themselves; their personal motivation and engagement levels. Two of the interviewees took contrary opinions about strategies involving increased student autonomy when referring to their top performing students. Despite these contrary positions, both teachers had high expectations of their high ability learners. Whether by choice or design, once the high ability students knew what was expected, they demonstrated to their teachers the ability to extend their learning into new areas, often beyond that of their peers.

Research supports the premise that student autonomy is one of the keys to unlocking

the potential for increased student engagement and success. “Engaging, student-oriented activities gradually replace the traditional, teacher-centred teaching methods. In these classrooms, students exhibit highly evolved technology skills as they become more actively involved in their own learning and move from competitive to collaborative work with their peers” (Marshall, 2002, p. 18). In order to move their pedagogy to a more student-centred approach, several educators were able to identify the enablers of student autonomy in their classrooms and provide personal evaluations about its relative effect in improving student outcomes.

Enablers of student autonomy

- *“What is essential for some, is good for all. It’s actually good for everyone to have a clearer idea of what people are being asked to do in a task and how they might be asked to present . . . technology provides multiple ways of being able to look at the same issue” (EIH01).*
- *“Need to be flexible and open to new technologies” (CUT01).*
- *“Try to give them choices” (CUT02).*
- *“I set fairly clear expectations around technology use in class. I’m fairly relaxed as to how the kids meet those expectations . . . trying to inculcate this idea that what works for them is not necessarily what works best for other people” (CUH01).*
- *“They have complete autonomy over their own design” (CUT03).*
- *“I instigated project-based learning . . . students worked through a series of activities . . . at their own pace with us just monitoring how they were progressing and giving them suggestions on how to move forward with their task” (EIH02).*
- *“These are the lessons that are available to us. These are the question ranges that you can go and access, my expectation is that you will get to some level, some basic level, but wherever you end up, above and beyond that, is great” (CUT06).*
- *“I create a sort of like flowchart of learning objectives. When they complete one it tells them what they need to learn next” (CUT05).*

- *“How they presented that information was really up to them” (CUH01).*

Students need a clear scaffold. As one exemplary integrator identified; structures that can help weaker students understand what they need to do, can be equally valuable for all students in seeking to meet the expectations of a particular lesson or task. The critical factors seemed to be about choice and capacity, both personal and digital. However to take the next step, there must be opportunity for students to be active in the learning process. Three of these educators summarised the elements succinctly. *“Kids have to have the opportunity to reflect on why they did things, what they found enjoyable, what they found frustrating or difficult and I think it’s really important they get the chance to share those things with their peers”* (CUH01). *“In Mathematics, you often mark the number of correct answers, but these tasks are about formulating and justifying opinions. They don’t want to do repetitive work until they’re perfect. They want to be enriched”* (EIH02). *“The quality of the learning is reflected in the quality of the questions students ask”* (EIH01).

The issue of student autonomy is a vexed one and many teachers struggle to let go of control in their classrooms, either because of the pressure to achieve the outcomes of a content-heavy syllabus or because of some diminished valuation of the students’ ability to cope with more self-direction and self-regulation. Despite these concerns, many of the interviewees, especially those identifying as exemplary integrators, emphasise the importance of student autonomy and well-scaffolded tasks, such as work flows, or project-based learning, to assist in guiding students to achieve their personal learning goals. This is an important ingredient for an exemplary integrator and could produce a significant benefit if included as a component of targeted professional learning.

4.8.6 Personal Learning Style

The sixth interview question was: If it was critical that you learned how to use a new piece of hardware and software for educational purposes, how would you prefer to learn? Two of the research questions relate directly to professional learning, how

different teachers learn and what skills and strategies would be most effective for increasing the number of exemplary integrators of technology. It should not come as a surprise that teachers are as diverse in their preferred learning styles and prior knowledge as their students. Equal numbers of interviewees from the three self-assessment categories mentioned a preference for small groups, however peer sharing was the most popular response to this question. 86% of the competent users and 33% of the exemplary teachers desired a local expert, either in their faculty or at least within their school, who could be used for professional learning as required. Whilst some teachers like the demonstration model (25% competent users, 33% exemplary integrators), most preferred to work independently or be self-taught (86% of competent users and 33% exemplary integrators), often in response to particular learning needs or desired learning activities and then consult an expert when they were unsure of how they should proceed.

Whilst the expectation on teachers to differentiate their instruction has been increasing over the past decade, this has not always been the experience of teachers as learners (Acevedo, 2013). This was reinforced by many interviewees; *“most development that is organised is at a basic level”* (CUT02). *“Most of the time (during the professional development webinar) I was just playing with Geogebra and getting to know it myself”* (EIT01). Teachers participating in the qualitative interviews had a diversity of views relating to the sort of professional learning they felt best suited their personal learning preference. *“I would prefer to be in a small group with one or two experts floating around”* (MAT01). *“Show and tell and check. A demonstration around that and some time to practice with it”* (EIH01). *“Someone show me how to use it and then come to a lesson with me and help the students in the class with me when it is being used”* (CUT01). *“Hands on”* (CUT02). *“I would rather just do it by myself. . . using the help files . . . I often google how to do things . . . then figure it out for myself. And I learn better that way”* (EIT01). *“Learn from a peer or a more knowledgeable person generally”* (CUH01). *“Time and trial and error, you need time to develop a decent understanding of how it’s used”* (CUT03). *“I like to have the online help available or you google and you look at the videos that other people have put up. I like to explore the software myself”*

(EIH02). *“I’d probably want to do a bit of research first . . . I want to make sure I’m investing my time in learning the right thing . . . someone just to talk you through the basics and teach me some basic skills and then I go away and do some practice and maybe come back to them and maybe learn a little more”* (CUT04). *“I tend to do a lot of reading of the documentation and asking on internet communities about things I’m stuck on . . . I try and get in touch, if possible, with people who have got experience or research in this if I want to do something differently in my classroom”* (CUT05). *“Give it to me and let me play with it and then I’ll tell you what I think of it. I don’t want it presented to me, I don’t even really want someone beside me telling me how they use it and what they’ve done to be effective in the classroom. I just want it in my hands . . . then when I get stuck, I’ll put my hand up and ask a question. The ideal way that we want our kids to learn is exactly how I want to learn. I just want full autonomy”* (CUT06).

Several teachers identified the importance of ongoing professional learning through a community of learners (Searcy-Hudson, 2005). Establishing a small group of resident experts, either in pedagogy, applications of technology in the classroom, or both can bring tremendous benefit. *“I think a lot of that product development around course development is in faculties. So people working in small groups around developing things”* (EIH01). *“The most powerful thing for teacher education . . . You just get practitioners that are actually using it in front of classrooms to get up and say what’s working for them”* (EIH01). *“I targeted ICT-capable teachers as part of the pilot program and tried to make sure that I had staff from a range of different faculties as part of the program. . . 3 minute walk to another staffroom to find somebody to help you with a problem”* (CUH01). *“More profound for them to see how other people are using it and what their other colleagues’ learnings are about. More peer learning is actually, I would see as being the most effective. Conversations are probably the most powerful, just being available on a one to one level”* (EIH01). *“I put up a board and got people to post how they would use it and who they would like to use it first. . . you are going to make more headway if you have a project where staff cooperate with each other and learn from each other and feel comfortable with each other”* (CUH01). *“You are expected to actually use your*

own time to develop a deeper understanding of that through trial and error. We collaborate together as a faculty and try to figure it, so we help each other” (CUT03).

Some schools have appointed a Director of eLearning, or similar role to coordinate ICT integration, develop and or team-teach with staff and who can oversee a more consistent approach to technology across the school. However in other schools, this is either not a priority, or not within the budget and hence the incidence of peer sharing is more problematic. *“Someone who can talk you through a few things. Hard to ask other teachers because they are all frantic”* (MAT01). *“It normally falls on teachers who are more confident, just more experienced with technology integration to support their colleagues in departments”* (CUT04).

There can also be resistance from some staff to the sharing of expertise. The digital age has created a lot of questions around intellectual property, who owns the knowledge and with whom it can be reasonably shared. *“As long as that one or two, those one or two individuals are willing to actually pass on their knowledge. That quite often isn’t the case too with teachers, they tend to be a little bit protective about stuff”* (CUT03).

The third characteristic of quality professional learning to emerge was that of authentic learning. *“I think it’s really important when you are learning something to actually have a real problem to solve or something to build”* (CUH01). *“I prefer to learn on an as-needs basis. I have an objective in mind, like students need to learn this particular thing, so I envision the particular interactive site or software or something that, or simulation that’s going to help them learn that. Then I go about actually making that. And as I go I’ll cover the skills that I need to actually make it. And I won’t learn any more than I need to”* (CUT05).

There appears to be a common thread amongst the exemplary integrators here regarding the desire to use the technology first, figure out what it can do, or how it may translate into the classroom, and then consult an expert to hone their skill development. Many of the interviewees were keen to develop their own resources

and ways of approaching different tasks with technology and much of this was indicative of a high level of innovation. The time pressures remain a sub-textual theme within these responses, and it may be very beneficial for schools to appoint an eLearning coordinator or similar role to be the resident expert on technology integration, either that or to encourage a small group of faculty-based experts to roll out their experiences. Resources, particularly time, would be needed for a pragmatic solution, such as team teaching or small group sharing.

4.8.7 Plans for Future ICT Integration

The final question to interviewees was: How do you see your classes operating in five years' time? Will they be much as they are now or will they change? If so, can you describe how they might change? Whilst this question may not appear directly relevant to this study as it requires interviewee to speculate on the rapid pace of change in technology, it does indicate how individual educators feel about the direction and importance of technology and hence can inform future professional learning experiences. Such questions can reveal the thinking patterns of teachers and how deeply they are planning not only tomorrow's lessons but how they want to develop in the future. Conceptualising the future is not new in educational literature. It has also been attempted in other studies, often in the context of educational ideals; "authentic and meaningful learning, independent and cooperative learning, cross-curricular and project-based learning, fitting in with the individual needs of students" and with teachers fulfilling "a wide spectrum of roles: instructor, trainer, coach, advisor, consultant and assessor" (Volman, 2005, p. 29). For this reason, and the added advantage of gaining an insight into how far some teachers have taken technology, and how much further they might wish to go, the qualitative interviews concluded with a specific look at each teacher's future classroom. As might be expected from such an open question, the responses were varied. Increased differentiation emerged as a theme for educators from all three self-assessed categories, however a predominant theme involved an increase in collaborative learning (42% of competent users), blended or flipped classroom approaches (42% of competent users) or increased differentiation and project based learning (28% of

competent users, 66% of exemplary integrators).

The changes foreshadowed by exemplary integrators, particularly those who have responsibility for ICT integration at the whole school level reveal more transformative visions of how technology may influence future pedagogy. Perhaps, as expected, many teachers are picking up on the blended learning and flipped classroom approaches and seeking ways of assimilating this approach into their teaching practice. “Incorporating technology into project-based learning enables the students to experience how to learn with technology as an active agent in their learning” (Wang, Ke, Wu, & Hsu, 2012, p. 131). The responses to this question have been divided into three distinct categories: survival strategies, consolidation activities and transformative visions, in a similar continuum to that described earlier in the SAMR model (Lubega et al., 2014; Puentedura, 2010).

Survival strategies

Despite the earlier identified push by governments and teacher accreditation institutes for increased use of effective technology integration, several of the interviewees identified the need to just try and survive with technology. “*So many teachers don’t use computers because they are not reliable or they don’t know how to*” (EIT01). “*Well for kids, it’s not the age of information, it’s the age of entertainment*” (CUT03).

Consolidation activities

Competent users of technology tend to be focussing on levels of augmentation and modification of existing tasks in order to make the best of what technology has to offer. “*More collaborative*” (CUT01). “*New principal has put together a team . . . focus on the kids*” (CUT02). “*I’m hoping that I will see more collaboration going on in my classes. That the quality of the problem solving my kids are doing is of a higher quality than it is at the moment . . . more opportunities to choose what they focus on*” (CUH01). These sorts of observations reinforce the findings of other studies regarding the “capacity of ICT to facilitate knowledge construction and to develop other skills including problem solving and communicating” (Hilton &

Hilton, 2013, p. 158). It is “*the difference that them having a device in their hands has made*” (EIH02).

Transformative visions

Both competent users of technology and exemplary integrators can see some of the ways in which the use of technology can transform and redefine learning, encouraging greater student autonomy and problem solving, reaching beyond the boundaries of the school. Such a vision supports the creation of entirely different kinds of learning experiences for students that truly tap into the potential of technology to revolutionise teaching and learning. Transformations currently planned or desired included project based learning; “*I can see the whole project based learning and some better integrations across faculties to be a much more useful way of learning . . . it would be very useful to have more integrated, real life problems to solve*” (EIH01), open-plan classrooms; “*If we are moving towards more open-plan in terms of our classes . . . more teaching collaboration and team teaching*” (CUH01), increased collaboration; “*we are looking at video conferencing with other schools so that we can connect up with a broader range of students and teachers*” (EIH02), innovation; “*how do we educate kids in the 21st century so they are more innovative?*” (CUH01) individualised learning; “*I think the most critical point of change that I can see is that students will be fully free to learn at the level they’re at, rather than still being limited by wherever the rest of the class are at*” (CUT05) or “*I envision working mostly with students as individuals rather than as a group . . .to be able to turn to something like technology instead of relying on the only teacher in the room to be able to help them, that’s pretty powerful I think*” (CUT05) and the flipped classroom; “*I’d really like to dabble with the whole flipped classroom idea. . . the positive impact that the flipped classroom has had on results*” (CUT04).

As more data is collected on the flipped and blended learning models, peer instruction and collaborative learning, more educators are seeking ways to make these types of learning accessible to their students. “Early data suggest significant increases in student learning and achievement when flipping compared to baseline

data on the same courses taught in the traditional classroom lecture mode, using the same assessments.” (Fulton, 2012, p. 16). As the flipped learning model is relatively new in educational terms, most of the evidence supporting its benefits are anecdotal or isolated, however this is slowly changing and flipped learning strategies are becoming a focus for current and future research and application. Despite this, several teachers identified strategies they had been thinking through to bring the flipped classroom model into their classrooms. *“Me recording my own videos would be the best way, would be the most effective way to do it”* (CUT04). *“There’s stuff that I’m going to present that I know I can present very, very well and I’ll do that and I know there is stuff that is better presented by somebody else and I’ll make that resource available to the kids. It’s a mixture of the two that’s going to be the best outcome”* (CUT06). *“How to make the class time more productive is to take the lecture part, it’s interactive, but take that part out of the classroom to have that freed up for more collaborative work for kids working on homework problems, getting help when they need it instead of having to wait for the next day . . . if the screen shots from excel are no longer current, you replace them, but in a video it’s a different job”* (CUT04). *“The course I’m doing now is the flipped maths classroom and I mean, you know, I can’t see that not being the future”* (CUT06). *“Any of the presentation of information, lecture-style stuff is going to move to being at home and then the classroom is going to open up into much more of a tute room where we work on questions that kids are getting stuck on. In 5 years time, I would see my classroom being completely flipped”* (CUT06). However, as with any new educational use of technology, there were warnings too about the nature and volume of empirical evidence that supports and improves learning outcomes with technology integration. *“How can we use technology to its best effect is better substantiated by better evidence than I think exists in some areas at the moment”* (CUH01). Perhaps one of the ways of addressing this void in the literature is for schools to start generating some of their own research; *“increase the amount of action research and sharing that with their colleagues”* (CUH01).

It is difficult to make generalisations about how successfully different individuals can read the future and adapt to assimilate the changes which will, inevitably, occur.

It does seem evident that exemplary integrators and especially those with a specified eLearning role in their schools have been thinking a lot about how their future school will operate and what role technology will play. It seems a sensible conclusion to suggest that exemplary integrators are seeking ways of increasing their effectiveness with technology, always looking to expand their range of strategies and incorporate some of the new ideas being reported in national and international studies. This is another important consideration for the planners of effective professional learning.

4.9 Correlation of predictive factors against self-assessment category

To address research questions one and two, the data was analysed to examine whether relationships existed between the teachers' self-assessed level of technology integration and their level of computer use (assessed using the LCU) against their personal self-efficacy (SE), outcome expectancy (OE) (assessed using the MUTEBI, according to Enochs, Riggs and Ellis (1993)) and the types of usage teachers made of technology, either themselves (teacher activities, TA) or with their students (student activities, SA). The last two statistics were derived from the data in Table 20 on page 175; an explanation of these variables may be found in section 4.6, earlier in this chapter.

4.9.1 Relationships between technology integration level and predictive variables for all data

Descriptive statistics for several variables were prepared using SPSS software. Technology integration self-assessment category was converted to a numerical scale with technophobe = 1, minimum adopter = 2, competent user = 3 and exemplary integrator = 4. Table 24 on the following page shows descriptive statistics and correlation coefficients for self-assessed integration category (TI), level of computer use (LCU), outcome expectancy (OE), personal self-efficacy (SE), student activities (SA) and teacher activities (TA) as discussed in section 4.6.3 on page 176. A Pearson correlation coefficient, based on a bivariate analysis for six factors, was conducted using SPSS v.23. The results are also displayed in Table 24.

Table 24

Correlation Coefficients based on TI and LCU.

Variable	Mean	Std. Dev.	Correlation with SA	Correlation with LCU
TI	3.26	0.55		
LCU	6.45	1.76	0.26*	
OE	20.96	4.58	0.12	0.24*
SE	59.52	6.93	0.54**	0.42**
SA	26.72	7.69	0.24*	0.22*
TA	28.59	6.61	0.44**	0.41**

N = 79
 *. Correlation is significant at the 0.05 level (1-tailed).
 **. Correlation is significant at the 0.01 level (1-tailed).

The teachers' level of computer use (LCU) was statistically significant and positively related to personal self-efficacy (SE) ($r = 0.42, p < 0.001$), outcome expectancy (OE) ($r = 0.24, p < 0.05$), teacher activities (TA) ($r = 0.41, p < 0.001$) and student activities (SA) ($r = 0.22, p < 0.05$). There was also statistically significant and positive relationships between teachers' self-assessment of computer integration (TI) to personal self-efficacy (SE) ($r = 0.54, p < 0.001$), level of computer use (LCU) ($r = 0.26, p = 0.005$), student activities (SA) ($r = 0.24, p = 0.03$) and teacher activities (TA) ($r = 0.44, p < 0.001$).

A separate multivariate ANOVA was conducted to determine whether teachers who are exemplary integrators of technology differ to non-exemplary integrators in terms of their level of computer use, outcome expectancy, personal self-efficacy, student usage score and teacher usage score. This produced a Box's test of equality of covariance $p = 0.05$. The Box test examines a null hypothesis that observed covariance of the dependent variables, itemised above, are equal across ICT integration groups. The result of the Box's test is suggestive of a degree of heterogeneity in the sample, probably due to the small number of self-assessed minimum adopters in the survey. The Wilks' Lambda test statistic was significant $F(10,136) = 4.97, p < 0.001$. This would indicate a significant effect of self-assessed level of integration on all dependent variables.

The Test of between-subject effects is shown in Table 25 below. This shows a level of significance between self-assessed integration groups for the dependent variables; level of computer use (LCU) $F(2,72) = 5.95, p = 0.004$, personal self-efficacy (SE) $F(2,72) = 24.23, p < 0.001$ and teacher activities (TA) $F(2,72) = 8.62, p < 0.001$.

The Pearson correlation coefficient test was also performed on each school culture represented in the study, where numbers were sufficiently high. This statistic was used to inform research question one about the degree to which identified enablers apply across schools of differing cultures. These statistics have been summarised in Table 26 below.

Table 25

Effects of self-assessed integration category with 5 dependent variables

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F
Corrected model for between category effects	LCU	32.44	2	16.22	5.95*
	OE	35.78	2	17.89	0.84
	SE	1574.08	2	787.04	24.23**
	SA	303.85	2	151.92	2.77
	TA	630.01	2	315.00	8.62**

Degrees of freedom = 2 and 72
 * significant at 0.005 level, ** significant at 0.001 level

Table 26

Correlation for LCU, OE, SE, TA and SA against TI by cultural group

		LCU	OE	SE	SA	TA
ATSI	Pearson Correlation	0.28	0.49*	0.60**	0.12	0.47*
JH	Pearson Correlation	-0.33	0.20	0.97*	-0.36	0.52
AH	Pearson Correlation	0.38	0.16	0.58*	0.11	0.16
EH	Pearson Correlation	0.14	0.04	0.41**	0.26	0.32

*. Correlation is significant at the 0.05 level (1-tailed).
 **. Correlation is significant at the 0.01 level (1-tailed).

For teachers identifying their schools in the demographic component of the online study, see Table 5 on page 146, as predominantly Aboriginal and Torres Strait Islander (ATSI) culture and heritage (N = 20), there was a statistically significant and positive relationship between self-assessment of technology integration level (TI) and outcome expectancy (OE) ($r = 0.49, p = 0.02$), personal self-efficacy (SE) ($r = 0.60, p = 0.005$) and teacher activities (TA) ($r = 0.47, p = 0.05$). There was no significant correlation between teachers' self-assessment and the level of computer use, nor student activities. Only four teachers identified their schools as predominantly Jewish (JH) culture and heritage. This small sample size affects the level of confidence placed in the correlation shown in Table 26 above. For teachers identifying their schools as predominantly Australian culture and heritage (AH) (N = 18), there was high positive correlation between self-assessment of technology integration level (TI) and personal self-efficacy (SE) ($r = 0.58, p=0.02$). For teachers identifying their schools as equally representing all cultures and heritage (EH) (N = 48), there was high positive correlation between self-categorised assessment of technology integration (TI) and personal self-efficacy (SE) ($r = 0.41, p = 0.005$). Only two teachers identified their school as Islamic culture and heritage, one as Catholic culture and heritage and one as 'other'. These samples were too small to analyse statistically. What emerged from this analysis is that the correlation between self-assessed category of technology integration and personal self-efficacy existed independent of the culture or heritage of the school. The higher the self-assessment rating, ie the more likely a teacher is to self-assess as an exemplary integrator of technology, the higher their personal self-efficacy regarding computers. It seems reasonable to conclude that at least the factor of high personal self-efficacy is common to exemplary integrators of technology independent of the culture of the school in which they work.

4.9.2 Evaluating other potential explanatory variables

SPSS software v.23 was used to determine the reliability of the data and its significance in predicting factors which may influence exemplary ICT integration. A Pearson correlation coefficient was calculated for the relationship between self-

assessed personal use and self-assessed professional use of technology. Participants show a high degree of correlation between self-assessed personal use (PerU – 0.50) and self-assessed professional use (ProU – 0.67) of technology, as shown in Table 27 below. This degree of significance holds for the relationship between Teaching Experience (TE) and professional computer use. It is likewise statistically significant at the 0.05 level for teaching experience and personal computer use. This confirms that more experienced teachers have been using technology for a longer period of time in both their personal and professional lives, which is what would be expected intrinsically. This is further emphasised by the high proportion of time spent accessing the internet from either home or school/work in Table 16 on page 156.

Table 27

Correlation between Computer Use and Teaching Experience

	ProU	TE
PerU	0.50**	0.17*
ProU	1	0.67**

N = 95
 *. Correlation is significant at the 0.05 level (1-tailed).
 **. Correlation is significant at the 0.01 level (1-tailed).

To further explore these relationships, a Pearson correlation coefficient was calculated between the following variables: Self-assessment of technology integration (TI), level of computer use (LCU), personal self-efficacy (SE), Sex (Sex), teaching experience (TE), personal ICT use (PerU), professional ICT use (ProU), and teaching/instruction hours (TH). This data was collected from the online survey and a description can be found in Chapter Three and in sections 4.2 and 4.3 above. The results of these calculations are displayed in Table 28 on the following page.

Other than those variables already identified earlier, the only other significant relationship existed between the level of computer use (LCU) and the number of teaching/instruction hours, which were highly positively correlated ($r = 0.30$, $p < 0.005$). This triangulation exercise confirms that participants who are identifying themselves as highly reliant users of technology on the LCU scale are also indicating high levels of use of technology for teaching and instruction.

Table 28

Pearson correlation coefficients for potential predictive variables

	Sex	TE	PerU	ProU	TH
TI	0.05	-0.12	0.15	0.07	0.20*
LCU	-0.08	0.00	0.04	0.07	0.30**
SE	-0.03	-0.06	0.38**	0.15	0.26**
Sex	1	0.12	0.24**	0.17	-0.27**
TE		1	0.17*	0.67**	-0.15
PerU			1	0.50**	-0.10
ProU				1	-0.12

N = 95
 *. Correlation is significant at the 0.05 level (1-tailed).
 **. Correlation is significant at the 0.01 level (1-tailed).

Teaching experience is highly positively correlated with professional use ($r = 0.67$, $p < 0.001$), however this may reflect the increase in many of the administrative tasks of a teacher now being completed with computer technology. Sex also demonstrated statistical significance across several factors, where males were more likely to have a higher personal ICT use ($r = 0.24$, $p < 0.01$) and females were more likely to use technology for teaching or instruction ($r = -0.27$, $p < 0.005$), suggestive of the notion that more male teachers are using computers for personal reasons rather than in their classrooms for teaching and learning. The reverse is true for females, with female participants more likely to be using the computer in their classroom for teaching or instruction and less likely to be using it for personal reasons. There is also a highly positive correlation between personal computer use and professional computer use ($r = 0.50$, $p < 0.001$), which again is unsurprising and suggestive that participants who identified a higher level of technology usage, did so across a number of different parameters (for example, level of computer use, self-assessment of technology integration, personal ICT use, professional ICT use, teaching/instruction hours, etc).

On the basis of these results, a multivariate ANOVA was carried out using the self-assessed technology integration category as the independent variable and sex, teaching experience, personal ICT use, professional ICT use and teaching/instruction

hours as the dependent variables. Despite passing the Box test for homogeneity ($p > 0.05$), none of these variables demonstrated a significant relationship at the 95% confidence level. On the basis of these results, there was no significant effect for self-assessed technology integration level for these four variables. As an aside, when this test was repeated using sex as the independent variable, there was a significant difference between groups for personal ICT use; $F(1,92) = 6.83, p = 0.01$, confirming that male teachers are more likely to report using ICT for personal use than female teachers.

4.9.3 Predictive effect of the type of computer-based activity on integration level

Two additional Pearson correlation tests were carried out on self-assessment technology integration (TI), level of computer use (LCU) and personal self-efficacy (SE) against different types of computer activities, by the students (SA) and by the teacher (TA). The codes used are shown in Table 29 on the following page. This information was used to determine whether exemplary integrators favoured one type of activity over another, both for their own personal use and when in the classroom for their students' use.

As described in section 4.6.3, each category was given a numerical value as follows: daily = 6, more than once a week = 5, weekly = 4, every two weeks = 3, once or twice a month = 2 and less often = 1. A larger mean is indicative of more frequent usage of that particular activity either for teacher use or for student use.

The statistical tests carried out in this section were designed to address research question three. From the descriptive statistics, the most common activities for teachers, as shown in Table 30 on the following page, were communication ($\bar{x} = 5.89$) and information retrieval ($\bar{x} = 5.69$), with simulations and educational games ($\bar{x} = 2.99$) and drill and practice activities ($\bar{x} = 2.57$) the least common amongst teachers, as can be seen from their respective mean values.

The results of the Pearson correlation analysis indicates that there is a statistically significant relationship between teacher self-assessed technology integration and imaging ($r = 0.31, p = 0.002$), publishing ($r = 0.36, p < 0.001$) and data logging and

analysis ($r = 0.26, p = 0.007$) as shown in Table 31 on the following page.

Table 29

Codes for teaching and learning activities

Activity	Code
Simulation & Ed Games – Students	SS
Simulation & Ed Games – Personal	ST
Imaging – Students	IS
Imaging – Personal	IT
Communication – Students	CS
Communication – Personal	CT
Publishing – Students	PS
Publishing – Personal	PT
Drill & Practice – Students	DS
Drill & Practice – Personal	DT
Information Retrieval – Students	RS
Information Retrieval – Personal	RT
DataLog and Analysis – Students	AS
DataLog and Analysis – Personal	AT

Table 30

Descriptive Statistics for Self-Assessment and Teacher Activity

	Mean	Std. Dev.	N
Self-Assessed Integration Category	3.26	0.55	96
Simulation & Ed Games – Personal	2.99	1.75	89
Imaging – Personal	4.12	1.92	84
Communication – Personal	5.89	0.50	93
Publishing – Personal	4.29	1.76	90
Drill & Practice – Personal	2.57	1.96	86
Information Retrieval – Personal	5.69	0.84	91
DataLog and Analysis – Personal	3.10	1.86	87

These results suggest that the more exemplary the integrator of technology, the more

likely they would be to use the technology for imaging, publishing and data logging and analysis. To determine whether this was the case, a multivariate ANOVA was carried out with the data using self-assessed technology integration as the independent variable and the listed activities as dependent variables. Differences were found between these groups for imaging ($F(2,76) = 5.12, p = 0.008$) and publishing ($F(2,76) = 6.09, p = 0.004$) at the 0.01 level and for drill and practice ($F(2,76) = 3.20, p = 0.046$) and data logging and analysis ($F(2,76) = 4.41, p = 0.015$) at the 0.05 significance level as shown in Table 32 below.

Table 31

Correlation between Self-Assessment of Technology Integration and Teacher Activity

		ST	IT	CT	PT	DT	RT	AT
TI	Pearson Corr.	0.18*	0.31**	0.15	0.36**	0.25*	0.14	0.26**
LCU	Pearson Corr.	0.15	0.30**	0.19*	0.23*	0.24*	0.25**	0.15
SE	Pearson Corr.	0.02	0.35**	0.14	0.30**	0.21*	0.22*	0.44**

N = 95

** . Correlation is significant at the 0.01 level (1-tailed).

* . Correlation is significant at the 0.05 level (1-tailed).

Table 32

Effects of self-assessed technology integration on teacher activities

Tests of Between-Subjects Effects			
Dependent Variable	Type III Sum of Squares	Mean Square	F
Simulation & Ed Games	8.13	4.07	1.32
Imaging	33.55	16.77	5.12**
Communication	0.43	0.22	0.88
Publishing	34.78	17.39	6.09**
Drill & Practice	24.00	12.00	3.20*
Information Retrieval	3.05	1.52	1.98
DataLog and Analysis	28.25	14.12	4.41*

Degrees of freedom = 2, 76

** . Correlation is significant at the 0.01 level (1-tailed).

* . Correlation is significant at the 0.05 level (1-tailed).

From these results it can be concluded that exemplary integrators of technology are

more likely to be using computers for creating images and publishing documents and to a lesser extent, checking drill and practice activities and gathering and analysing data from data logging technologies.

A similar analysis was also performed on the self-reported frequencies for each of the same activities being undertaken by students. From the descriptive statistics, shown in Table 33 below, the most common activities required of students were communication ($\bar{x} = 5.05$) and information retrieval ($\bar{x} = 5.12$), with publishing ($\bar{x} = 3.21$) and data logging activities ($\bar{x} = 2.03$) being the least commonly allocated student activities, as can be seen from their respective mean values.

The results of the Pearson correlation analysis indicates that there is a statistically significant relationship between teacher self-assessed technology integration and student publishing ($r = 0.286, p < 0.003$), drill and practice ($r = 0.249, p = 0.008$) and data logging and analysis ($r = 0.294, p = 0.003$) as shown in Table 34 on the following page. In order to further investigate whether any relationship actually exists, a multivariate ANOVA was carried out with the data using self-assessed technology integration as the independent variable and the listed activities for students as dependent variables.

Table 33

Descriptive Statistics for Self-Assessment of Technology Integration and Student Activity

	Mean	Std. Dev.	N
Self-Assessed Integration Category	3.26	0.55	96
Simulation & Ed Games - Students	3.86	1.76	92
Imaging - Students	3.77	2.03	87
Communication - Students	5.05	1.61	95
Publishing – Students	3.21	1.75	91
Drill & Practice – Students	3.47	1.80	93
Information Retrieval – Students	5.12	1.50	93
DataLog and Analysis – Students	2.03	1.33	88

The Box's test of equality provided confidence in the homogeneity of the data despite differences in group sizes. Differences were found between these groups for data logging and analysis ($F(2,79) = 4.97, p = 0.009$) at the 0.01 level and for publishing ($F(2,79) = 4.71, p = 0.012$) and drill and practice activities ($F(2,79) = 3.58, p = 0.032$) at the 0.05 significance level as shown in Table 35 below.

Table 34

Correlation between Self-Assessment of Technology Integration and Student Activity

		SS	IS	CS	PS	DS	RS	AS
TI	Pearson Corr.	-0.01	0.09	0.09	0.29**	0.25**	0.16	0.29**
LCU	Pearson Corr.	-0.06	0.12	0.06	0.12	0.18*	0.20*	0.21*
SE	Pearson Corr.	-0.08	0.07	0.04	0.19*	0.27**	0.13	0.35**

N = 95

** . Correlation is significant at the 0.01 level (1-tailed).

* . Correlation is significant at the 0.05 level (1-tailed).

These results suggest that exemplary ICT integrators were more likely to provide opportunities for autonomous and creative student usage of technology such as publishing and data logging and analysis, as well as, drill and practice activities.

Table 35

Between group effects for student activities with technology

Tests of Between-Subjects Effects			
Dependent Variable	Type III Sum of Squares	Mean Square	F
Simulation & Ed Games	12.49	6.25	1.96
Imaging	11.70	5.85	1.41
Communication	0.78	0.39	0.15
Publishing	26.30	13.15	4.71*
Drill & Practice	21.80	10.90	3.58*
Information Retrieval	5.24	2.62	1.20
DataLog and Analysis	16.38	8.19	4.97**

Degrees of freedom = 2, 79

** . Correlation is significant at the 0.01 level (1-tailed).

* . Correlation is significant at the 0.05 level (1-tailed).

In summary, exemplary teachers were more likely to prepare rich lessons through the

use of personal images as well as published technology products. They were also more likely to provide students with opportunities to collect and analyse data and publish their work.

4.9.4 Identifying predictive variables for exemplary integrators

Several patterns emerged when the data were analysed using Pearson correlation calculations. However in order to address research question two and each of its parts 2a to 2f, it is necessary to identify the specific predictive factors which are most likely to define or preselect a teacher to be an exemplary integrator of technology. To achieve this, multiple regression analyses were carried out using SPSS v.23 software to determine the degree of association between four dependent variables: teacher self-assessment of technology integration (TI), level of computer use (LCU), frequency of teacher activities involving technology (TA) and frequency of student activities involving technology (SA) and potentially eight independent variables; personal self-efficacy (SE), outcome expectancy (OE), frequency of teacher activities involving technology (TA), frequency of student activities involving technology (SA), sex, teaching experience (TE), personal computer use (PerU) and professional computer use (ProU).

A linear regression was carried out using SPSS which involved the stepwise method to exclude individual potential predictor variables sequentially from the analyses in order to isolate the most significant predictor variables. The stepwise method produced two models. In the first model, the eight explanatory variables above were chosen to determine the degree of association with the dependent variable 'Teacher's Self-assessment of Technology Integration', with the second model providing an adjusted R^2 value of 0.35 which was statistically significant, $F(2,69) = 20.288, p < 0.001$. Several additional models were analysed through sequential subtraction to identify whether there was a model which could explain more of the variance, however the second model proved to be the best one with the available data. Using the second model, the explanatory variables jointly accounted for over 35% of the variance in the teacher's level of technology integration efficacy.

Table 36 below shows the standardised regression coefficients (Beta), the t-scores and the level of significance. Two of the eight variables were highly significant contributors to explaining the variance between groups; personal self-efficacy and frequency of teacher activities involving technology. This can be interpreted to suggest that teachers were more likely to identify themselves nearer the exemplary integrator end of the technology integration scale as their personal self-efficacy ($p < 0.001$) and their frequency of usage of different applications involving technology ($p < 0.024$) increased.

In the second model, the same eight explanatory variables (personal self-efficacy, outcome expectancy, teacher activities, student activities, sex, teaching experience, personal computer use and professional computer use) were chosen to determine the degree of association with the dependent variable; level of computer use (LCU). The stepwise method again produced two models with the second model providing an adjusted R^2 value of 0.20 which was statistically significant, $F(2,69) = 9.837, p < 0.001$. Hence the explanatory variables jointly accounted for almost 20% of the teacher's level of computer use.

Table 36

Stepwise Regression Analysis Summary for Self-assessment of Technology

Integration

Model		Standardised Coefficients	t
		Beta	
1	(Constant)		1.11
	SE	0.57	5.77***
2	(Constant)		0.83
	SE	0.47	4.53***
	TA	0.24	2.30*

***. t score is significant at the 0.005 level.
*. t score is significant at the 0.05 level.

Table 37 on the following page shows the standardised regression coefficients (Beta), the t-scores and the levels of significance. The same two of the eight variables were significant; personal self-efficacy and teacher activity. This can be

interpreted to suggest that as a teacher's personal self-efficacy ($p < 0.013$) and the teacher's frequency of usage of different applications involving technology ($p < 0.024$) increased, so they were more likely to report a high level of computer use.

Table 37

Stepwise Regression Analysis Summary for Level of Computer Use

Model	Standardised Coefficients		t
		Beta	
1	(Constant)		0.29
	SE	0.40	3.68***
2	(Constant)		-0.01
	SE	0.30	2.56**
	TA	0.27	2.30*

***. t score is significant at the 0.005 level.
 **. t score is significant at the 0.01 level.
 *. t score is significant at the 0.05 level.

This confirms the previous result, increases confidence in the self-assessment of technology integration statistic and, by implication, suggests that teachers who report a high LCU are more likely to be an exemplary integrator of technology in the classroom.

In the third model, eight explanatory variables were chosen to determine the degree of association with the dependent variable 'Student Activities'. The stepwise method again produced two models with the second model providing an adjusted R^2 value of 0.345 which was statistically significant, $F(2,69) = 19.684$, $p < 0.001$. Hence the explanatory variables jointly accounted for over 34% of the student activity. Table 38 on the following page shows the standardised regression coefficients (Beta), the t-scores and levels of significance. Two of the eight variables were significant; teacher activities and teaching experience.

This can be interpreted to suggest that as a teacher's frequency of usage of different applications involving technology ($p < 0.001$) and the teacher's experience ($p < 0.019$) increased, so they were more likely to increase the frequency of their students

undertaking activities involving technology. This is consistent with some other studies (S. Hsu, 2011), although not all. The findings of Mueller et al., (2008) suggested “that teachers at all stages of their career were equally able to integrate computer technology (Mueller et al., 2008, p. 1533)”.

Table 38

Stepwise Regression Analysis Summary for Student Activities

Model	Standardised Coefficients		t
		Beta	
1	(Constant)		2.39*
	TA	0.56	5.61***
2	(Constant)		1.05
	TA	0.56	5.86***
	TE	0.23	2.39*

***. t score is significant at the 0.005 level.
 **. t score is significant at the 0.01 level.
 *. t score is significant at the 0.05 level.

Further research may shed greater clarity on this relationship, although it may have more to do with the types of activities being integrated and the relationship with classroom management and experience in pedagogy. This, however, is beyond the scope of this study. In the final model, the eight explanatory variables were chosen to determine the degree of association with the dependent variable ‘Teacher Activities’. The stepwise method again produced two models with the second model providing an adjusted R^2 value of 0.379 which was statistically significant, $F(2,69) = 22.629, p < 0.001$. Hence the explanatory variables jointly accounted for almost 38% of the teacher activity. Table 39 on the following page shows the standardised regression coefficients (Beta), the t-scores and levels of significance.

Two of the eight variables were again significant; student activities and personal self-efficacy. This can be interpreted to suggest that as the students’ frequency of usage of different applications involving technology ($p < 0.001$) and the teacher’s personal self-efficacy ($p < 0.003$) increased, so they were more likely to reflect an increase in the frequency of their own activities involving technology.

Table 39

Stepwise Regression Analysis Summary for Teacher Activities

Model		Standardised Coefficients Beta	t
1	(Constant)		6.71***
	SA	0.56	5.61***
2	(Constant)		0.16
	SA	0.50	5.21***
	SE	0.30	3.13***

***. t score is significant at the 0.005 level.

4.10 Testing for common enablers of exemplary integrators

In order to determine whether there are differences between groups on the basis of self-assessed technology integration, a one way ANOVA was performed using Self-Assessment of Technology Integration (TI) as the factor variable, with a comparison of means using the dependent variables; personal self-efficacy (SE), student activities (SA), teacher activities (TA), outcome expectancy (OE), teaching experience (TE), formal PD (fPD) and informal PD (iPD). The purpose of the analyses undertaken in this section is to address the specific qualities or characteristics of exemplary integrators of technology and how they might differ from other users of technology as per research question two, in order to inform research question three. In addition to the investigation into the enablers of exemplary technology integration as per research question one, the data was sufficiently rich to enable testing of null hypotheses across some culture, sex and main subject taught as additional categories to address research question two. These tests provided some conclusions based on factors which are common to exemplary integrators of technology.

A series of null hypotheses were proposed for testing. The null hypotheses were that there would be no differences between group means; in this case, no differences between the means for b) A minimal adopters (MA), c) technologically competent (TC) and d) an exemplary integrators (EI) for each of the variables tested. As no participant self-assessed as technophobe, this category was excluded from the

analyses. Null hypotheses are as follows:

1. H_0 (SE): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
2. H_0 (student activity): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
3. H_0 (teacher activity): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
4. H_0 (OE): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
5. H_0 (teaching experience): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
6. H_0 (formal PD): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
7. H_0 (Informal PD): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$

A Tukey test carried out post-hoc on the data could have been impacted by significant differences in group sizes between groups. However some confirmation patterns emerged as seen in Table 40 on the following page.

Differences between groups were significant for personal self-efficacy, $F(2,88) = 23.964, p < 0.001$ and teacher activity, $F(2,86) = 9.432, p < 0.001$. The conclusion is that exemplary integrators are more likely to score higher on the personal self-efficacy scale and spend more time on technology-facilitated activities than technologically competent teachers or minimum adopters. Hence null hypotheses 1 and 3 were rejected.

Table 40 revealed other individual patterns worthy of comment. While the difference between the means of the technologically competent and exemplary indicators was not significant at the 0.05 level for student activity, a 95% confidence interval was quite wide and included 0 at the lower end. With a $p = 0.06$ this is still an important result.

It is worth noting that mean formal professional development hours for technologically competent users are much higher than those for exemplary integrators and this pattern is reversed for the means or informal professional development hours. However, neither of these difference are statistically significant, and hence there are no grounds for rejecting the null hypotheses on this data.

Table 40

Between group differences for experience, activities and training

Dependent Variable	(I) Self-Assess	(J) Self-Assess	Mean Diff. (I-J)
SE	EI	MA	18.33**
	TC	MA	13.77**
	EI	TC	4.57**
SA	EI	MA	4.76
	TC	MA	0.58
	EI	TC	4.18
TA	EI	MA	10.91**
	TC	MA	6.16
	EI	TC	4.75**
OE	EI	MA	3.07
	TC	MA	2.52
	EI	TC	0.55
TE	EI	MA	0.23
	TC	MA	0.46
	EI	TC	-0.70
fPD	EI	MA	40.67
	TC	MA	83.01
	EI	TC	-42.34
iPD	EI	MA	92.66
	TC	MA	51.91
	EI	TC	40.74

** . Significant at the 0.01 level. * . Significant at the 0.05 level.

4.10.1 Differences between groups based on school culture and heritage

A similar ANOVA test was carried out within identified school cultures. Several groups could not be included due to insufficient sample size, however two groups were larger enough to provide an analysis.

For schools identified as Aboriginal and Torres Strait Islander culture, there were two minimum adopters, 13 technologically competent and six exemplary integrators. Null hypotheses tested within this cultural focus were as above:

1. H_0 (SE): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
2. H_0 (student activity): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
3. H_0 (teacher activity): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$

4. H_0 (OE): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
5. H_0 (teaching experience): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
6. H_0 (formal PD): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
7. H_0 (Informal PD): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$

Significant differences between group means were identified for personal self-efficacy $F(2,17) = 7.04, p = 0.01$, and outcome expectancy, $F(2, 18) = 4.05, p = 0.04$. Null hypotheses 1 and 4 were rejected. A classical eta-squared statistic was also calculated for each group. “Classical eta-squared is defined as the proportion of total variation attributable to the factor, and it ranges in value from 0 to 1” (Pierce, Block, & Aguinis, 2004). Using the data in the ANOVA summary table, the classical eta-squared statistic was computed using the following equation:

$$\eta^2 = SS_{\text{factor}}/SS_{\text{total}},$$

where SS_{factor} is the variation attributable to the specific factor listed (Self-assessment of Technology Integration (TI)) and SS_{total} is the total variation within that group. This statistic was calculated for each dependent variable (personal self-efficacy (SE), student activity (SA), teacher activity (TA), outcome expectancy (OE), teaching experience (TE), formal professional development (fPD) and informal professional development (iPD). It was found that a large proportion of the variance in personal self-efficacy (45%) and outcome expectancy (31%) is accounted for by the self-assessed ICT integration factor. This suggests that exemplary teachers in Aboriginal and Torres Strait Islander Schools are more likely to have a higher personal self-efficacy and outcome expectancy scores. The results of this analysis as well as the means and standard deviations are shown in Table 41 on the following page.

A multivariate ANOVA was conducted with self-assessed technology integration as the independent variable and the same seven factors as dependent variables with a similar outcome. Personal self-efficacy; $F(2,15) = 6.34, p = 0.01$ and outcome expectancy; $F(2,15) = 3.97, p = 0.04$ were the only factors found to be statistically significant at the 95% confidence interval.

Table 41

Between group differences for schools with a focus on ATSI Culture

		Mean	SD		df	F	Eta squ.
Personal self-efficacy	MA	42.50	0.71	Between Gps	2	7.04**	0.45
	CU	58.67	6.34	Within Gps	17		
	EI	63.17	8.16	Total	19		
Student Activity	MA	20.00	12.73	Between Gps	2	0.18	0.02
	CU	23.45	7.42	Within Gps	16		
	EI	24.17	10.02	Total	18		
Teacher Activity	MA	18.00	1.41	Between Gps	2	2.33	0.24
	CU	26.10	6.98	Within Gps	15		
	EI	30.50	8.19	Total	17		
Outcome Expectancy	MA	20.00	7.07	Between Gps	2	4.05*	0.31
	CU	20.23	4.30	Within Gps	18		
	EI	26.50	4.59	Total	20		
Teaching Experience	MA	4.00	4.24	Between Gps	2	1.53	0.15
	CU	4.69	2.14	Within Gps	18		
	EI	2.83	1.47	Total	20		
Formal PD	MA	0.00	-	Between Gps	2	1.13	0.14
	CU	6.73	6.89	Within Gps	14		
	EI	14.00	16.73	Total	16		
Informal PD	MA	4.00	2.83	Between Gps	2	2.31	0.20
	CU	19.77	27.04	Within Gps	18		
	EI	63.33	74.48	Total	20		

N = 21

** . Significant at the 0.01 level. * . Significant at the 0.05 level.

There were only four teachers from schools with a Jewish culture and heritage who completed sufficient questions for analysis. One of these self-assessed as

technologically competent and three as exemplary integrators. The sample was too small for an analysis. There were only two teachers from schools with an Islamic culture and heritage who completed sufficient questions for analysis. One of these self-assessed as technologically competent and another as an exemplary integrator. The sample was too small for an analysis.

Eighteen teachers from schools with a nominated Australian culture and heritage completed sufficient questions for analysis. One of these self-assessed as a minimum adopter, 16 as technologically competent and another as an exemplary integrator.

The sample was too small for a meaningful analysis. However a multivariate ANOVA carried out as a component of the previous analysis demonstrated a statistically significant result for the relationship between exemplary technology integration and high personal self-efficacy; $F(2,10) = 8.40, p = 0.007$.

Forty five teachers from schools which identified all cultures and heritages as equally represented completed sufficient questions for analysis. One of these self-assessed as a minimum adopter, 28 as technologically competent and 19 as exemplary integrators.

The following null hypotheses were tested:

1. H_0 (PE): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
2. H_0 (student activity): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
3. H_0 (teacher activity): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
4. H_0 (OE): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
5. H_0 (teaching experience): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
6. H_0 (formal PD): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
7. H_0 (Informal PD): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$

Significant differences between group means were identified for personal self-efficacy ($F(2,42) = 4.42, p = 0.02$). The results of this analysis along with descriptive data are shown in Table 42 on the following page.

Table 42

Between group differences for schools with equal focus on different cultures

		Mean	SD		df	F	Eta squared
Personal self-efficacy	MA	50.00	-	Between Gps	2	4.42*	0.17
	CU	58.48	6.93	Within Gps	42		
	EI	63.00	4.70	Total	44		
Student Activity	MA	34.00	-	Between Gps	2	2.90	0.14
	CU	25.96	8.26	Within Gps	37		
	EI	31.19	4.93	Total	39		
Teacher Activity	MA	28.00	-	Between Gps	2	2.13	0.11
	CU	28.20	7.16	Within Gps	34		
	EI	32.19	3.51	Total	36		
Outcome Expectancy	MA	16.00	-	Between Gps	2	0.37	0.02
	CU	20.19	4.97	Within Gps	44		
	EI	20.05	4.50	Total	46		
Teaching Experience	MA	6.00	-	Between Gps	2	0.52	0.02
	CU	5.54	1.95	Within Gps	45		
	EI	5.00	1.76	Total	47		
Formal PD	MA	10.00	-	Between Gps	2	0.25	0.01
	CU	170.4	781	Within Gps	43		
	EI	47.84	80.4	Total	45		
Informal PD	MA	30.00	-	Between Gps	2	0.04	0.00
	CU	108.9	389	Within Gps	42		
	EI	123.9	273	Total	44		

N = 45

** Significant at the 0.01 level. * Significant at the 0.05 level.

An ANOVA was conducted on participants separated on the basis of sex. The analysis was carried out with one factor; teacher self-assessment of technology integration (TI) with a comparison of means using five dependent variables; level of computer use (LCU), student activity (SA), teacher activity (TA), outcome expectancy (OE) and personal self-efficacy (SE). Null hypothesis 1 was rejected.

These analyses suggest that exemplary teachers in schools emphasising cultural equality are more likely to have a higher personal self-efficacy score. A calculation of the eta-squared statistic showed that 17% of the variation in personal self-efficacy for teachers in these schools can be accounted for by the level of self-assessed technology integration.

In summary there is a consistent pattern across different cultural groups in terms of the relationship between high personal self-efficacy and a high level of self-assessed technology integration in secondary classrooms. Small sample sizes have potentially reduced the generalisability of these results.

4.10.2 Differences between groups based on sex

An ANOVA was conducted on participants separated on the basis of sex/gender. The analysis was carried out with one factor; teacher self-assessment of technology integration (TI) with a comparison of means using five dependent variables; level of computer use (LCU), student activity (SA), teacher activity (TA), outcome expectancy (OE) and personal self-efficacy (SE).

The null hypotheses were that there would be no differences between the means for b) a minimal adopter, c) technologically competent and d) an exemplary integrator in each of the variables tested, ie:

1. H_0 (level of computer use): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
2. H_0 (student activity): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
3. H_0 (teacher activity): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
4. H_0 (OE): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
5. H_0 (SE): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$

A Tukey test carried out post-hoc on the data could have been impacted by significant differences in group sizes between groups. However some confirmation patterns emerged as seen in Table 43 on the following page.

Significant differences between group means were identified for personal self-efficacy $F(2,45) = 9.79, p < 0.001$. Null hypothesis 5 was rejected. This suggests that female exemplary ICT integrators are more likely to have a higher personal self-efficacy scores than females who are minimal adopters or technologically competent. All other null hypotheses were accepted based on these results.

Significant differences between group means were identified for personal self-efficacy $F(2,40) = 13.71, p < 0.001$, teacher activity $F(2, 37) = 6.88, p = 0.003$ and

Level of Computer Use, $F(2, 42) = 3.78, p = 0.03$. Null hypotheses 1, 3 and 5 were rejected. This suggests that male exemplary ICT integrators are more likely to have a higher personal self-efficacy scores, higher level of computer use scores and higher personal activity involving technology than males who are minimal adopters or technologically competent. Null hypotheses 2 and 4 were accepted based on these results.

Table 43

Between group differences for key enablers for female and male participants

Dependent Variable	(I) Self-Assess	(J) Self-Assess	Female	Male
			Mean Diff. (I-J)	Mean Diff. (I-J)
Level of Computer Use	EI	MA	2.36	2.88*
	TC	MA	2.09	2.23
	EI	TC	0.27	0.64
Student Activities	EI	MA	6.73	3.52
	TC	MA	2.50	-0.54
	EI	TC	4.23	4.07
Teacher Activities	EI	MA	7.88	13.12*
	TC	MA	3.13	8.46
	EI	TC	4.76	4.66
Outcome Expectancy	EI	MA	-0.86	6.06
	TC	MA	-0.50	5.12
	EI	TC	-0.36	0.95
Personal Self-efficacy	EI	MA	17.93*	18.48*
	TC	MA	12.75*	14.46*
	EI	TC	5.18*	4.02

** . Significant at the 0.01 level. * . Significant at the 0.05 level.

4.10.3 Differences between groups based on main subject taught

An ANOVA was conducted on participants divided into categories based on their main subject taught. The analysis was carried out with one factor; teacher self-assessment of technology integration (TI) with a comparison of means using five dependent variables; level of computer use (LCU), student activity (SA), teacher activity (TA), outcome expectancy (OE) and personal self-efficacy (SE).

The null hypotheses were that there would be no differences between the means for

b) a minimal adopter, c) technologically competent and d) an exemplary integrator in each of the variables tested, ie:

1. H_0 (level of computer use): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
2. H_0 (student activity): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
3. H_0 (teacher activity): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
4. H_0 (OE): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$
5. H_0 (SE): $\mu_{\text{minimal}} = \mu_{\text{competent}} = \mu_{\text{exemplary}}$

A Tukey test carried out post-hoc on the data could have been impacted by significant differences in group sizes between groups. However some confirmation patterns emerged as seen in Tables 44 to 46.

Significant differences between group means were identified for personal self-efficacy $F(2,53) = 20.57, p < 0.001$, level of computer use, $F(2,55) = 6.72, p = 0.002$ and teacher activity, $F(2, 45) = 5.70, p = 0.01$. Null hypotheses 1, 3 and 5 were rejected. This suggests that exemplary ICT integrators in science are more likely to have a higher personal self-efficacy scores, higher levels of computer usage and higher teacher activity than science teachers who are minimal adopters or technologically competent. Null hypotheses 2 and 4 were accepted based on these results.

A calculation of the eta-squared statistic showed that 20% of the variation in level of computer use, 44% of the variation in personal self-efficacy and 20% of the variation in teacher activity for teachers in these schools can be accounted for by the self-assessed ICT integration category. Deeper analysis showed that the predictive effect was significant for male science teachers but only personal self-efficacy was a significant predictor of self-assessed technology competence for female science teachers. These results are displayed in Tables 45 and 46 on the following pages.

When science teachers were analysed after the data was divided on the basis of sex, significant differences between group means for female science teachers were identified for personal self-efficacy $F(2,24) = 6.70, p = 0.005$. A calculation of the eta-squared statistic showed that 14% of the variation in level of computer use, 36%

of the variation in personal self-efficacy and 25% of the variation in student activity for female science teachers in these schools can be accounted for by the level of self-assessed technology integration. No other descriptors showed statistical significance.

Table 44

Between group differences for key enablers for science participants

		Sum of Squares	df	F	Eta squared
Level of Computer Use	Between Groups	30.83	2	6.72**	0.20
	Within Groups	126.27	55		
	Total	157.10	57		
Outcome Expectancy	Between Groups	74.55	2	1.75	0.06
	Within Groups	1192.63	56		
	Total	1267.19	58		
Personal Self-efficacy	Between Groups	1194.04	2	20.57*	0.44
	Within Groups	1537.96	53		
	Total	2732.00	55		
Student Activities	Between Groups	156.09	2	1.55	0.06
	Within Groups	2262.91	45		
	Total	2419.00	47		
Teacher Activities	Between Groups	464.20	2	5.70**	0.20
	Within Groups	1833.47	45		
	Total	2297.67	47		

** . Significant at the 0.01 level. * . Significant at the 0.05 level.

When science teachers were divided on the basis of gender, for the purpose of separate analysis, male science teachers confirmed the overall pattern. Significant differences between group means were identified for personal self-efficacy $F(2,26) = 14.28, p < 0.001$, level of computer use, $F(2,27) = 4.04, p = 0.03$ and teacher activity, $F(2, 24) = 4.55, p = 0.02$. Outcome expectancy was just outside the range of significance, however it was a significant predictor of difference between minimum adopters and exemplary ICT integrators ($p = 0.040$). This suggests that male science teachers who identify as exemplary ICT integrators are more likely to have a higher personal self-efficacy scores, higher levels of computer usage and

higher teacher activity than male science teachers who are minimal adopters or technologically competent.

Table 45

Between group differences for key enablers for female science participants

		Sum of Squares	df	F	Eta squared
Level of Computer Use	Between Groups	9.57	2	2.05	0.14
	Within Groups	58.29	25		
	Total	67.86	27		
Outcome Expectancy	Between Groups	35.51	2	0.80	0.06
	Within Groups	577.46	26		
	Total	612.97	28		
Personal Self-efficacy	Between Groups	461.05	2	6.70**	0.36
	Within Groups	826.13	24		
	Total	1287.19	26		
Student Activities	Between Groups	214.21	2	3.03	0.25
	Within Groups	635.60	18		
	Total	849.81	20		
Teacher Activities	Between Groups	127.87	2	1.43	0.14
	Within Groups	804.80	18		
	Total	932.67	20		

** . Significant at the 0.01 level. * . Significant at the 0.05 level.

A calculation of the eta-squared statistic showed that 23% of the variation in level of computer use, 52% of the variation in personal self-efficacy, 20% of the variance in outcome expectancy and 28% of the variation in teacher activity for male science teachers in these schools can be accounted for by the self-assessed technology integration level. All of these values are comparatively large and indicative of some causal relationship.

Mathematics teachers were also analysed in a similar way and the results shown in Tables 47 and 48 on the following pages. Significant differences between group means were identified for student activity $F(2,30) = 3.45, p = 0.045$, and teacher activity, $F(2, 26) = 6.90, p = 0.004$. Null hypotheses 2 and 3 were rejected. Null hypotheses 1, 4 and 5 were accepted based on these results.

Table 46

Between group differences for key enablers for male science participants

		Sum of Squares	df	F	Eta squared
Level of Computer Use	Between Groups	19.63	2	4.04*	0.23
	Within Groups	65.57	27		
	Total	85.20	29		
Outcome Expectancy	Between Groups	112.52	2	3.33	0.20
	Within Groups	456.85	27		
	Total	569.37	29		
Personal Self-efficacy	Between Groups	740.49	2	14.28**	0.52
	Within Groups	674.27	26		
	Total	1414.76	28		
Student Activities	Between Groups	71.41	2	0.64	0.05
	Within Groups	1346.67	24		
	Total	1418.07	26		
Teacher Activities	Between Groups	354.92	2	4.55*	0.28
	Within Groups	935.16	24		
	Total	1290.07	26		

** . Significant at the 0.01 level. * . Significant at the 0.05 level.

This was the only occasion in the study where no significant predictor effect was found between teachers' self-assessed level of technology integration and personal self-efficacy. However, a calculation of the eta-squared statistic showed that 35% of the variation in teacher activity and 19% of the variation in student activity for mathematics teachers in these schools can be accounted for by self-assessed technology integration level. This was an interesting contrast to that of science teachers, and indeed teachers in general. It may provide a stimulus for further investigation.

Table 47

Between group differences for key enablers for mathematics participants

		Sum of Squares	df	F	Eta squ
Level of Computer Use	Between Groups	1.40	2	0.20	0.01
	Within Groups	128.96	36		
	Total	130.36	38		
Student Activities	Between Groups	461.46	2	3.45*	0.19
	Within Groups	2006.72	30		
	Total	2468.18	32		
Teacher Activities	Between Groups	406.77	2	6.90**	0.35
	Within Groups	766.67	26		
	Total	1173.45	28		
Outcome Expectancy	Between Groups	45.31	2	0.95	0.05
	Within Groups	837.67	35		
	Total	882.97	37		
Personal Self-efficacy	Between Groups	190.82	2	2.25	0.11
	Within Groups	1486.76	35		
	Total	1677.58	37		

** . Significant at the 0.01 level. * . Significant at the 0.05 level.

These results suggest that exemplary ICT integrators in mathematics are more likely to have a higher student and teacher activity than mathematics teachers who are minimal adopters or technologically competent. Deeper analysis showed that the predictive effect was significant for male mathematics teachers but not for female mathematics teachers, as seen in Table 48.

When mathematics teachers were analysed after the data was divided on the basis of sex for the purpose of analysis, significant differences between group means were identified for student activity $F(1,13) = 5.72, p = 0.03$, and teacher activity, $F(1, 12) = 11.81, p = 0.005$. No male mathematics teacher self-assessed as a minimum adopter, hence there were only two groups for comparison, and no descriptors were significant for female mathematics teachers.

A calculation of the eta-squared statistic showed that 50% of the variation in teacher activity and 31% of the variation in student activity for male mathematics teachers and 23% of the variation in teacher activity for female mathematics teachers in these schools can be accounted for by self-assessed technology integration level.

Table 48

Between group differences for key enablers for mathematics teachers based on sex

My sex is . .			Sum of Squares	df	F	Eta squ
Female	Student Activity	Between Groups	151.37	2	0.99	0.12
		Within Groups	1141.74	15		
		Total	1293.11	17		
	Teacher Activity	Between Groups	130.73	2	1.75	0.23
		Within Groups	448.88	12		
		Total	579.60	14		
	Outcome Expectancy	Between Groups	24.08	2	0.48	0.05
		Within Groups	479.79	19		
		Total	503.86	21		
	Personal Self-efficacy	Between Groups	132.65	2	1.72	0.15
		Within Groups	733.21	19		
		Total	865.86	21		
Level of Computer Use	Between Groups	2.60	2	0.35	0.03	
	Within Groups	74.36	20			
	Total	76.96	22			
Male	Student Activity	Between Groups	353.63	1	5.72*	0.31
		Within Groups	803.30	13		
		Total	1156.93	14		
	Teacher Activity	Between Groups	293.49	1	11.8**	0.50
		Within Groups	298.22	12		
		Total	591.71	13		
	Outcome Expectancy	Between Groups	18.62	1	0.79	0.05
		Within Groups	331.38	14		
		Total	350.00	15		
	Personal Self-efficacy	Between Groups	62.76	1	1.17	0.08
		Within Groups	748.18	14		
		Total	810.94	15		
Level of Computer Use	Between Groups	6.91	1	2.16	0.13	
	Within Groups	44.84	14			
	Total	51.75	15			

** . Significant at the 0.01 level. * . Significant at the 0.05 level.

No similar ANOVA based on these predictors was conducted on technology teachers as a result of the small sample size.

4.10.4 Differences between groups based on teacher and student activities

To determine whether the dominant types of activities involving technology engaged in by exemplary teachers differed with those engaged in by non-exemplary teachers, several ANOVA were performed on the data set produced in the online surveys.

Table 49 below shows the results of an ANOVA for the differences between the three groups of ICT integrators based on the dominant types of technology-facilitated activities undertaken by the teacher themselves.

Table 49

Differences between groups for a range of activities by teachers

		Sum of Squares	df	F	Eta squ
Simulation & Ed Games	Between Groups	9.09	2	1.49	0.03
	Within Groups	261.90	86		
	Total	270.99	88		
Imaging	Between Groups	33.62	2	5.02**	0.11
	Within Groups	271.19	81		
	Total	304.81	83		
Communication	Between Groups	0.52	2	1.05	0.02
	Within Groups	22.40	90		
	Total	22.93	92		
Publishing	Between Groups	35.00	2	6.30***	0.13
	Within Groups	241.49	87		
	Total	276.49	89		
Drill & Practice	Between Groups	19.97	2	2.72	0.06
	Within Groups	305.11	83		
	Total	325.08	85		
Information Retrieval	Between Groups	2.17	2	1.56	0.03
	Within Groups	61.21	88		
	Total	63.39	90		
DataLog and Analysis	Between Groups	23.06	2	3.52*	0.08
	Within Groups	275.01	84		
	Total	298.07	86		

***. Significant at the 0.005 level .

**. Significant at the 0.01 level.

*. Significant at the 0.05 level.

As previously reported, patterns of teacher usage are significant at the 0.05 level when analysing how exemplary integrators use imaging ($F(2,81) = 5.02, p = 0.009$), publishing ($F(2, 87) = 6.30, p = 0.003$) and data logging and analysis ($F(2, 84) = 3.52, p = 0.03$) in comparison with non-exemplary technology integrators. These types of activities can be used to encourage student choice and control in their learning.

This was also verified by a one way ANOVA by integration group for student use of technology. See Table 50 below. Significance at the 0.05 level was observed when analysing how exemplary integrators encourage student use of publishing ($F(2,88) = 5.22, p = 0.007$), drill and practice activities ($F(2, 90) = 3.53, p = 0.03$) and data logging and analysis ($F(2, 85) = 4.08, p = 0.02$).

Table 50

Differences between groups for a range of activities by students

		Sum of Squares	df	F	Eta squared
Simulation & Ed Games	Between Groups	13.10	2	2.18	0.05
	Within Groups	268.06	89		
	Total	281.16	91		
Imaging	Between Groups	11.79	2	1.45	0.03
	Within Groups	341.61	84		
	Total	353.40	86		
Communication	Between Groups	2.70	2	0.52	0.01
	Within Groups	240.03	92		
	Total	242.74	94		
Publishing	Between Groups	29.19	2	5.22**	0.07
	Within Groups	245.84	88		
	Total	275.03	90		
Drill & Practice	Between Groups	21.62	2	3.53*	0.07
	Within Groups	275.56	90		
	Total	297.18	92		
Information Retrieval	Between Groups	5.53	2	1.24	0.03
	Within Groups	200.17	90		
	Total	205.70	92		
DataLog and Analysis	Between Groups	13.56	2	4.08*	0.09
	Within Groups	141.33	85		
	Total	154.90	87		

** . Significant at the 0.01 level. * . Significant at the 0.05 level.

4.10.5 Differences between groups based on professional learning

In Question 16 of the online survey, participants made a guess as to the number of hours spent on formal training activities and informal training activities. A comparison was made for each category on whether they had assessed the number of formal professional development hours as higher, lower or equal to the number of informal professional development hours. The results of this comparison are shown

in Table 51 below.

Exemplary ICT integrators were almost one and a half times more likely (75%) to assess informal professional development hours as a higher value compared with formal professional development hours than were competent users (58%).

This suggests that exemplary ICT integrators highly value informal professional development opportunities, such as learning on their own, learning from a colleague or peer sharing. This is consistent with, and supportive of, the data in Tables 12 and 13 on page 152.

Table 51

Summary of self-assessed PD hours vs category

Teacher Self-Assessed Category	Formal PD Hours Higher	Informal PD Hours Higher	Both Numbers equal	TOTAL
Minimum Adopter Technologically Competent	0	3	1	4
Exemplary Integrator	13	31 (58%)	9	53
	4	21 (75%)	3	28

* 11 respondents did not provide one or both values for this question

4.11 Summary

In this chapter, all results from the online survey and qualitative interviews were presented and analysed. A total of 96 educators completed the survey, representing a 69% completion rate. The detailed nature of the survey may have contributed to the fact that only two-thirds of the educators who began the survey, completed the entire six sections. Rich data was collected from participants willing to take further part in this research and 11 educators participated in a personal interview which clarified many of the key issues relating to effective ICT integration. This additional data was critical to the study as it enabled several areas which had been previously raised to be examined, building a clearer picture of the enablers and inhibitors to exemplary ICT integration and, potentially, informing the decision making around future

professional development opportunities targeting ICT integration. Data was most significant for secondary science and mathematics teachers as they dominated the survey demographics.

Data was triangulated to confirm reliability and reduce ambiguity. Measures of statistical significance were identified involving the independent variable, self-assessed technology integration category, and several dependent variables such as level of computer use, outcome expectancy and personal self-efficacy and the frequency and type of activities performed with technology by both the teacher and their students. The implications of these findings and how well they address each of the research questions will be discussed further in the next chapter.

Chapter 5 Discussion

5.1 Introduction

In the previous chapter, the raw data was presented for both the online survey and qualitative interview components of the research. A series of statistical tests were carried out to analyse the data and determine its reliability, significance and degree of commonality regarding the enablers of exemplary ICT integration. Correlation, regression and multivariate analyses further probed the data for identifiable and statistically significant patterns in order to narrow down the set of factors most likely to be related to exemplary technology usage in the secondary mathematics and science classroom. From this information, a set of key competencies will be configured to assist teachers to become more able integrators of technology in their classrooms.

The subject of this chapter is the assimilation of the data analysis in the context of the research questions as well as a discussion involving the pragmatic applications of this data. It will begin with an examination of the study analyses and how they directly link to the first two research questions. The chapter will conclude with an examination of how the data can be applied to inform future professional learning opportunities. Research question three provides the framework for this discussion as it sought to facilitate recommendations for professional development leaders and providers, including school principals and training organisations, about the methods by which teachers can increase their effective use of technology in the classroom.

5.2 Evaluating the drivers of this study

In the previous chapter, statistical analyses were carried out on the data supplied in the online surveys and qualitative interviews with the intention of finding answers to the questions regarding what factors have enabled the successful integration of ICT into classrooms, particularly those of New South Wales science and mathematics teachers. An attempt was made to identify common enablers and inhibitors of technology integration and to make some broad conclusions. As outlined in Chapter One, computer technology has been available to schools for over 30 years and yet

“learning, surely the most important human resource in the world, is not benefiting from the greatest technical resource on the planet” (Fullan, 2013, p. 72). This research sought to bring together more effectively the most important human resource and the greatest technical resource as labelled by Fullan (2013).

5.2.1 The unique characteristics of exemplary integrators

The how of ICT integration is much explored, but its effectiveness, in terms of improved student learning outcomes, remains steeped in inconclusive evidence and, sometimes, reluctant compliance. “Studies linking the provision and use of technology with attainment tend to find consistent but small positive associations with educational outcomes. However a causal link cannot be inferred from this kind of research. It seems probable that more effective schools and teachers are more likely to use digital technologies more effectively than other schools” (Higgins et al., 2012, p. 3). Many such studies issue caution around using technology as a direct link to improved outcomes and yet there is much evidence to suggest that engaged and motivated students will perform better academically (Badge, Saunders, & Cann, 2012; Hoppe, 2010; Marshall, 2002). “When technology is employed purposefully for defined outcomes, it can support and facilitate learning” (Marshall, 2002, p. 23). Separating the technology use from the teacher to measure impact has been a very difficult research goal. This has been exacerbated by the continuing evolution of technology and the pace of change. Technology continues to advance on an exponential scale while educators and researchers are trying to quantify, and often disagree on, its impact on student learning. “With computer and digital technologies there is a recurrent and specific challenge in understanding and applying the research evidence as it takes time for robust evidence to emerge in education and the rapid pace of change of technology makes this difficult to achieve” (Higgins et al., 2012, p. 15). Similar points were raised during the interviews for this study as educators try to evaluate the importance of computer technology to student learning and whether or not the current assessment is actually asking the right questions (EIH01). The fact that exemplary teachers have high personal self-efficacy, are regular users of technology for both personal and professional use and that their use of computers is

often to encourage deeper learning and student autonomy as reported in Chapter Four, provides evidence that there is a set of skills or characteristics of teachers who demonstrate exemplary technology integration practice that separates them from minimum adopters, and to a lesser extent, from competent users. These factors will be expanded further in the following sections.

5.2.2 The important factors affecting ICT integration

The participants in this study varied in terms of their school types with 63% from high schools or senior schools and the remainder from K-12 schools. Almost one-third came from the government sector with the remainder spread between the Independent and Catholic sectors, as shown in Table 3 on page 145. This produced a range of religious and/or cultural affiliations, not all of which provided large enough samples for meaningful statistical analysis as indicated in Table 5 on page 146. However, correlation between different sources of data is sufficiently high to provide confidence in the findings. The presence of high numbers of classroom teachers and heads of department in the surveys (Table 6 on page 147), provide two different perspectives on the issue of effective ICT integration. This was further strengthened by the duplication in these groups for the qualitative interviews, (Table 23 on page 180). There was sufficient representation from both science and mathematics teachers from New South Wales secondary schools, as reported in Table 7 on page 147, to inspire confidence in the generalisability of the data to the wider population of secondary science and mathematics teachers in New South Wales. However this is not the case for technology teachers who were underrepresented in this study and hence have not been assessed as a separate group.

The teaching experience was diverse, as shown in Table 9 on page 149, and correlated well against birth years as expected, providing a range of data for inclusion in a study focussed on the commonality of responses. Such commonality needs to take into account the experience and qualifications of the members of the teaching profession in order to ensure all levels have some representation. This study involved teachers in their first few years of teaching (10%) and those in, presumably, the twilight of their careers (17%), as reported in Table 9. The span of personal

qualifications for participants was broad, see Table 8 on page 148, further strengthening the argument around the commonality of responses, although to pull out each sub-category within academic qualifications for individual analysis would require a much larger sample size. Representation was widely sought to collect a range of perspectives and the demographic data has revealed that this component of the research was achieved satisfactorily. This adds weight to the commonality argument around the factors which enable or inhibit effective ICT integration in the classroom. On this basis, it seems reasonable to conclude that the set of inhibitors which mitigate against exemplary ICT integration and the enablers which facilitate exemplary ICT integration have some commonality across a range of teachers in a range of school settings. In addition, the conclusions drawn from the data can be generalised across some of the cultural, subject specific or sex categories. There is sufficient evidence to support the notion of commonality and conclude that the qualities or characteristics of teachers who demonstrate exemplary ICT integration practice are consistent across some cultural, sex and subject-based groupings. Specifically, evidence gathered supports the factors reported in the literature around high personal self-efficacy and student autonomy and hence these findings can be cautiously extrapolated to include state and national boundaries.

5.2.3 Transference of factors for future professional learning

This study gathered specific examples of the types of activities students had undertaken, as reported by their experienced, committed and self-assessed exemplary ICT integrators. All participants self-reported and/or participated in qualitative interviews without independent observations of their lessons or methods. Despite this, some interesting patterns emerged that could inform future professional learning and school-based organisation. In analysing the preferred training methods, correlations appeared which were consistent with both those reported in the literature and across the later qualitative interview phase of this study. As seen in Tables 12 and 13 on page 152 in Chapter Four, teachers identified overwhelmingly that they preferred to learn on their own or from a peer when it came to integrating technology. This emphasised the importance of collegiality when working and

learning with technology and also the importance of differentiated training methods; many teachers preferred to use the technology themselves, at their own pace, prior to introducing it to the classroom. *“I know I’ve tried a whole range of different strategies in that space and I agree the conversations are probably the most powerful, just being available on a one to one level”* (EIH01). Qualitative interviews reinforced this nature of learning through a focus on learning new software or hardware and from which the previous quote was sourced. This is supported in the literature (W. Ng, 2015). Most participants’ suggestions that their need to use technology themselves and to learn from a more knowledgeable peer as their preferred learning strategies are consistent with the quantitative data. As a consequence, it is reasonable to assume that the qualities or characteristics of teachers who demonstrate exemplary ICT integration practice can be configured into a skill set which could be developed into new and experienced teachers using an effective professional development model. The next four sections will specifically draw together the findings from this study into a broader view of how it contributes to the current status of ICT integration in the field in the context of the three research questions.

5.3 Enablers of exemplary ICT integration practice in secondary education

In seeking to evaluate research question one, information collected from the literature review was compared with the quantitative and qualitative responses from participants in the online surveys and personal interviews. The research sought to answer the following question:

1. What are the enablers and inhibitors of exemplary ICT integration?

The study has revealed a number of enablers of exemplary ICT integration practice in secondary education which are consistent with those in the literature and which appear to suggest levels of commonality across both international borders and within the New South Wales education sectors. Once teachers gain confidence and competence in the technology, they are “able to concentrate on student learning outcomes and evaluate the use of ICT in terms of enhancing the learning experience”

(Schibeci et al., 2008, p. 323). Survey responses echoed this finding, as exemplary integrators were assessed by participants as having a pedagogical focus on technology to enhance learning outcomes. Responses including the creation of “*an online environment for student learning*” (FT25), the use of “*digital resources to provide engaging student-centred activities*” (MH19) and using “*technology to promote student collaboration, communication, flipped classroom*” (FP01) reinforced the notion that exemplary ICT integrators were able to focus more on the student and less on the technology. “Appropriate use of technology enables teachers to create a flexible learning environment to meet the different needs of students in their science learning” (Wang et al., 2012, p. 126).

Studies seeking to link the use of technology to student performance are hard to isolate from teacher quality and pedagogical approaches. “Hattie’s 2003 analysis agreed that teacher quality accounts for 30 per cent of the variance in student performance” (Ainley, 2013, p. 4). However, even such a high percentage cannot explain all, or even most of the variance in student performance. In terms of increasing engagement and improving student outcomes in the classroom, it is important for teachers to reflect on and seek ways of improving their craft. From the responses of educators in this study, there seems to be a genuine link between exemplary integration practice and the development of teaching as a craft. “*Often these teachers will discuss their plans and successes as well as hearing what students are talking about at school*” (ME02). There seems to be a genuine personal desire to improve learning outcomes and meet student needs. One respondent summarised this by identifying an exemplary ICT integrator as a “*confident teacher who spends time thinking about how to deliver knowledge in an effective, efficient manner*” (FH06).

This study has focussed on several indicators of exemplary ICT integrators, in particular, those evidenced in secondary science and mathematics classrooms. One consistent enabler to appear statistically significant was high personal self-efficacy. This has been discussed regularly in the literature (Buabeng-Andoh, 2012; Harteis, Gruber, & Hertramph, 2010; Mumtaz, 2000; So et al., 2012) with So, Choi, Lim and

Xiong (2012) suggesting it may have “predictive power for student-teachers’ intention for ICT integration on future teaching”, (So et al., 2012, p. 1236) and may “significantly influence one’s willingness to use computers in future teaching practices”. However, high personal self-efficacy can be difficult to separate from epistemic beliefs, particularly as they are applied to technology utility in a classroom. Although Harteis et al (2010) warn that an individual’s “epistemic belief system does not significantly relate to the amount of e-learning, but it is related with the quality of learning processes” (Harteis et al., 2010, p. 208). As it applies to technology integration, Abbitt and Klett (2007) proposed that “a teacher’s perception that he or she can effectively use technology in the process of teaching and learning will impact that teacher’s ability to do so”. The fact that this study found significant correlation ($r = 0.54, p < 0.001$) between teachers’ self-assessment of ICT integration and personal self-efficacy, as well as between the level of computer use and personal self-efficacy ($r = 0.42, p < 0.001$), further strengthens that supposition.

Exemplary ICT integrators also make different choices about where they get their knowledge and how they use technology in the classroom. “Early adopters appear to regard technology knowledge and skills as one type of expertise, and pedagogical skills as another type of expertise” (Jacobsen, 2000, p. 8). They have “intrinsic motivation and a belief structure that integrating technology into their teaching is the right thing to do” (Jacobsen, 2000, p. 8) and all appear to possess “a willingness to share their knowledge and expertise in some way to encourage further adoption of technology by peers” (Jacobsen, 2000, p. 8). Confidence and openness are critical enablers of effective ICT integration. Whilst the values were not significant statistically, exemplary ICT integrators spend more hours on informal professional development rather than formal professional development. In many of the qualitative interviews, teachers described the importance of having an opportunity to “*explore the software myself*” (EIH02), or to be “*doing it by myself*” (EIT01), “*give it to me and let me play with it*” (CUT06), “*time and trial and error*” (CUT03) and “*learning from a peer or more knowledgeable person generally*” (CUH01). This is also supported in the literature (Almekhlafi & Almeqdadi, 2010) and is regularly cited as a benefit of the current technologies.

“*More peer learning*” (EIH01) seems to be a mantra of successful ICT integrators and those charged with the responsibility of increasing ICT effectiveness in their schools. “Educators are nowadays able to share expertise and to learn informally from one another through social media and online support” (Kukulka-Hulme, 2010, p. 4). The time to practice and learn independently were further supported in Tables 12 and 13 on page 152, where a majority of respondents identified the importance of self-directed and peer learning. This confirms previous ideas (Beisenherz, 1993) about the characteristics of exemplary teachers; “self-training and risk-taking are the characteristics of exemplary teachers” (Hakverdi-Can & Dana, 2012, p. 107). However they do qualify this by suggesting “self-training is not enough to use those technologies in the classroom” (Hakverdi-Can & Dana, 2012, p. 107). Whilst there was no significant difference across the ICT integration level groups based on the importance of learning independently, there was a high correlation between teachers’ self-assessed ICT integration level and the value they placed on state/district/school level workshops ($r = 0.310, p = 0.006$) and learning from my peers ($r = 0.305, p = 0.002$). In both cases, exemplary ICT integrators spent less time on each of these activities, despite their value as information providers (Hakverdi, 2005). This may be a result of the exemplary integrators already being cognisant of much of the information presented in a workshop and/or the resident experts within a school or district and hence are more likely to be consulted than to consult. An ANOVA test confirmed the latter; ($F(2, 85) = 4.662, p = 0.012$). Further analysis suggested a higher, but not significant mean difference between minimum adopters and technologically competent teachers, but a significant difference at the 0.05 confidence level ($F(57, 26) = -1.2395, p = 0.014$) between technologically competent and exemplary integrators in terms of learning from peers. This could suggest that the technologically competent teachers know what to ask, and whom to visit in order to refine their ICT knowledge and skills. This accords with the findings of Martin and Vallance (2008) regarding the focus of responses from competent users of technology as centring “more on pedagogy and learning, and less on the technical issues” (S. Martin & Vallance, 2008, p. 41).

There also appears to be a degree of commonality in the types of technology-based

learning activities undertaken and utilised by exemplary integrators. Table 49 on page 235 revealed differences between the three groups of ICT integrators based on teacher activity. The patterns of teacher usage suggest that exemplary integrators report the use of imaging, publishing and data logging and analysis significantly more often than minimum adopters and competent users. Whilst it may be difficult to speculate on why this might be the case, it is suggestive of the fact that teachers who have experience both in using and teaching with technology have a different mind-set to teachers who use technology less regularly. “IT educators in particular have a unique set of personal values, motivators, organisational politics and alliances that influence technology adoption decisions. Given the nature of their chosen field, most IT educators place value on creativity and learning” (Gillard et al., 2008, p. 24). This argument gained further weight when the types of activities carried out by students were analysed for the three different categories of technology integration. Table 50 on page 235 revealed differences between the three groups of ICT integrators based on student activities. The patterns of student usage, as reported by their teachers, suggest that exemplary integrators report student use of publishing, drill and practice activities and data logging and analysis significantly more often than minimum adopters and competent users. This was consistent with the findings of a similar study in 2005 (Hakverdi, 2005). Exemplary computer-using teachers had more frequent and greater exposure to a range of technology-facilitated activities and were selectively passing this additional experience on to their students; these exemplary integrators appear to have had “significantly more well-rounded educational experiences than the other teachers had had” (Donnelly, McGarr, & O'Reilly, 2011). As a result, it would appear a reasonable conclusion from this research that exemplary integrators are more likely to encourage greater technology use generally, and to use technology specifically for student self-directed learning.

This suspicion around the importance of using technology for the purpose of increasing student choice in their learning was confirmed in the personal interviews. Qualitative interviews affirmed the importance of student autonomy to exemplary ICT integrators as a means of increasing student engagement and improving the efficacy of technology. “In recent years it has become evident that the processes of

knowledge construction themselves are now being transformed by ICT use” (Downes et al., 2001, p. 10). Other studies (Donnelly et al., 2011) have likewise highlighted the importance of student autonomy; “the students who experienced science in the student-centred STS (Science Technology and Society) sections were able to demonstrate greater creativity in terms of questioning and hypothesising skills than students in the teacher-directed sections for all grade levels (6 to 9)” (Akçay & Yager, 2010, p. 608).

5.4 Common Inhibitors of ICT integration practice

The study corroborated the findings of other researchers with respect to inhibitors of effective or exemplary ICT integration in secondary classrooms. “There are many factors that act as barriers for teachers to put their beliefs and frameworks for action into practice” (Mansour, 2009, p. 39). However, one of the major barriers is the attitude of the teachers themselves towards technology. “Not only knowledge and skills are important factors, but teachers’ attitude towards technology and their pedagogical beliefs play a major role in the success of technology integration” (Fisser et al., 2015). The importance of personal self-efficacy in relation to technology usage is reflected in its significance across a range of variables, supporting the earlier literature review findings in Chapter Two. “Teachers who have not had a chance to develop a vision of what can be done with the technologies or view models of how curriculum can be enhanced with the use of ICT cling to the ‘content’ and resist moving on their journey because it is ‘not easy’ to change” (Newhouse et al., 2002, p. 44). When a school has a significant number of such teachers, it can be almost impossible to facilitate change. “The attitudes and beliefs of people in the school shape the culture. . . Change is successfully implemented in a culture of innovation, collaboration and coordination where all participants in the system are involved in the change effort” (Menchaca, Bischoff, & Dara-Abrams, 2003, p. 3).

In New South Wales, the Australian curriculum has been modified to fit with a more traditional state-based model and has remained relatively content heavy. This is particularly true of the stage six courses (the final two years of high school, ie Years

11 and 12 in New South Wales), although those are about to change from 2018. Many of the teachers interviewed in the qualitative phase expressed their frustration at the density of content in both preliminary and higher school certificate courses and highlighted this challenge as a major inhibitor to more effective practice, mainly based on time pressures. In addition, school leaders often begin with the intended results of technology usage and then develop action plans for their achievement (Baylor & Ritchie, 2002). In a climate of change, it is hoped a new senior science and mathematics curricula in New South Wales, promised for implementation in 2018, will help facilitate a major pedagogical shift, reduce the content burden, free up the time needed for adequate planning and development and encourage greater student autonomy. Early reading of these new documents by the researcher, suggest that some of these concerns have been addressed. Whilst there are many factors present, the primary inhibitor to many of these is the lack of time.

Some of the schools represented in the qualitative survey had a Head or Director of eLearning and were approaching the issue of effective technology integration in a systematic way. This approach to increasing frequency of ICT use in classrooms is supported in the research (Pelgrum, 2001; Wastiau et al., 2013). However many schools did not have anyone in this role. One of the teachers during their interview lamented this vacuum in his school *“I wish we did. We desperately need someone . . . it normally falls on teachers who are more confident . . . to support their colleagues . . . but no, there’s not one person assigned to that role”* (CUT04). Budget constraints will always impact staffing. However all schools represented in this study have at least one competent to exemplary practitioner in their school when it comes to reflecting on ICT integration and looking for methods of improvement. Perhaps time is a commodity required by these teachers to better support their colleagues and extend their own knowledge base. *“High integration schools expressed an interest in developing high end user differentiation and capacity”* (Baskin & Williams, 2006, p. 465). Where the expertise does not reside in a single school, or where schools are geographically isolated from other schools, teachers may benefit from a well-established network. *“There should be collaboration between schools where teachers can exchange ideas and successful technology*

integration techniques” (Almekhlafi & Almeqdadi, 2010). The very nature of technology enables it to cross geographical barriers and facilitate establishment of networks of users. However these networks need a personal interaction. Just as the better results in a flipped classroom approach have come from the students’ personal relationship with the teacher (Fulton, 2012) so we should expect better integration outcomes for teachers who are connecting with other teachers they already know. One exemplary integrator reinforced this message during his interview: “*it (technology) works much better, and that’s why it works well in schools. It’s because you already have a social context and you have a social grounding around that*” (EIH01).

One of the great challenges of the teaching profession is the constancy of change. A significant proportion of teachers have been teaching for many years and have seen successive changes in governments, curricula, school leadership and student cohorts. “Being a teacher is a creative profession. One of the reasons that schools fail and systems stumble is that teachers as well as students become disengaged.” (Robinson, 2011, p. 267). Remaining resilient in the face of change and generating a personal self-belief in the ability to effectively use the tools available to engage students and foster learning can be a significant challenge for many teachers. Yet disengaged teachers may lack belief in the power of technology to enhance learning at all. Many teachers point to the paucity of empirical evidence, as do some researchers (Ainley, 2013; Marshall, 2002) and some negative data around particular strategies. One source of this negative attitude towards the benefits of technology can be observed in the use of WebQuests. “In neither of these experiences did the WebQuest activity lead to superior learning relative to conventional instruction” (Gaskill et al., 2006, p. 136). Alternately, Abbitt and Ophus (2008) reported on a 2003 study by Popham and Wentworth (2003) which “found a significant correlation between problem-solving activities and critical thinking” and yet also acknowledge “most of our knowledge regarding the benefits of the WebQuest strategy comes from anecdotal accounts of how this strategy is being used” (Abbitt & Ophus, 2008, p. 452). Yet more recent studies have argued that WebQuest-styled activities are important because “ordinary use of technology is insufficient for students, but systems like

Web Macerasi allow students to perceive technology differently” as they “facilitate different collaborations among virtual groups and the strict timing of the projects makes students take responsibility” for their role and their learning (Gülbahar, Madran, & Kalelioglu, 2010, p. 149).

Despite the fact that “there is substantial evidence that using technology as an instructional tool enhances student learning and educational outcomes” (Gulek & Demirtas, 2005, p. 7) and “ample evidence that the use of technology can have a significant positive effect on student learning” (Bielefeldt, 2005, p. 344), many teachers are still reluctant to use technology and cite lack of empirical evidence as a reason. There are two levels to this; persuasive evidence in the literature at the broad level and personal evidence of a benefit within a classroom. “Teachers need to be given the evidence that ICT can make their lessons more interesting, easier, more fun for them and their pupils, more enjoyable and more motivating” (Mumtaz, 2000). This belief, however, is changing. Students’ motivation and confidence are increased when technology is integrated into classroom instruction (Mouza, 2005; Torff & Tirota, 2010).

Computer engagement has also been linked to improved student academic achievement (Kusano et al., 2013). Similar findings around increased academic learning are associated with flipped learning (Herreid & Schiller, 2013) and gaming methodologies (Barab & Dede, 2007; Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007; Barab et al., 2009). However, one Head of eLearning postulated during the qualitative interviews that it may be the way evidence is being gathered that may be as significant as the evidence itself: “*there is plenty of research to say that technology has no impact on student outcomes at all. . . I think it’s really to do with what they are actually measuring or how they haven’t changed what they measure . . . if we are actually measuring (literacy) on a test from 1990, 25 years later when we now have multiple devices and multiple literacies in terms of what we actually do and how we deal with data on a day to day basis, you can’t expect the outcome to be different if you don’t change what we are actually testing*” (EIH01).

The longer the teaching profession remains fractured on this issue, the more

frustrated students will become. Yet this too may be a function of the way in which individual teachers view technology use in the classroom; “there are also legitimate concerns over the effectiveness of 1:1 laptop environments which in many cases are grounded in a generational struggle over what constitutes effective educational use” (Bate, MacNish, & Males, 2012, p. 18). In evaluating a 1:1 laptop program with a physics context, Zucker and Hug (2008) noted “despite the excellent use of laptops for teaching and learning, the use of these devices presents challenges, including managing off-task activities by students (Zucker and McGhee 2005). Laptops also need repair from time to time and students may forget to bring their computer to school. As a result, some students (perhaps 5%) do not have a working laptop any given day. However, the great majority of teachers (79%) report that this is a minor problem or hardly a problem at all, while a minority (21%) reports that this is a more serious problem” (Zucker & Hug, 2008, p. 593). It is speculative whether the difference noted is a difference in perception or in reality. One theme that resonates in this study is the ability of teachers with high personal self-efficacy to minimise potential barriers and carry on seeking to maximise the impact of technology use in their classrooms.

It would be naive to suggest that if schools were able to remove all the barriers that every teacher would become an exemplary ICT integrator. No matter what the level of expense, inhibitors can always be found, just as they can be overcome. However, one significant way in which schools can radically address the most common inhibitors of exemplary ICT integration is to become less isolated and more a part of their local and global learning communities and to find ways of better connecting their teachers with those communities in a spirit of authentic collaboration focussed on local and global issues. “As long as digital immersion and schooling function in isolation, and are not steeped in real-life problem solving, we will not see any progress” (Fullan, 2013, p. 40). Encouraging teachers to use technology to open their classrooms and link their students in a spirit of ‘anytime’ and ‘anywhere’ learning, the less likely the inhibitors are to influence what is happening inside and outside the classroom.

5.5 Factors which separate minimum adopters, competent users and exemplary integrators

State and national expectations often drive school expectations as well as teacher training institutions and teacher professional development providers around minimum standards for teachers. The difficulty, as always with technology, is that as technology continues to evolve, so teachers must strive to keep pace, constantly moving what may generally be regarded as the minimum standard. This may be highlighted in the challenge given by Black and Aitken (1996) in Downes et al (2001) “to achieve [these benefits], teachers will have to change almost every aspect of their professional equipment. They will have to reconsider themselves entirely: not only the structures of their material and their classroom techniques, but even their fundamental beliefs and attitudes concerning learning” (Downes et al., 2001, p. 27). Information technology literacy has become a basic literacy expectation required by all teachers, especially the neophyte or graduate teacher. This was further emphasised in the study through participant responses to the open-ended question about minimum requirements. Most participants acknowledged, some grudgingly, that technology is ubiquitous and teacher response to technology were encouraged to be “*always looking to improve skills*” (MT14), as “*there is no minimum amount*” (FL01). While self-assessed minimum adopters thought they could continue to survive with a minimum of technology, mainly used “*once a cycle per main stream class*” (FT24), a competent user of technology stated “*education department mandates the specific use of ICT and software in science. I must use ICT in every class!*” (FH10). This is not merely a reflection of some teachers working within the New South Wales education sector, but also of the wider international focus on increasing the technological capacity and expectation of educators. In the context of the American-developed International Society for Technology in Education standards discussed in Chapter Two, O’Connell and Groom (2010) propose that “whichever standards are used by schools or by education authorities, they need to highlight the ways in which educators must become co-learners with their students

and with global colleagues in the context of a 21st Century new media learning and teaching” (O’Connell & Groom, 2010, p. 8). It is in the context of such challenges that this study sought to investigate six factors emergent from previous research which distinguish exemplary integrators of technology from those educators who are less effective in its incorporation in the classroom.

For a teacher to progress from merely competent in the use of technology to an exemplary practitioner, there are a couple of key factors which must be taken into account. In their review of professional development practices involving the integration of technology into teaching and learning, Lawless and Pellegrino (2007) summarised “that high-quality professional development activities are longer in duration (contact hours plus follow-up), provide access to new technologies for teaching and learning, actively engage teachers in meaningful and relevant activities for their individual contexts, promote peer collaboration and community building, and have a clearly articulated and a common vision for student achievement” (Lawless & Pellegrino, 2007, p. 579). One of our definitions may need to be modified. While there will always remain critical debate about what constitutes an exemplary teacher, it may be worth considering Fullan’s (2013) definition; “high levels of knowledge and understanding of the subjects they teach, can guide learning to surface and deep outcomes; can successfully monitor learning and provide feedback that assists students in progress; can attend to more attitudinal attributes of learning (such as self-efficacy and mastery motivation); and can provide defensible evidence of positive impacts of the teaching on student learning” (Fullan, 2013, p. 48). This is a big ask for our teachers, many of whom could already claim mastery in some of these areas. This is in part a result of “significant differences between being an adept user of ICT and being a teacher who makes creative and effective use of the same technologies in teaching and learning” (Lloyd & Mukherjee, 2013, p. 86). However, if the profession is to move forward to such heights of situated, productive ICT integration, there must be a discussion about the time needed to develop these additional skills and competences in a rapidly changing education landscape. However, just as the process of becoming an exemplary teacher is a gradual one, so the process of becoming an exemplary technology integrator is likewise. Each of the

components of research question two contributes in some way to the building of a model of an exemplary technology integrator. As discussed in Chapter Three, research question two was expanded to evaluate six specific factors from which the sets of skills, outcomes or personal motivators which separate the minimum adopter, the competent user and the exemplary integrator in the context of ICT integration practice could be assessed. These included whether exemplary integrators' preferred training methods differ from other integrators of technology, whether exemplary integrators' patterns of technology usage, both inside and outside the classroom, differ from other integrators of technology, whether the preferred pedagogy or personal self-efficacy of teachers who view themselves as exemplary integrators differed from other computer-using teachers and whether the differences observed were consistent for the different sexes and/or different subject specialties, ie science and mathematics. Each of these sub-categories is evaluated in the subsequent six sub-sections.

5.5.1 Preferred training methods of exemplary integrators

Results from Table 51 on page 236 suggested that exemplary ICT integrators were almost one and a half times more likely (75%) to assess informal professional development hours as having a higher value than formal professional development hours. Only 58% of competent users assessed informal professional development hours as having a higher value than formal professional development hours. This suggests that exemplary ICT integrators highly value informal professional development opportunities, such as learning on their own, learning from a colleague or peer sharing. To truly transform practice requires this paradigm shift in thinking (Masters & Yelland, 2002). “If learning is the impetus that drives the use of technology in school, then teachers and students ought to be partners in the learning process, altering traditional paradigms of the teacher providing wisdom and the student consuming knowledge” (Baskin & Williams, 2006, p. 464). As teachers must work at differentiating their lessons on a daily basis, so professional development providers must think more carefully about how they are differentiating the learning for teachers at different stages in the technology integration continuum.

“Research suggests that a “one-size fits all” approach in professional development does not provide teachers with an opportunity to grow within their content area” (Acevedo, 2013, p. 181). Acevedo’s research is supported by the observations of teachers in this study. Many were very specific about the inadequacy of professional learning which was often aimed either too low for those familiar with technology and/or a particular application, or too high for those taking something on for the first time. What may be overlooked is the potential for negative impact on personal self-efficacy relating to technology of poor professional development and, perhaps, the consequent reversal of an intended outcome. “Teacher educators should treat teachers as they expect teachers to treat students - it only makes sense to model best technology integration practices when attempting to get teachers to use them” (Swan et al., 2002, p. 2). This affects both ends of the learning spectrum as well for both face to face and online delivered professional development. Thinking through the issues of differentiated instruction may overcome some of the challenges of neophyte teachers seeking to begin their careers; “Trainee teachers also felt unprepared to put forward their ideas in the ‘public’ way required in discussion forums, and feared criticism from others about their own ideas and suggestions” (Pearson, 2003, p. 50).

For schools to become centres of ICT integration excellence, they will need to investigate the practicalities and value of Baskin and Williams (2006) observations: “diverse teams of varying viewpoints are a critical structure for completely exploring ICT integration ideas, and to date, these teams do not yet exist in schools” (p. 468). Some schools are allocating resources to Heads of eLearning, seeking a systemic approach to ICT integration. Others are seeking methods by which they can develop teams based on corporate skills and shared philosophy. “Carpe Diem (Armellini & Jones, 2008; Salmon, Jones & Armellini, 2008) is a well-researched, team-based intervention to promote innovation in learning design and assessment practices by academic course teams. The intervention includes a 2-day workshop in which teams design online learning activities (e-tivities) for effective and collaborative learning within their online, blended and face-to-face courses” (Armellini & Aiyegbayo, 2010, p. 922). While the paper focussed on a study involving university level educators, the principles and outcomes are relevant within the secondary education

sector too. “All participating course teams made significant changes to the ways in which they design for student learning, with particular emphasis on the online components of their courses. The e-tivities generated during Carpe Diem show a shift from designs based on content repositories to task-based, learner-centred approaches” (Armellini & Aiyegbayo, 2010, p. 933). Encouraging schools and districts to provide the time needed for collaborative team sharing and problem solving, including scaffolded discussions around pedagogy and the relevance and use of particular technologies within the school context, are critical phases in the development of the community of learners (Mueller et al., 2008). They are equally critical to moving teachers and school communities along the continuum from competent users to exemplary integrators. Exemplary ICT integrators recognise the importance of collaboration with their peers within the context of a coherent school policy. “According to Cohen and Hill (2001), the most effective teacher training experiences are school subject specific practices, immediately relevant for classroom instruction and connected to school policy” (Tondeur et al., 2008, p. 214).

5.5.2 Patterns of technology usage of exemplary integrators

Exemplary teachers are characterised by the thought patterns they have around their craft and their students’ individual needs. “The attitude of the educator towards technology use in the classroom is indicative of how well technology will be integrated in the classroom during instruction” (Kusano et al., 2013, p. 39). It is not simply about mastery of the technology; “each approach reflects a distinctly different world view - not just differing views about how ICT might be used in the classroom, but differing views about how children in this latest generation learn, how knowledge is created and used, and what roles parents, teachers and schools will need to play in this environment if today’s children are to participate as effective citizens and workers in tomorrow’s world” (Downes et al., 2001, p. 29). Data from Table 28 on page 209 suggested that participants who were identifying themselves as highly reliant users of technology on the Level of Computer Usage scale are more likely to identify as exemplary integrators and also indicate higher levels of usage of technology for teaching and instruction. In the context of how teachers use the

technology, the study confirmed that exemplary integrators were more likely to use technology for imaging, publishing documents and for data logging and analysis in comparison with non-exemplary technology integrators. This data was separately confirmed in Table 32 on page 213 and Table 49 on page 235.

5.5.3 Preferred teaching style of exemplary integrators

Exemplary integrators were more likely to favour strategies broadly regarded as student-centred learning. This involved student autonomy and choice, student self-regulation and direction and students as facilitators within the lesson. Exemplary integrators recognised and utilised the power of technology to create more choice and place greater control in the hands of their students. They were more likely to encourage their students in the use of publishing documents, drill and practice activities and the use of computers for data logging and analysis tasks, as can be seen from Table 34 on page 215 and Table 50 on page 235. These types of activities can be used to encourage student choice and control in their learning leading to increased student autonomy and/or differentiation.

This approach is about partnerships and collaboration. “Some researchers suggest that a clear benefit of educational computer use arises from the mere fact that computers lend themselves so well to collaborative modes of use” (Angeli, 2008, p. 274). It is about “the distinction between digital natives and digital immigrant. The typical history of immigrant communities is that children teach the adults about the new culture. The adults recreate the culture of the old country in the new one, and aim to preserve the old ways for the sake of nostalgia and security. The young ones . . . bring it home and aim to teach the older generation the new values and ways of doing things. It is often this way with digital culture. . . In education, our children have a lot to teach us about the possibilities of the tools and the ways of thinking that they have grasped intuitively and that some of their teachers hesitate to engage” (Robinson, 2011, p. 253). Many teachers are wary of technology because they are less comfortable with it than their students. The fear of being shown up or asked questions that cannot be answered prevents some teachers from pursuing certain avenues of inquiry and from using technology effectively (Wallace, 2004). “Despite

their professional relationship with uncertainty and the unknown, most scientists find it hard to admit ignorance” (Brown, 2013). This applies equally to teachers, especially teachers of science. Effective ICT integrators seek out experts in fields or with applications when they wish to expand their knowledge. They know what questions to ask and better questions are an indicator of deeper knowledge (Fullan & Longworthy, 2014). Exemplary integrators recognise the value of students as key collaborators in the creation of knowledge and design their lessons to utilise technology in the most effective ways to achieve their learning goals.

5.5.4 Personal self-efficacy of exemplary integrators

The study supports previous research findings about the importance of high personal self-efficacy of exemplary technology integrators. This was the case for every variable with just one exception; between group differences for mathematics teachers (Table 47 on page 232). Analyses reported in Tables 41 and 42 on pages 224 and 226, demonstrated that exemplary teachers in Aboriginal and Torres Strait Islander Schools or in schools which report as valuing all cultures equally, are more likely to have a higher personal self-efficacy and outcome expectancy scores. High correlation between exemplary integration and personal self-efficacy was present for female and male teachers, as reported in Table 43 on page 228, for science teachers in Table 44 on page 229 and for both male and female science teachers, see Tables 45 and 46 on page 231. This is one key enabler which has been tested over a range of categories and in each case has proven to be a significant indicator of exemplary integration as reported extensively in this study.

As a result, there is clear evidence in both the literature and in schools in New South Wales, that teacher confidence in technology and self-belief in the ability to use technology to enhance learning is critical to its actual integration into the classroom (Ottenbreit-Leftwich et al., 2010). This is where the dependence exists between technology use and personal self-efficacy. “Previous research has found that teachers’ self-efficacy predicted the teachers’ technology use (Albion, 1999; Becker & Anderson, 1998; Maracas, Yi, & Johnson, 1998)” (Hakverdi-Can & Dana, 2012, p. 106). This study has added evidence to other studies (Hakverdi, 2005) that there is

a strong correlation between how teachers perceive their ability to use computers effectively in their teaching and whether or not they actually use them. Either way, the benefits for the students of a shift in thinking can be substantial when they are in an “interactive, high tech class. The differences include adjusting both to new technology and to a new learning paradigm that requires different study skills and time requirements” (Runge et al., 1999, p. 37). Whilst it may be hard to separate high personal self-efficacy from preferred training methods, it is often the personal beliefs that drive the choice and attitude to professional learning. “Teacher educators who use ICT innovatively, develop their competence based on the educational goals they want to accomplish with the help of ICT. Their active attitude and the ICT goals they set for themselves, play an important role in this” (Drent & Meelissen, 2008, p. 195). Such teachers keep active contact lists to assist in professional development around ICT issues, a concept described by Drent and Meelissen as “personal entrepreneurship” to contextualise the notion of specific contacts for the purpose of doing ICT-innovative business. So critical is this network of contacts for different types of learning and technical knowledge, Drent and Meelissen conclude that “personal entrepreneurship turns out to be the anchor point for stimulating the innovative use of ICT in education” (p. 197).

5.5.5 Effect of sex on exemplary integration

Table 43 on page 228 suggested that female exemplary ICT integrators were more likely to have a higher personal self-efficacy score than female teachers who are minimal adopters or technologically competent independent of the subject they taught. While Table 43 suggested that male exemplary ICT integrators were more likely to have a higher personal self-efficacy score, higher level of computer use score and higher personal activity with computers than males who are minimal adopters or technologically competent independent of their subject.

Table 46 on page 231 suggested that male science teachers who identified as exemplary ICT integrators in science are more likely to have a higher personal self-efficacy score, higher levels of computer usage and higher teacher activity than male science teachers who are minimal adopters or technologically competent. This was

not the case for female science teachers, as shown in Table 45 on page 231, where those teachers who identified as exemplary ICT integrators in science were only more likely to have a higher personal self-efficacy score than female science teachers who identified as minimal adopters or technologically competent. This was also not the case for male mathematics teachers who were more likely to have higher student and teacher activity scores than male mathematics teachers who were minimal adopters or technologically competent (Table 48 on page 234).

5.5.6 Effect of subject-specialisation on exemplary integration

The data collected from the online survey limited the across subject data to just two groups: science and mathematics. Technology teachers also participated in the survey, however their numbers were insufficient to make any statistically relevant comparisons. As a result, the conclusions regarding the effect of subject specialisation on exemplary integration is limited to just the two subjects. Despite this, data from Table 44 on page 229 suggests that exemplary ICT integrators in science are more likely to have a higher personal self-efficacy score, higher levels of computer usage and higher teacher activity than science teachers who identified as minimal adopters or technologically competent. By contrast, exemplary ICT integrators in mathematics were more likely to have a higher student and teacher activity score than mathematics teachers who were minimal adopters or technologically competent, according to the analysis displayed in Table 47 on page 232. It is one of the few occasions where the high personal self-efficacy variable has been tested and not demonstrated statistical significance against the self-assessed technology integration category. This is clearly an area for additional research.

5.6 Key competencies for professional learning around effective technology integration

In evaluating the data with the intention of adding a pragmatic component to this study, several interesting patterns emerged. Whilst it is difficult to make recommendations to prospective employers or professional learning providers regarding ways of increasing personal self-efficacy amongst teachers, there are ways of creating learning communities which foster growth and contribution. “Becoming

a teacher requires coming to understand one's self and developing the expertise needed to grow as a professional in the wider community" (Nager & Shapiro, 2007, p. 29). As neophyte teachers emerge from universities and teaching colleges this decade, the issues relating to the value of technology cease to require relevance. "Literature to date has reported that preservice teachers who have acquired higher level of technological skills are more willing to use technology in (the) classroom" (Chai, Koh, & Tsai, 2010, p. 64). This is also the finding of a 2013 study; "participation in professional development activities can significantly influence their ICT use" (Wastiau et al., 2013, p. 16). This study also highlighted the importance of informal training methods, blended training, relevant just-in-time training and collaboration between colleagues (Wastiau et al., 2013). Volman (2005) suggests that the positions of ICT coordinators or Head of eLearning may become redundant or "disappear" in line with the expectation that "teachers will work together more" (Volman, 2005, p. 19).

What appears to be of greater importance is "*technology-enabled learning* so that ICT is seen as the means for engaging in meaningful learning activities rather than ICT integration being adopted as an isolated goal" (Albion et al., 2015b, p. 657). If technology use is so closely tied to personal self-efficacy, as appears from this and other studies, it may no longer be worth trying to convert teachers who are nearer the end of their careers and still haven't embraced technology. "In order to increase teachers' technology uses in the classroom, professional development programs need to align with teachers' value beliefs" (Ottenbreit-Leftwich et al., 2010, p. 1323).

What may be of greater long-term value to education in general is to provide professional learning that is targeted, differentiated and practical in terms of immediacy of classroom applications and portable so it can be carried out by teachers in their own time and space. "Education systems may need to go further than simply training teachers in basic IT skills" (Downes et al., 2001, p. 12). The Australian Government response during the DER was to provide ICT integration to schools in a systematic and integrated manner which required appropriate professional development and training from pre-service teacher through to experienced staff (Albion et al., 2015b). The TPACK framework was used to embed the identified

skills and knowledge to encourage more effective ICT integration. As a result the professional standards continued to develop and refine towards their current form, in which teachers, depending on their level of experience, are required to integrate ICT as a component of how they teach the content, part of teaching standard 2.6 (NSW Institute of Teachers, 2013).

- Graduate teachers are expected to “implement teaching strategies for using ICT to expand curriculum learning opportunities for students.”
- Proficient teachers are expected to “use effective teaching strategies to integrate ICT into learning and teaching programs to make selected content relevant and meaningful.”
- Highly accomplished teachers are expected to “model high-level teaching knowledge and skills and work with colleagues to use current ICT to improve their teaching practice and make content relevant and meaningful.”
- Lead teachers are expected to “lead and support colleagues within the school to select and use ICT with effective teaching strategies to expand learning opportunities and content knowledge for all students.” (Leadership, 2011)

The selection and use of ICT resources to engage students is another key standard in NSW. A number of practical and theoretical ideas emerged from the Downes et al (2001) study which may have had a unique impact on subsequent and future professional development activities. “Effective and adequate teacher training is an integral element of successful learning programs based on, or assisted by, technology” (Noeth & Volkov, 2004). Situating the specific tools for learning within a professional learning experience may help teachers make direct links to their own classrooms. In WebQuests, a vehicle which has been previously used to promote student collaboration, “learners analyse a body of knowledge, transform it in some way and demonstrate in-depth understanding of the material by creating a final product that others can react or respond to” (Gaskill et al., 2006). Mobile apps are being utilised because of their ubiquitous nature and convenience. “The innovation in mobile apps has raised interests among educators because it facilitates teaching and learning” (Y.-C. Hsu & Ching, 2013, p. 118). Some studies have combined the

two with positive outcomes; “We found that using WebQuest with outdoor instruction makes a positive influence (*on*) the learning performance of students” (Chang et al., 2011, p. 1237). Several teachers reported students who routinely take out their mobile phones and take a photograph of a science experiment or mathematical proof, written on a whiteboard. Authentic assessment and contextualised professional learning is of such importance that many researchers provide multiple ways in which teachers can pick up an idea and translate it directly into their classrooms (Boss, 2012; November, 2012; Ormiston, 2011; Richardson, 2010; Solomon & Schrum, 2007). November (2012) posed the rhetorical question: “what if we could apply autonomy, mastery and purpose to the learning culture for every student? That is the goal that drives the Digital Learning Farm model; to create a culture of learning in which students feel autonomous, masterful and purposeful” (November, 2012, p. 13). November’s solution, at least in part, is to “teach students to use information and communication technologies to innovate, solve problems, create and be globally connected” (November, 2012, p. 14).

Most participants in the survey, irrespective of their ICT integration ability, identified the importance of independently learning the skills they needed around technology. “95% of the exemplary technology-using teachers indicated some of their technology-related skills had been learned on their own” (Hakverdi, 2005). Technology can be a tremendous user of time and many professional development activities are not differentiated sufficiently for all teachers to benefit equally. It is reasonable to assume most teachers will recapitulate the phases of technological diffusion; substitution to transition and then transformation (Plomp, ten Brummelhuis, & Pelgrum, 1997) as they are becoming more confident in their own use of technology. Different teachers will progress through these stages, or perhaps the stages of the SAMR model (Puentedura, 2010) more quickly than others, or perhaps the activities will change in terms of the proportion of higher level, transformative uses of technology. It seems equally relevant that teachers bring real problems or plans to professional learning sessions as technology instruction without context is of limited value. Contextualised instruction which provides learner autonomy and an expert facilitator is a model of effective professional learning

which can be duplicated in the classroom. Teachers need the opportunity to work within an ideal model of delivery that can be easily transferred to the classroom setting.

Schools can also take a major role in the development of ICT capacity within their teaching staff. “A well-developed staff development program is critical to achieving successful implementation of computer use in the classroom” (Al-Alwani & Soomro, 2009, p. 152). By allocating additional resources to target individual teacher support, team teaching approaches or collaborative learning (Hilton & Hilton, 2013), schools can establish a community of learners who support each other through a shared vision of what effective ICT integration looks like for their school. “The attitude of faculty toward computers was found to be associated with the use and adoption of computers in teaching activities” (Yang, 2010). A whole school plan is equally critical if teachers are made to feel secure in using ICT technologies and brave in extending their application. “The way in which ICT will influence education should be a question of pedagogical not educational choices” (Volman, 2005, p. 20).

Unfortunately many schools have the process in reverse; “school leaders often start by thinking about the intended *results* that technology should provide within their school environment. Next, these leaders take certain *actions* regarding the attainment, allocation, use, and support of technology” (Baylor & Ritchie, 2002, p. 396).

Perhaps it is the paradigm around professional development itself which is changing. “Effective professional development of teachers is the key to widespread and effective integration of technology into classrooms” (Newhouse et al., 2002, p. 44). If teachers are to become more effective integrators of technology, then professional learning providers need to put the tools in their hands and provide the time and support necessary to ensure these tools can be used effectively in the classroom. “The sharing of information, and the networking amongst teachers that develops as a result of participation in conferences of this kind, present important opportunities for teachers to shape their own professional development” (Pearson, 2003, p. 44). This can, and probably should, include a school-based mentor (Kopcha, 2012). It is at the

school level where some of the greatest gains can be made; “situated professional development has tremendous potential to promote long-term changes in teachers’ attitudes toward and practices with technology” (Kopcha, 2012, p. 1110).

One of the challenges associated with effective professional learning activities is “we know very little, for example, about the sustained level of teacher change as a result of participation in technology professional development” (Lawless & Pellegrino, 2007, p. 607). We also have limited evidence about the efficacy of technology integration on student learning outcomes. However there are questions about how evidence is gathered, what evidence should be gathered and even how we should assess, or if our previous methods of assessment are still relevant in the current paradigm (Australian Curriculum, 2008; Gulek & Demirtas, 2005; Sciences, 2012). Some discussions appear to be occurring around these issues and they will impact on current and future professional learning opportunities. However we are learning that “when students have clearly defined expectations for learning achievement, and are then given responsibility for their own learning and support during the process, they achieve significantly more in less time” (Fullan & Longworthy, 2014, p. 53). Professional agencies need to remember this and deliver courses which treat teachers in a similar way. “When we share online, we create the potential for connections in ways that were simply not possible even a few years ago” (Richardson, 2010). Motivated teachers seeking answers to questions about technology are going to colleagues, user group forums, online help, experts within and beyond their school or district to gain the knowledge they require. “Previous studies report an important positive effect of collaborative learning on peoples’ learning experiences” (Hui et al., 2008, pp. 247-248). Effective professional learning targeting exemplary ICT integration will facilitate this form of collaboration to extend the talented and gifted teachers in this area of their craft. “The collaborative construction of knowledge by those willing to contribute is redefining the ways we think about teaching and learning at every level” (Richardson, 2010). It will also benefit the students. “If we want our students to be competitive in the global economy, we must challenge them to communicate to, and collaborate with, a worldwide, authentic audience” (November, 2012, p. 70). In order to do this, “we need more educational leaders and

front-line teachers who are willing to empower students to co-create curriculum, own their learning and make contributions to the collaborative process of learning” (p. 89). That is why it requires a paradigm shift.

5.7 Summary

In this chapter, an analysis of both online survey and qualitative interview data was reported in the context of the research questions and the wider field of technology integration. This led to a clarification of the issues surrounding enablers and inhibitors of exemplary ICT integration practice, the specific factors which link most closely to exemplary technology integration and recommendations for future professional learning. Whilst several samples were too small to demonstrate statistical significance, similar causal factors and reported behaviours were characteristic of minimum adopters, competent users and exemplary ICT integrators.

In seeking to clarify the answers to research questions one to three, statistical support was provided to suggest personal qualities of the teacher, their level of computer usage inside and outside the classroom and their professional development experiences were the key enablers of exemplary ICT integration. These enablers included teachers’ personal self-efficacy, their high level of computer usage, the time they allocate to finding and/or developing relevant ICT resources, the presence of expert peers willing to share their knowledge and skills, the development of a student-centred pedagogy, their opportunities for informal PD, and the recognition of the importance of informal PD in developing knowledge and understanding, the types of computer use both in a professional context and in the classroom and the movement away from a traditional, didactic pedagogy to a progressive, student-centred model. These findings were largely independent of the culture or gender of the participants as well as the subject they taught.

Inhibitors to exemplary ICT integration identified included equity of access to technology, recognition of the value of technology and/or the time invested in learning with and through technology, the lack of practical support from a network of learners and/or a dedicated local (school level) expert in ICT integration, low

personal self-efficacy relating to ICT integration, professional development which is not differentiated, irrelevant or too broad and the lack of allocated time for technology exploration.

The three research questions will be summarised in the final chapter, along with a focus on the pragmatic element of the research and recommendations for the direction of future professional learning around ICT integration. Some limitations and recommendations for future research will close the last chapter of this study.

Chapter 6 Conclusions

6.1 Introduction

The previous chapter has presented an analysis of the quantitative and qualitative data in the context of current understandings. It sought to cover all three of the research questions and evaluate them against the collected data. The discussion focussed on the relevance of high personal self-efficacy; regular and diverse computer usage, both inside and outside the classroom; ongoing professional development in a peer-supported learning environment and a focus on student autonomy as enablers of exemplary ICT integration. Several inhibitors were also reinforced regarding time, technology infrastructure and access to quality professional learning networks.

As a result of Chapter Five, some definitive findings from this study have been generated and discussed. These findings and the conclusions from this study will be summarised in this final chapter. These findings will be presented in the context and order of each of the research questions. Each research question will be addressed, along with practical applications for future professional learning, perceived limitations of the study and some recommendations for future research.

6.2 The importance of this research

The volume of research available regarding technology integration into secondary classrooms is large and growing at a rapid rate. This study has sought to add an additional level of detail to this body of knowledge by focussing on the pragmatic methods by which teachers may seek to improve their implementation of technology integration with their classes. The richness in the qualitative data and breadth and depth of individual responses produced in both the online survey and personal interview components of the study has provided some clear directions for schools and teachers seeking to build capacity in ICT integration. “We cannot meet the challenges of the 21st century with the educational ideologies of the nineteenth.” (Robinson, 2011, p. 283). It is the premise of this study that the 21st century has demanded new approaches to teaching and learning; especially when it comes to the

application of information and communication technologies. “Schools can play a different role, contributing to a reinvention of better and alternative futures” (Egea, 2014, p. 281). Whilst many proponents of the approach to creative schooling (Robinson, 2011), new pedagogies and deep learning (Fullan & Longworthy, 2014), augmented learning (Klopfer, 2008) or an expansion in the tools and techniques of Web 2.0 (Solomon & Schrum, 2007) and Web 3.0 tools (Rajiv, 2011) may be requiring too great an investment from already strained teachers and school administrators, there are several ways in which schools and individual teachers, and even professional development providers, can modify their practice to improve student engagement and facilitate more effective ICT integration. “The evolution of Web 2.0 tools has enabled a greater level of participation, collaboration, and knowledge construction among students (Brandon, 2008)” (Ertmer et al., 2012, p. 432). This applies equally, and perhaps even more so, to teachers, many of whom may not have embraced the collaborative nature of the Web 2.0 tools as readily as the students. The following sections summarise the findings of the research, some of which may contain pragmatic suggestions for teachers, heads of departments, eLearning coordinators and principals, as well as providers of professional learning.

6.3 Summary of findings from the study

6.3.1 Research Question 1

What are the enablers and inhibitors of exemplary ICT integration?

Research question one referred to the identification of the enablers and inhibitors of exemplary ICT integration practice in secondary education. The study revealed a number of enablers and inhibitors in secondary classrooms, consistent with those in the literature. Exemplary integrators have a pedagogical focus rather than a substitutive or utilitarian focus on technology to enhance learning outcomes. Exemplary ICT integrators focus on the student and how they learn and less on the technology. It is important to recognise the persistence of many of these factors across differences in school culture, teacher’s sex and subject taught.

Enablers of exemplary ICT integration practice include:

- The teacher's personal self-efficacy; the greater a teacher's perception that he or she can effectively use technology in the process of teaching and learning, the more likely the teacher has the ability to do so.
- A high level of computer usage; effective technology use is increased as technology becomes an indispensable tool for both teacher and students in the classroom.
- Time for finding and/or developing relevant ICT resources (allocated or personal); the more time teachers spend in or out of the classroom interacting with technology, the greater their use of technology in the classroom.
- Expert peers willing to share their knowledge and skills; the stronger the community of learners, the more likely exemplary practices will flourish as teachers have a local expert with whom they can consult.
- Student-centred pedagogy, where students are creating and organising knowledge; exemplary integrators favour student autonomy with clear scaffolding of tasks and the broad use of technology in order for students to achieve their personal learning goals.
- Opportunities for informal professional learning; all teachers benefit from time to explore technology and the various applications, however exemplary ICT integrators use peers, their students and online sources to supplement their own learning.
- Recognition of the importance of informal professional development in increasing knowledge and understanding of technology integration; current teacher accreditation practices do not always place the same importance on informal professional development activities as they do on formal ones by registered providers. Despite this, exemplary ICT integrators are more likely to pursue technology usage in their own time and in their own way.
- The types of computer use both in a professional context and in the classroom; exemplary ICT integrators are creating and targeting content and experiences for their students in order for them to become active learners and to subsequently create content of their own.
- A movement away from a traditional, didactic pedagogy to a progressive,

student-centred model involving blended learning and flipped classroom strategies; exemplary ICT integrators are becoming more comfortable in the role of facilitator rather than lecturer.

Common inhibitors of ICT integration practice identified in this study include:

- Equity of access to technology; challenges relating to infrastructure, hardware and software, educational sector and/or budgetary constraints and/or broadband access all reduce the effectiveness of ICT integration in the classroom.
- Recognition of the value of technology and/or the value of time invested in learning with and through technology; some less effective integrators of technology manifest a justification for the minimum use of technology on the basis of a lack of evidence of the efficacy of technology as a legitimate learning tool.
- Lack of practical support from a network of learners and/or a dedicated local (school level) expert in ICT integration.
- Low personal self-efficacy relating to ICT integration.
- Professional development which is not differentiated, irrelevant or too broad in its scope. One head of eLearning identified during the interview the challenge of actually having “*a real problem to solve or something to build*” (CUH01). Just in time learning (Lim, 2007) and deep learning (Fullan & Longworthy, 2014) are becoming increasingly important for teachers as well as students to increase the productivity of both teacher and learner.
- Lack of allocated time for technology exploration; this may include systemic software, such as a new school learning management system, or an application deemed interesting and/or relevant for a particular group of students in a class.

6.3.2 Research Question 2

What are the sets of skills, outcomes or personal motivators which separate the minimum adopter, the competent user and the exemplary integrator in the context of

ICT integration practice?

Research question two sought to clarify the sets of skills, outcomes or personal motivators which separate the minimum adopter, the competent user and the exemplary integrator in the context of ICT integration practice. The literature review and both online survey and qualitative interviews suggest that there were six primary areas which determined, or contributed to exemplary integration both across international communities and within the New South Wales education sectors. The volume of literature dedicated to ICT integration, along with the valuable input and observations of practicing teachers, make clear that the following issues have a significant effect on the quality and quantity of ICT integration which is occurring in the classrooms. These six questions formed the framework for addressing research question two.

- 2a. How do the exemplary integrators' preferred training methods differ from other integrators of technology?

The training methods of exemplary integrators: exemplary technology integrators are more likely than competent users or minimum adopters to prefer informal training which is differentiated, targeted and collaborative. It should be facilitated by an expert, which could be a colleague and will have a component of follow-up and access to the expert peers which encourage ongoing learning.

- 2b. How do exemplary integrators' patterns of technology usage, both inside and outside the classroom, differ from other integrators of technology?

The patterns of technology usage of exemplary integrators: exemplary technology integrators are more likely to use technology in a different way to competent users or minimum adopters. They seek more challenging technology and applications in their own learning and may even design their own tools for specific student needs. They will encourage students to use tools which drive self-directed learning and give students greater exposure to data gathering, analysis and presentation.

- 2c. What is the preferred pedagogy of teachers who view themselves as exemplary integrators?

The teaching style or pedagogy of exemplary integrators: exemplary technology integrators are more likely than competent users or minimum adopters to facilitate learning activities which encourage student autonomy. They seek options for students to demonstrate choice and differentiate activities to increase student motivation levels.

- 2d. Do exemplary integrators have a higher personal self-efficacy than other integrators of technology?

The personal self-efficacy of the exemplary integrators: exemplary technology integrators are more likely than competent users or minimum adopters to have high personal self-efficacy regarding their ability to effectively use technology in their classrooms.

- 2e. Do the differences between teachers, in terms of their degree of technology integration, persist between male and female teachers?

The sex of the exemplary integrators: exemplary technology integrators are neither more nor less likely than competent users or minimum adopters to be female, however if they are, they are more likely to have a high personal self-efficacy regarding computer usage in the classroom. If they are male, they are more likely to have a higher personal self-efficacy, higher level of computer use and higher personal activity with computers than male competent users or male minimum adopters.

- 2f. Do the differences between teachers, in terms of their degree of technology integration, persist across different subject-specific (maths and science) groupings?

The subject taught by the exemplary integrators: exemplary technology integrators are neither more nor less likely than competent users or minimum adopters to be science teachers than mathematics teachers.

However if they are science teachers, then they are more likely to have a higher personal self-efficacy score, higher levels of computer usage and higher teacher activity score than science teachers who identified as competent users or minimal adopters. If they are exemplary integrators in mathematics, they are more likely to have a higher student and teacher activity than mathematics teachers who were competent users or minimal adopters.

6.3.3 Research Question 3

What are the key competencies required as a component of targeted professional development for effective and exemplary ICT integration in the Australian Curriculum context?

The final research question sought to add a level of pragmatism to the study. In research question three, the key competencies required for effective and exemplary ICT integration in the Australian curriculum context, specifically in New South Wales schools, were identified for the purpose of informing and targeting future professional development opportunities.

Key competencies for professional development include:

- Teacher as learner – differentiation through student autonomy is critical for student engagement and this principle should be no different for teachers. Teachers need to be taught as they are expected to teach.
- Teacher as creator – teachers need the opportunity to create content in a supportive environment; to examine tools and applications, to record and embed videos, to gather and analyse data and to present information in a variety of formats, relevant to their needs and those of their students. This requires time and hence needs to be a part of individual personal development programs.
- Teacher as team member – too many teachers are wrestling with the same issues and often coming up with similar solutions. Facilitating a collaborative community of learners, either within a school or across school

boundaries helps keep the learning dynamic and ongoing. It allows ideas to be shared, trialled, manipulated and changed to suit the individual and their specific classes.

On the basis of the assumption that teachers interested in increasing their technology integration efficacy will seek to model best practice, there were several additional competencies identified to encourage the development of exemplary ICT integrators.

Additional competencies for the development of exemplary technology integration practice include:

- Teacher as collaborator – professional learning needs to involve the teacher in a wider learning community to provide access to other experts and to encourage high personal self-efficacy through status and consultation. This could, and arguably should, also include students.
- Teacher as innovator – professional learning needs to focus on creating content and providing the tools necessary for teachers to be drivers of the experiences that occur in their classrooms and beyond. This could involve flipped learning-style communities of learners, where teachers attend group-based, explanatory professional development based on video material they have watched prior to the group session. Exemplary integrators in the study were more likely to use presentation software and imaging to create rich content for their student use both in and outside the classroom. There seems to be no apparent reason why the teacher could not learn under a similar model.
- Teacher as motivator – in the new paradigm, the teacher needs to shift from the role as pedagogue to one of facilitator. Provisioning students with scaffolded tasks, learning activities and a variety of tools and pathways to fulfil the requirements of those tasks can encourage increased student autonomy and engagement. This can be achieved through the increased use of applications specifically designed for data analysis, and content creation, including publishing software.

This section has presented the key findings for each of the research questions in this study. In the final sections, limitations of the study are discussed, along with recommendations for future research.

6.4 Contribution to the body of knowledge regarding exemplary ICT integration

The primary goal of this research was to apply the known inhibitors and enablers of technology integration to the New South Wales context. Against a background of data analysing common inhibitors to technology integration and the enablers which have sought to overcome these inhibitors on a global scale, as well as studies into exemplary science teachers use of technology (Hakverdi, 2005), this study has contributed the following key outcomes.

1. New South Wales science and mathematics teachers, like their counterparts in many parts of the world, are frustrated by the lack of reliable devices available to their students and the quality and consistency of connection to the internet.
2. Many New South Wales science and mathematics teachers feel constrained by the competing demands on their time and the need to allocate sufficient time to finding, developing and evaluating technology based learning objects.
3. Many New South Wales science and mathematics teachers find many approaches to professional learning unproductive and undifferentiated to the extent that a high percentage prefer to learn about technology on their own or with the assistance of a local peer or expert.
4. High personal self-efficacy is a primary enabler of technology integration and a good indicator of an exemplary ICT integrator, independent of cultural focus, sex or subject taught. New South Wales science and mathematics teachers reinforce the patterns observed in previous studies.
5. Exemplary integrators of technology in New South Wales science and mathematics classrooms are characterised by higher usage of computers for imaging and publishing than other technology-using teachers.
6. Exemplary integrators of technology in New South Wales science and

mathematics classrooms are more likely to require their students to work autonomously and use technology creatively, ie for publishing and data logging and analysis, and more often than other technology-using teachers.

7. Exemplary integrators in New South Wales teaching secondary mathematics or science are more likely to value informal professional learning activities than formal ones, including learning independently or with a local colleague.

6.5 Limitations of the Study

Despite the richness of the data supplied by participants in this study, some limitations were apparent and will be discussed in this section. In broad terms, these limitations relate to the levels of confidence placed on conclusions drawn from this research in the context of the number of participants in the online survey, the representative nature of the sample and whether all the groups are equally represented, pre-existing attitudes to technology use and/or academic research and the completion of questionnaires in the self-selection process, the self-selection process itself, the time invested to complete the online survey and the survey tools which were specifically developed for this study.

6.5.1 Sample size

The size of the survey sample created some statistical limitations for this survey. While the literature continues to build and, in many cases, confirm previous findings, the small sample size prevented some analyses from providing statistically significant results. Whilst a number of patterns were established regarding the level of computer usage, personal self-efficacy, preferred training and student and teacher activity relating to specific applications, a larger sample, from a broader range of school cultures and subjects may have been better able to address specific issues arising from the research questions. There are also several warnings in the literature about being too broad in seeking to generalise about ICT usage; “there is no universal truth when it comes to applying ICTs in education, and that there is no advice that can be directly applied without considering each country’s reality, priorities and long-term budgetary prospects and commitment” (Kok, 2006). Some

of the paucity in the online survey data has been partially compensated for by the richness of the data collected from each individual who completed the online survey and by those who completed the subsequent qualitative interviews. Future studies may be able to pick up on some of these factors and, with an expanded sample size, more effectively comment on their degree of significance.

6.5.2 Representative nature of the sample

Conclusions based on common enablers or inhibitors are only valid when the various groupings are of a large size and of similar numbers. This was not the case for some of the groupings in this research. New South Wales is a large and diverse state with systemic differences, budgetary and funding challenges relating to equity of access and strong competition between schools for Higher School Certificate (HSC) academic rankings (Gonski et al., 2011). There are good reasons why teachers and principals may be reluctant to allow their staff to be involved in sharing practices with teachers or researchers based in other schools. Despite these difficulties, 140 educators began the survey and 96 of these participants reached the final question. This may only represent a fraction of the science, technology and mathematics teachers across the state, but it does represent a very motivated and self-reflective group keen to promote the place of technology integration in the curriculum. Self-selection for participation in such a survey may favour those with a predisposition towards effective technology integration, as they may be more likely to contribute to a survey in which they have a personal interest (Groves, Presser, & Dipko, 2004). Unfortunately, the number of technology teachers was too small in the initial quantitative survey to produce meaningful statistical analysis.

Sample sizes from different states outside of New South Wales were also too small and these states were excluded from the data set. They could prove to be a suitable target for future research. There was no attempt to skew the representation in the sample, other than to seek additional participants from sectors or groups which appeared underrepresented in the study. This was not particularly successful for some cultural groupings, such as Jewish schools and Islamic schools and as a result their small sample size has precluded them from separate statistical analyses. Future

studies may seek to target a number of different sub-groups within this broad sample to focus more deeply on the emergent patterns.

6.5.3 Pre-existing preferences and assumptions within the participant group

Teachers who participate in a study about technology usage may already be confident and capable users of technology. Alternately, they may be holding a bias against technology and seeking a forum in which to express their negative views. There may also be inherent differences between the ways in which teachers who are willing to participate in an online survey about technology interact with technology in their classroom and those teachers who are unwilling or unable to participate in such a survey. An unwilling or time-poor teacher may be disinterested in technology, or may be very busy with or without technology. They may have made a decision that dedicating the time needed to complete a lengthy survey would not have provided sufficient perceived personal benefit against other priorities. Hence bias may be present in this study as a consequence of self-selection and or those who already work in a more collaborative mode. This applies equally to whether the invitations sent to principals, or their designate, were passed on to the appropriate educators in their schools.

6.5.4. The time required for the online survey and/or the qualitative interview

The length of the online survey and the personal interviews may also have impacted on the quality of responses. Surveys typically took between 20 and 40 minutes to complete and the qualitative surveys lasted for between 15 and 45 minutes. This time commitment may have dissuaded many busy teachers from completing either or both surveys. As identified in the previous section, this form of voluntary participation may favour those with a predisposition towards effective technology integration, as they may be more likely to contribute to a survey in which they have a personal interest (Groves et al., 2004). Detailed information with many open-ended questions can be challenging and time consuming and some responses were left blank or with “abc” type responses in order for a participant to move on to the next question. Sections were separated in order to regularly thank participants for their

responses and encourage them to provide thoughts in a subsequent section. Despite this, there may have been participants who were conscious of the time they were spending and in seeking to accelerate their progress through the survey provided less detailed responses to some of the questions than they may have done with more available time. This may have diminished the strength of the messages, particularly in some of the open-ended questions.

6.5.5 Self-selected categories of technology integration

Only five participants identified themselves as minimum adopters in the survey, so many of the findings focus on the distinction between competent technology users and exemplary ICT integrators and this distinction is not rigid, both in the literature (Mumtaz, 2000) and by participants. Errors appeared in scales such as the level of computer use, although the reliability tests were encouraging. Despite this, there have been concerns raised in the literature about the value of these sorts of surveys, as some researchers infer that surveys similar to the one used in this study “are not always considered effective measures of technology integration” (Judson, 2006, p. 585). This has also been expressed in the context of self-assessment regarding pedagogy and instructional technology; “researchers stepped into the classrooms with a constructivist lens and found there was no significant correlation between teachers’ reported beliefs about instruction and their actual practice of integrating technology” (Judson, 2006, p. 590). Whilst the correlations appeared sound, the interviewees challenged some of these labels. One participant self-assessed as a competent user and upon interview reported a role in eLearning within his school. In addition his responses suggested a high level of technology usage in the classroom and techniques and innovations which were suggestive of an exemplary integrator. If the number of participants who self-assessed their level of technology integration were either too modest in their abilities, or over-valued their competency, it could affect some of the conclusions from this study.

6.5.6 Untested components of the online survey

The reflection on computer usage section of the online survey was new and

developed for this particular study. It has not been verified other than through statistical tests of significance against responses from the same participants to other questions and hence forms an additional qualitative component of the study. Activities were arbitrarily chosen to try and highlight the most common uses of technology both inside and outside the classroom and activities which were more likely to invoke levels of student choice, autonomy and self-direction. The changing nature of technology has implications for such activities and in a few years' time there may be greater value in selecting a completely different group of activities as indicators of exemplary technology integration. There may also be some value in teacher observation, either by a peer, supervisor or researcher, as a means of verifying self-assessment of the level of technology integration.

6.6 Recommendations for Future Studies

This study suggests that a number of teachers in New South Wales secondary science and mathematics classrooms are dynamic, creative educators seeking a range of tools and experiences to motivate their students. Technology continues to expand our personal networks and put school communities on either side of the planet in contact with one another. However, "technology may mean little without appropriate objectives and goals for its use, structures for its application, trained and skilful deliverers, and clearly envisioned plans for evaluating its effectiveness" (Noeth & Volkov, 2004, p. vi). According to this study, many of the exemplary integrators know what they want technology to do, both for themselves and for their students. The self-assessed categories of technology integration were chosen for practicality in this study and perhaps more research may need to occur around defining each of these categories of technology usage and/or seeking a general agreement on how to unambiguously define an exemplary integrator of technology. Of course, as with all technology-related practices, this is bound to change over time. Despite this, there are five recommendations which have emerged from this study. Each of these will be discussed in the paragraphs below.

6.6.1 Recommendation 1 – Increasing the time allocation

It is recommended that, for teachers to be able to effectively integrate technology in their classrooms they are given a specific allocation of time. Teachers shared their preparedness to allocate the necessary time to develop lessons and manipulate the technology to suit their personal, classroom needs, often in their own time. However, many of the teachers, whether they were exemplary integrators or not, consistently raised the issue of time pressures, often in the context of large amounts of content which they were needing to deliver to their students. The damage this content-pressure can do to a teacher's creativity has been highlighted previously in the literature; "policy makers typically narrow the curriculum to emphasise a small group of subjects, tie schools up in a culture of standardised testing and limit the discretion of educators to make professional judgments about how and what to teach. These reforms are typically stifling the very skills and qualities that are essential to meet the challenges we face: creativity, cultural understanding, communication, collaboration and problem solving" (Robinson, 2011). Despite the costs associated with allocating teachers a 'technology integration' period, such a scheme may provide some small incentive for teachers to explore applications and add to their knowledge and skills in order to more effectively integrate technology into their lessons. It may be a way for principals to acknowledge the additional burden placed on teachers to be effective integrators of technology and to encourage the regular use of time for exploring technology and sharing the results of these investigations with their colleagues.

6.6.2 Recommendation 2 – Ongoing professional learning

It is recommended that future planners of professional development could seek ways of increasing the involvement of teachers in their scheduled professional learning activities. In light of the comments made by a number of exemplary integrators regarding the undifferentiated and isolated nature of professional development, professional learning providers could develop experiences which involve a regular, ongoing interaction with teachers to reinforce their learning and address any concerns raised as teachers apply their knowledge and skills in their own classrooms.

Researchers may wish to determine the efficacy of one-time professional learning against this series of learning experiences. In practical terms, instead of organising a single event where teachers gather, absorb information and leave, collaborative groups may be established with several check-in dates. This allows teachers to absorb and apply what has been learned and return to the group with relevant questions and specific applications for their classrooms to update their knowledge and continue the learning process. Many of the enablers identified in this study centre on the teachers; their personal self-efficacy and individual needs. “One of the major arguments in the literature is that, historically, professional development has always been the focus of what the policymakers and administrators thought was best without taking into consideration the teachers that are going to implement innovations” (Vaughan, 2002). The teachers in this survey shared their knowledge of their specific needs. Having articulated it clearly, there were demonstrably different needs for different teachers. Some of the research implores administrators to use exemplary teachers as their innovation leaders (Proctor & Marks, 2013). Perhaps professional learning providers and principals could plan to use exemplary integrators more effectively to lead these collaborative learning groups and facilitate ongoing support through a project-based learning framework for teachers.

6.6.3 Recommendation 3 – Strengthening the commonality argument

It is recommended that, in order to increase the generalisability of the results, a larger sample is chosen to include greater representation from some of the groups under-represented in this sample. A larger scale study would be useful to determine if many of the observed patterns remained statistically significant for a broader sample, as was indicated by the qualitative data from this study. Cultures underrepresented in the survey, such as Jewish and Islamic Schools, or Japanese, French or German Schools could be the focus of future studies as the results may support a wider application of the principles identified in this study. Previous studies, for example, comparing Hebrew and Arabic-speaking teachers’ use of ICT found “among science teachers, Hebrew-speaking teachers indicate greater ICT usage in their target class. This may be the result of science being associated with collaborative learning,

complying with an emerging pedagogical paradigm that is found more within the Hebrew-speaking sector compared with the Arab-speaking sector” (Nachmias et al., 2010, p. 504). It would be profitable to conduct a similar study to compare a wider range of cultural or subject-specific groupings than were obtained through self-selection in this study. Increasing the sample size for science, technology and mathematics teachers and examining more closely the patterns of technology usage by these teachers may also reveal some important trends.

6.6.4 Recommendation 4 – Observations and principal recommendations

It may prove valuable to change the selection process for representation in each of the different categories in this study. As our understanding of exemplary ICT integration practice grows, it may be possible for principals to familiarise themselves with this sort of survey and provide an independent assessment of participants’ abilities to integrate technology in their lessons. This could be based on their personal knowledge and/or lesson observations, or as part of the ongoing New South Wales Teacher Accreditation process. A measure of external assessment of technology integration may counter some of the incongruity in self-assessment of the level of computer usage required by this study. Principals could nominate a teacher they felt was exemplary, one who was competent and one who was a minimum adopter to complete a survey. This may eliminate problems between the group sizes when conducting analyses of variance tests on means. Of course, this may simply move the ambiguity from a large group to a smaller one.

6.6.5 Recommendation 5 – Expanding the sub-groups

It is recommended that a large scale study could be undertaken to examine other micro-groupings which have emerged within this study, but for which there were too few participants for meaningful analysis. The small sample size in the online survey has hence limited some of the generalisability of the findings from this study, and future researchers may wish to expand the number of participants or target specific subgroups within the sample, eg female science teachers in Catholic schools. Whilst it is critical to understand the differing needs between exemplary integrators and

minimum adopters, it may also be of interest to examine the differences between rural, male, experienced science teachers in a school which has a predominantly Aboriginal culture and history focus with rural, female, experienced science teachers in a school which has a predominantly Aboriginal culture and history focus. Such a study would necessitate a very large number of independent variables and hence would need a very large sample of participants to produce meaningful results. The number of participants in this study was insufficient for this level of detail.

6.7 Summary

In this chapter, practical applications in the context of exemplary ICT integration have been presented. Several key competencies, including personal self-efficacy, collaborative learning and creativity have emerged as strong drivers of exemplary practice. Limitations of the research have been identified along with some recommendations for future principals, professional learning providers and researchers.

A key practical outcome of this study has been the identification of the enablers and inhibitors of exemplary ICT practice and the need to target professional learning experiences to encourage the presence of the enablers within individual teachers, their classrooms and across the wider school community. The research findings suggest that the presence of the following enablers significantly increase the level of exemplary ICT practice in classrooms and across the school.

- The teacher's personal self-efficacy.
- A high level of computer usage in teaching and learning.
- Time allocated for finding and/or developing relevant ICT resources.
- Expert peers willing to share their knowledge and skills.
- Student-centred pedagogy.
- Opportunities for informal professional development.
- Recognition of the importance of informal professional development.
- The active creation of content and experiences for and by students.
- A progressive, student-centred learning model where the teacher acts as

facilitator.

If teachers can identify the following factors present in their own teaching environments, they may acknowledge them as potential inhibitors of exemplary practice.

- Equity of access to technology and infrastructure.
- Personal recognition of the value of technology.
- Personal recognition of the value of time invested in learning about technology integration.
- Lack of practical support from a network of learners.
- Absence of a dedicated local (school level) expert in ICT integration.
- Low personal self-efficacy relating to ICT integration.
- Professional development which is not differentiated, irrelevant or too broad in its scope.
- Lack of allocated time for technology exploration.

If such factors are identified within the teacher and/or the learning environment, they would need to be identified as having a negative effect on technology integration. Targeted professional learning designed to enhance the use of technology in the classroom could benefit from a consideration of the following:

- The teacher as a learner - structure the learning to cater for different needs and experiences.
- The teacher as a creator - provide the opportunity to create content in a diverse and supportive environment.
- The teacher as a team member - facilitate a collaborative community of learners to keep the learning dynamic and ongoing.

In consideration of the additional factors which seek to target the most experienced ICT integrators and those educators seeking to extend their effective use of technology in the classroom, the following could be considered:

- The teacher as a collaborator – establish professional learning communities as

they are essential if exemplary practice is to filter through the school or system and these communities will also need a degree of differentiation if they are to extend the most capable technology-integrating teachers.

- The teacher as innovator – the creation of content and provision of adequate tools for teachers to access prior to, within and beyond the initial professional learning experience.
- The teacher as motivator – facilitate the shift in role from pedagogue to facilitator.

No research provides a single solution to every problem, however this study has provided a number of important indicators which may assist individual teachers and school communities to improve their experiences with technology and enhance the learning experiences of their students.

The author of this study would strongly recommend schools are given the opportunity to benefit from the findings of this study. A summary of the key findings will be made available through publication in relevant teacher/educator journals or school magazines. Workshop activities will also be designed and delivered as a consequence of this study. As both an observer in the process of this study and a practicing teacher, the researcher is ideally placed to identify differences which have emerged in his own teaching practice and the changes he has made in response to this study. As a believer in collegial practice, he will likewise share these findings with other New South Wales and Australian teachers in order to leverage the benefits from such a significant body of work.

References

- Abbitt, J. T., & Klett, M. D. (2007). Identifying influences on attitudes and self-efficacy beliefs towards technology integration among pre-service educators. *Electronic Journal for the Integration of Technology in Education*, 6, 28-42.
- Abbitt, J. T., & Ophus, J. (2008). What we know about the impacts of WebQuests: A review of research. *AACE Journal*, 16(4), 441-456.
- Abdelwahed, S. (2014). ICT Integration in Education and Training in Tunisia. In A. I. T. Force (Ed.), *The integration of ICT into education and training systems in Africa: The Cases of Argentina, Burkina Faso, Côte d'Ivoire, Paraguay, Senegal, Tunisia and Uruguay* (pp. 181-218). Tunisia: Association for the Development of Education in Africa
- Abuhmaid, A. (2008). *An analysis of ICT integration within the Jordanian education system*. (PhD), University of Technology, Sydney.
- Acevedo, E. M. (2013). *Professional learning for teachers through a differentiated professional development program*. (Ed.D.), College of Saint Elizabeth, New Jersey.
- Adams, W. K., Alhadlaq, H., Malley, C. V., Perkins, K. K., Olson, J., Alshaya, F., . . . Wieman, C. E. (2010). Making on-line Science course materials easily translatable and accessible worldwide: Challenges and solutions. *Journal of Science Education and Technology*, 21(1), 1-10.
- Ainley, J. (2013). *Great teaching, inspired learning: What does the evidence tell us about effective teaching?* Sydney: Centre for Education Statistics and Evaluation.
- Akca, H., & Yager, R. E. (2010). The impact of a Science/Technology/Society teaching approach on student learning in five domains. *Journal of Science Education and Technology*, 19(6), 602-611.
- Al-Alwani, A. E. S., & Soomro, S. (2009). Integration of information technology in Science education at Yanbu, Kingdom of Saudi Arabia. In A. Lazinica & C. Calafate (Eds.), *Technology, Education and Development* (pp. 151-162): InTech.
- Al-Rasbi, A. J., Al-Balushi, M. S., Al-Kharusi, S. A., Al-Harhty, S. S., & Al-Zadjali, A. M. (2008). Oman: Analysis of differences in mathematics achievement of Grade 8 students in Arabic countries depending on the availability and use of computers. In P. Lietz, H. Wagemaker, O. Neuschmidt & J. Hancke (Eds.), *Educational issues in the Middle East North Africa Region: Outcomes of the IEA Arab region training seminar series 2006/2007*. Hamburg, Germany: IEA data processing and research centre.

- Albion, P. R., Tondeur, J., Forkosh-Baruch, A., & Peeraer, J. (2015a). Teachers' professional development for ICT integration: Towards a reciprocal relationship between research and practice. *Education and Information Technologies, 20*(4), 655-673.
- Albion, P. R., Tondeur, J., Forkosh-Baruch, A., & Peeraer, J. (2015b). Teachers' professional development for ICT integration: Towards a reciprocal relationship between research and practice. *Educ Inf Technol, 20*(4), 655-673.
- Almekhlafi, A. G., & Almeqdadi, F. A. (2010). Teachers' perceptions of technology integration in the United Arab Emirates school classrooms. *Educational Technology & Society, 13*(1), 165-175.
- Alsop, S., Bencze, L., & Pedretti, E. (2005). *Analysing exemplary Science teaching*. Berkshire, England: Open University Press.
- Alsulaimani, A. A. (2012). What impedes Saudi science teachers from using ICT? *Journal of Education and Practice, 3*(12), 146-155.
- Altbach, P. G., Reisberg, L., & Rumbley, L. E. (2010). Tracking a global academic revolution. *Change: The magazine of higher learning, 42*(2), 30-39.
- Alwani, A. E. S., & Soomro, S. (2010). Barriers to effective use of information technology in Science education at Yanbu, Kingdom of Saudi Arabia. In S. Soomro (Ed.), *E-Learning Experiences and Future* (pp. 35-46): InTech.
- Angeli, C. (2008). Distributed cognition: A framework for understanding the role of computers in classroom teaching and learning. *Journal of Research on Technology in Education, 40*(3), 271-279.
- Angelo, T. A. (1996). Relating exemplary teaching to student learning. *New Directions for Teaching and Learning, 65*, 57-64.
- Angrist, J., & Lavy, V. (2002). New evidence on classroom computers and pupil learning. *The Economic Journal, 112*(October), 735-765.
- Anh, N. N., Peeraer, J., & Tran, T. N. M. (2010). Peer-reviewing integration of ICT in teaching practice: Are Vietnamese teacher educators ready to learn from each other? Retrieved 16 May, 2016, from [http://www.academia.edu/2787689/Peer-reviewing Integration of ICT in Teaching Practice Are Vietnamese Teacher Educators Ready to Learn from Each Other](http://www.academia.edu/2787689/Peer-reviewing_Integration_of_ICT_in_Teaching_Practice_Are_Vietnamese_Teacher_Educators_Ready_to_Learn_from_Each_Other)
- Armellini, A., & Aiyegbayo, O. (2010). Learning design and assessment with e-tivities. *British Journal of Educational Technology, 41*(6), 922-936.
- Australian Curriculum, A. a. R. A. (2008). The Australian curriculum v5.0 general capabilities. *The Australian Curriculum*. Retrieved 21 July 2013, 2013, from <http://www.australiancurriculum.edu.au/GeneralCapabilities/Overview/Gener>

[al-capabilities-in-the-Australian-Curriculum](#)

- Australian, G. (2013). DER mid-program review: Assessing progress of the DER and potential future directions. Final report. Retrieved 1 September 2017, 2017, from https://docs.education.gov.au/system/files/doc/other/digital_education_revolution_program_review.pdf
- Australian Government Department of Education, E. a. W. R. (2008). *Success through partnership: DER strategic plan*. Canberra: DEEWR.
- Australian Government Department of Education, E. a. W. R. (2011). Digital education revolution. Retrieved 24 November, 2011, 2011, from <http://www.deewr.gov.au/Schooling/DigitalEducationRevolution/Pages/default.aspx>
- Australian Institute for Teaching and School Leadership. (2008). *Success through partnership: Achieving a national vision for ICT in schools*. Retrieved from http://www.aitsl.edu.au/docs/default-source/apst-resources/success_through_partnership_-_achieving_a_national_vision_for_ict_in_schools.pdf.
- Aypay, A. (2010). Information and Communication Technology (ICT) usage and achievement of Turkish students in PISA 2006. *The Turkish Online Journal of Educational Technology*, 9(2), 116-124.
- Backhouse, B. (2003). Information and Communication Technology integration: Beyond the early adopters. *TechTrends*, 47(3), 5-8.
- Badge, J. L., Saunders, N. F. W., & Cann, A. J. (2012). Beyond marks: New tools to visualise student engagement via social networks. *Research in Learning Technology*. Retrieved 16 May, 2016, from <http://www.researchinlearningtechnology.net/index.php/rlt/article/view/16283>
- Baek, Y., Jung, J., & Kim, B. (2008). What makes teachers use technology in the classroom? Exploring the factors affecting facilitation of technology with a Korean sample. *Computers & Education*, 50, 224-234.
- Baggott la Velle, L., Wishart, J., McFarlane, A., Brawn, R., & John, P. (2007). Teaching and learning with ICT within the subject culture of secondary school Science. *Research in Science, Technology and Education*, 25(3), 339-349.
- Balanskat, A., Blamire, R., & Kefala, S. (2006). The ICT impact report: A review of studies of ICT impact on schools in Europe. In E. Schoolnet (Ed.), (pp. 77).
- Barab, S., & Dede, C. (2007). Games and immersive participatory simulations for Science education: An emerging type of curricula. *Journal of Science*

Education and Technology, 16(1), 1-3.

- Barab, S., Sadler, T. D., Heiselt, C., Hickey, D., & Zuiker, S. J. (2007). Relating narrative, inquiry, and inscriptions: Supporting consequential play. *Journal of Science Education and Technology*, 16(1), 59-82.
- Barab, S., Scott, B., Siyahhan, S., Goldstone, R., Ingram-Goble, A., Zuiker, S. J., & Warren, S. (2009). Transformational play as a curricular scaffold: Using videogames to support Science education. *Journal of Science Education and Technology*, 18, 305-320.
- Barrera-Osorio, F., & Linden, L. L. (2009). The use and misuse of computers in education: Evidence from a randomized experiment in Colombia. *World Bank Policy Research Working Paper*. Retrieved 16 May, 2016, from <http://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-4836>
- Baskin, C., & Williams, M. (2006). ICT integration in schools: Where are we now and what comes next? *Australasian Journal of Educational Technology*, 22(4), 455-463.
- Bate, F., MacNish, J., & Males, S. (2012). Understanding parent perceptions of a 1:1 laptop program in Western Australia. *Australian Educational Computing*, 27(2), 18-21.
- Baylor, A. L., & Ritchie, D. (2002). What factors facilitate teacher skill, teacher morale, and perceived student learning in technology-using classrooms? *Computers & Education*, 39, 395-414.
- BBC. (2015). Bitesize. Retrieved 16 May, 2016, from <http://www.bbc.co.uk/education>
- Beatty, I. D., & Gerace, W. J. (2009). Technology-enhanced formative assessment: A research-based pedagogy for teaching Science with classroom response technology. *Journal of Science Education and Technology*, 18, 146-162.
- Becker, H. J. (1994). How exemplary computer-using teachers differ from other teachers: Implications for realizing the potential of computers in schools. *Journal of Research on Computing in Education*, 26(3), 291-321.
- Becker, H. J. (2000). How exemplary computer-using teachers differ from other teachers: Implications for realizing the potential of computers in schools. *Contemporary Issues in Technology and Teacher Education*, 1(2), 274-293.
- Beisenherz, B. C. (1993). "E" is for exemplary - Yes! You, too, can be an exemplary science teacher. *Science and Children*, 31(1), 22-24.
- Bielefeldt, T. (2005). Computers and student learning: Interpreting the multivariate analysis of PISA 2000. *Journal of Research on Technology in Education*, 37(4), 339-347.

- Bingimlas, K. A. (2009). Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. *Eurasia Journal of Mathematics, Science & Technology Education*, 5(3), 235-245.
- Black, G., & Smith, K. (2009). *Hot topic: ICT in pre-service teacher training*. Dulwich, SA: Education.au.
- Blignaut, A. S., Hinostroza, J. E., Els, C. J., & Brun, M. (2010). ICT in education policy and practice in developing countries: South Africa and Chile compared through SITES 2006. *Computers & Education*, 55, 1552-1563.
- Boe, M. V., Henriksen, E. K., Lyons, T., & Schreiner, C. (2011). Participation in science and technology: Young people's achievement-related choices in late-modern societies. *Studies in Science Education*, 47(1), 37-72.
- Bornmann, L., & Mutz, R. (2015). Growth rates of modern science: A bibliometric analysis based on the number of publications and cited references. *Journal of the Association for Information Science and Technology*, 66(11), 2215-2222.
- Boss, S. (2012). *Bringing innovation to school empowering students to thrive in a changing world*. Bloomington IN: Solution Tree Press.
- Bouhlila, D. S. (2011). The quality of secondary education in Middle East and North Africa: What can we learn from TIMSS results? *Compare: A Journal of Comparative and International Education*, 41(3), 327-352.
- Brown, S. (2013). "Not knowing" as a pedagogic strategy in the sciences. *Radical Pedagogy*(8), 1-6.
- Buabeng-Andoh, C. (2012). Factors influencing teachers' adoption and integration of information and communication technology into teaching: A review of the literature. *International Journal of Education and Development using Information and Communication Technology*, 8(1), 136-155.
- Buabeng-Andoh, C. (2015). Teachers' ICT usage in second-cycle institutions in Ghana: A qualitative study. *International Journal of Education and Development using Information and Communication Technology*, 11(2), 104-112.
- Chai, C. S., Koh, J. H. L., & Tsai, C.-C. (2010). Facilitating preservice teachers' development of Technological, Pedagogical, and Content Knowledge (TPACK). *Educational Technology & Society*, 13(4), 63-73.
- Chandra, V., & Lloyd, M. (2008). The methodological nettle: ICT and student achievement. *British Journal of Educational Technology*, 39(6), 1087-1098.
- Chang, C.-S., Chen, T.-S., & Hsu, W.-H. (2011). The study on integrating WebQuest with mobile learning for environmental education. *Computers & Education*, 57, 1228-1239.

- Chase, C. C., Chin, D. B., Opezzo, M. A., & Schwartz, D. L. (2009). Teachable agents and the protege effect: Increasing the effort towards learning. *Journal of Science Education and Technology*, 18, 334-352.
- Cheung, S. K. S., Yuen, K. S., Li, K. C., Tsang, E. T. M., & Wong, A. (2012). *Open access textbooks: Opportunities and challenges*. Paper presented at the Engaging learners through emerging technologies, Hong Kong.
- Clarke, J., & Dede, C. (2009). Design for scalability: A case study of the River City curriculum. *Journal of Science Education and Technology*, 18, 353-365.
- Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (7th ed.). London: Routledge.
- Creswell, J. W., Klassen, A. C., Plano Clark, V. L., & Smith, K. C. (2011). Best Practices for Mixed Methods Research in the Health Sciences (pp. 37): Office of Behavioural and Social Sciences Research.
- Crouch, C. H., & Mazur, E. (2001). Peer instruction: Ten years of experience and results. *American Journal of Physics*, 69, 970-977.
- Danielson, C. (2009). *Talk about teaching! Leading professional conversations*. California: Corwin Press.
- Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer-technology - A comparison of 2 theoretical models. *MANAGEMENT SCIENCE*, 35(8), 982-1003.
- Dede, C., & Barab, S. (2009). Emerging technologies for learning Science: A time of rapid advances. *Journal of Science Education and Technology*, 18(4), 301-304.
- DEST. (2002). *Raising the standards: A proposal for the development of an ICT competency framework for teachers*. Canberra.
- Dimiceli, V. E., Lang, A. S. I. D., & Locke, L. (2010). Teaching calculus with Wolfram|Alpha. *International Journal of Mathematical Education in Science and Technology*, 41(8), 1061-1071.
- Dodge, B. (1995). FOCUS: Five rules for writing a great WebQuest. *Learning & Leading with Technology*, 28(8), 6-9.
- Donelan, H., Kear, K., & Ramage, M. (2010). *Online communication and collaboration*. London: Routledge.
- Donnelly, D., McGarr, O., & O'Reilly, J. (2011). A framework for teachers' integration of ICT into their classroom practice. *Computers & Education*, 57, 1469-1483.

- Downes, T., Fluck, A., Gibbons, P., Leonard, R., Matthews, C., Oliver, R., . . . Williams, M. (2001). *Making better connections: Models of teacher professional development for the integration of information and communication technology into classroom practice*. Canberra: Goanna Print.
- Drent, M., & Meelissen, M. (2008). Which factors obstruct or stimulate teacher educators to use ICT innovatively? *Computers & Education, 51*, 187-199.
- Dunleavy, M., Dede, C., & Mitchell, R. (2008). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology, 18*(1), 7-22.
- Dweck, C. S. (2006). *Mindset How you can fulfil your potential*. New York: Random House.
- Ebenezer, J., Columbus, R., Kaya, O. N., Zhang, L., & Ebenezer, D. L. (2011). One Science teacher's professional development experience: A case study exploring changes in students' perceptions of their fluency with innovative technologies. *Journal of Science Education and Technology, 21*(1), 22-37.
- Education, N. S. W. D. o. (1983). *Computers in schools: A general policy statement*. Sydney: Government Printer.
- Education Queensland. (2007). *Flying start induction toolkit for beginning teachers*. Queensland Government.
- Egea, O. M. (2014). Neoliberalism, education and the integration of ICT in schools. A critical reading. *Technology, Pedagogy and Education, 23*(2), 267-283.
- Elletson, H., & Burgess, A. (2015). The eLearning Africa Report 2015 (2015 ed., pp. 1-132). Addis Ababa.
- Enochs, L. G., Riggs, I. M., & Ellis, J. D. (1993). The development and partial validation of microcomputer utilisation in teaching efficacy beliefs instrument in a Science setting. *School Science and Mathematics, 93*(5), 257-263.
- Erixon, P.-O. (2010). School subject paradigms and teaching practice in lower secondary Swedish schools influenced by ICT and media. *Computers & Education, 54*, 1212-1221.
- Ersoy, M., & Akbulut, Y. (2014). Cognitive and affective implications of persuasive technology use on mathematics instruction. *Computers & Education, 75*, 253-262.
- Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration. *Educational Technology Research and Development, 53*(4), 25-39.

- Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education*, 42(3), 255-284.
- Ertmer, P. A., Ottenbreit-Leftwich, A. T., Olgun, S., Emine, S., & Polat, S. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education*, 59, 423-435.
- European Commission. (2008). *Using ICT to support innovation and lifelong learning for all - A report on progress*.
- Farrell, G., & Isaacs, S. (2007). Survey of ICT and education in Africa: A summary report, based on 53 country surveys. In M. Trucano (Ed.), *ICT and Education Series* (Vol. 1, pp. 74). Washington DC, USA.
- Fisser, P., Voogt, J., van Braak, J., & Tondeur, J. (2015). Measuring and assessing TPACK (Technological Pedagogical Content Knowledge). In J. M. Spector (Ed.), *The SAGE encyclopedia of educational technology*: SAGE Publications Inc.
- Fuchs, T., & Woessmann, L. (2007). What accounts for international differences in student performance? A re-examination using PISA data. *Empirical Economics*, 32(2), 433-464.
- Fullan, M. (2013). *Stratosphere: Integrating technology, pedagogy, and change knowledge*. Toronto: Pearson.
- Fullan, M., & Longworthy, M. (2014). *A rich seam: How new pedagogies find deep learning* (pp. 87). Retrieved from http://michaelfullan.ca/wp-content/uploads/2014/01/3897.Rich_Seam_web.pdf
- Fulton, K. (2012). Upside down and inside out: Flip your classroom to improve student learning. *Learning & Leading with Technology*, 39(8), 12-17.
- Gabriel, R., Day, J. P., & Allington, R. (2011). Exemplary teacher voices on their own development. *Phi Delta Kappa International*, 92(8), 37-41.
- Gao, P., Choy, D., Wong, A. F. L., & Wu, J. (2009). Developing a better understanding of technology based pedagogy. *Australasian Journal of Educational Technology*, 25(5), 714-730.
- Gaskill, M., McNulty, A., & Brooks, D. W. (2006). Learning from WebQuests. *Journal of Science Education and Technology*, 15(2), 133-136.
- Ge, X., & Ruan, J. (2012). Integrating Information and Communication Technologies in literacy education in China. In C. Leung & J. Ruan (Eds.), *Historical, philosophical, & sociocultural perspectives on literacy teaching & learning in China* (pp. 34). New York: Springer.

- Gillard, S., Bailey, D., & Nolan, E. (2008). Ten reasons for IT educators to be early adopters of IT innovations. *Journal of Information Technology Education*, 7, 21-33.
- Global, T. (2015). TES. from <https://www.tes.com/teaching-resources/>
- Gobbo, C., & Girardi, M. (2006). Teachers' beliefs and integration of information and communications technology in Italian schools *Journal of Information Technology for Teacher Education*, 10(1-2), 63-85.
- Gokalp, M. S., Sharma, M., Johnston, I., & Sharma, M. (2013). Implementing WebQuest based instruction on Newton's second law. *Teaching Science*, 59(2), 11-19.
- Gonski, D., Boston, K., Greiner, K., Lawrence, C., Scales, B., & Tannock, P. (2011). *Review of funding for schooling - Final report*. Canberra: Australian Commonwealth Department of Education, Employment and Workplace Relations.
- Gorny, P. (1995). Teacher education in IT in Germany. *Journal of Computer Assisted Learning*, 11, 40-45.
- Grandgenett, N. (2007). Geogebra. *Mathematics and Computer Education*, 41(3), 276-278.
- Groff, J., & Mouza, C. (2008). A framework for addressing challenges to classroom technology use. *AACE Journal*, 16(1), 21-47.
- Groves, R. M., Presser, S., & Dipko, S. (2004). The role of topic interest in survey participation decisions. *Public Opinion Quarterly*, 68(1), 2-31.
- Gülbahar, Y., Madran, R. O., & Kalelioglu, F. (2010). Development and evaluation of an interactive WebQuest environment: "Web Macerasi". *Educational Technology & Society*, 13(3), 139-150.
- Gulek, J. C., & Demirtas, H. (2005). Learning with technology: The impact of laptop use on student achievement. *The Journal of Technology, Learning and Assessment*, 3(2), 1-39.
- Gundy, M. S., & Berger, M. J. (2013). Laptop computers: Reflecting on innovation in science. *International Journal of Information and Education Technology*, 3(2), 139-142.
- Hakverdi-Can, M., & Dana, T. M. (2012). Exemplary science teachers' use of technology. *The Turkish Online Journal of Educational Technology*, 11(1), 94-112.
- Hakverdi, M. (2005). *Factors influencing exemplary science teachers' levels of computer use*. (Doctor of Philosophy), University of Florida.

- Hakverdi, M., Dana, T. M., & Swain, C. (2011). Factors influencing exemplary science teachers' levels of computer use. *Hacettepe Universitesi Journal of Education*, 41, 219-230.
- Hamdy, A. (2007). ICT in education in Tunisia. In M. Trucano (Ed.), *Survey of ICT in Education in Africa* (Vol. 2, pp. 11). Washington DC, USA.
- Hargis, J. (2001). Can students learn science using the internet? *Journal of Research on Computing in Education*, 33(4), 475-467.
- Hargreaves, A., & Lo, L. N. K. (2000). The paradoxical profession: Teaching at the turn of the century. *Prospects*, 30(2), 167-180.
- Harrison, C. R. (1999). Spinning a web around forensic science and senior biology. *Australian Science Teachers Journal*, 45(3), 17-20.
- Harteis, C., Gruber, H., & Hertrampf, H. (2010). How epistemic beliefs influence e-learning in daily work-life. *Educational Technology & Society*, 13(3), 201-211.
- Hennessy, S., Wishart, J., Whitelock, D., Deaney, R., Brawn, R., la Velle, L., . . . Winterbottom, M. (2007). Pedagogical approaches for technology-integrated science teaching. *Computers & Education*, 48, 137-152.
- Herreid, C. F., & Schiller, N. A. (2013). Case studies and the flipped classroom. *Journal of College Science Teaching*, 42(5), 62-66.
- Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development*, 55(3), 223-252.
- Higgins, S., Xiao, Z., & Katsipataki, M. (2012). The impact of digital technology on learning: A summary for the education endowment foundation (pp. 52). Durham: Durham University.
- Hilton, A., & Hilton, G. (2013). Incorporating digital technologies into science classes: Two case studies from the field. *International Journal of Pedagogies and Learning*, 8(3), 153-168.
- Hoppe, K. (2010). Assessing student motivation, performance, and engagement with an action research project. *Science Scope*, 34(1), 56-60.
- Howie, S. J., & Blignaut, A. S. (2009). South Africa's readiness to integrate ICT into mathematics and science pedagogy in secondary schools. *Educ Inf Technol*, 14, 345-363.
- Hsu, P.-S. (2016). Examining current beliefs, practices and barriers about technology integration: A case study. *TechTrends*, 60, 30-40.

- Hsu, S. (2011). Who assigns the most ICT activities? Examining the relationship between teacher and student usage. *Computers & Education*, 56, 847-855.
- Hsu, Y.-C., & Ching, Y.-H. (2013). Mobile app design for teaching and learning: Educators' experiences in an online graduate course. *The International Review of Research in Open and Distance Learning*, 14(4), 117-139.
- Huang, J. J. S., Yang, S. J. H., Huang, Y.-M., & Hsaio, I. Y. T. (2010). Social learning networks: Build mobile learning networks based on collaborative services. *Educational Technology & Society*, 13(3), 78-92.
- Hui, W., Hu, P. J.-H., Clark, T. H. K., Tam, K. Y., & Milton, J. (2008). Technology-assisted learning: a longitudinal field study of knowledge category, learning effectiveness and satisfaction in language learning. *Journal of Computer Assisted Learning*, 24, 245-259.
- Hung, P.-H., Lin, Y.-F., & Hwang, G.-J. (2010). Formative assessment design for PDA integrated ecology observation. *Educational Technology & Society*, 13(3), 33-42.
- Irish, S. J. (2017). *A Teacher Retrospective of a Decade of One-to-One Devices*. (Doctor of Education), Walden University, Minneapolis.
- Isaacs, S. (2007). ICT in Education in South Africa. In M. Trucano (Ed.), *Survey of ICT and education in Africa* (Vol. 2, pp. 29). Washington DC, USA.
- Jacobsen, M. (2000). *Excellent teaching and early adopters of instructional technology*. Paper presented at the World Conference on Educational Multimedia/Hypermedia & Educational Telecommunication, 26 June-1 July, Montreal, Quebec, Canada.
- Jacobson, M. J., Richards, D., Kennedy-Clark, S., Thompson, K., Taylor, C., Hu, C., . . . Kartiko, I. (2010). *Scenario-based MUVE for science inquiry*. Paper presented at the 16th UniServe Science Annual Conference, University of Sydney.
- Joiner, R., Iacovides, J., Owen, M., Gavin, C., Clibbery, S., Darling, J., & Drew, B. (2010). Digital games, gender and learning in engineering: Do females benefit as much as males? *J. Sci. Educ. Technol.*, 20(2), 178-185.
- Jones, A. (2003). The development of a national curriculum in technology for New Zealand. *International Journal of Technology and Design Education*, 13, 83-99.
- Jones, A., & Cowie, B. (2011). Evaluation approaches for a national ICT initiative: the example of laptops for New Zealand teachers. *Educ Res Policy Prac*, 10, 3-15.
- Judson, E. (2006). How teachers integrate technology and their beliefs about

- learning: is there a connection? *Journal of Technology and Teacher Education*, 14(3), 581-597.
- Jung, I., Kudo, M., & Choi, S.-K. (2012). Stress in Japanese learners engaged in online collaborative learning in English. *British Journal of Educational Technology*, 43(6), 1016-1029.
- Jung, I., & Latchem, C. (2011). A model for e-education: Extended teaching spaces and extended learning spaces. *British Journal of Educational Technology*, 42(1), 6-18.
- Jungic, V., & Mulholland, J. (2014). Is close enough good enough? Reflections on the use of technology in teaching calculus. *International Journal of Mathematical Education in Science and Technology*, 45(7), 1075-1084.
- Kafyulilo, A., & Keengwe, J. (2014). Teachers' perspectives on their use of ICT in teaching and learning: A case study. *Education and Information Technologies*, 19, 913-923.
- Kagame, P. (2008). Presidential address. Challenges and prospects of advancing science and technology in Africa: the case of Rwanda. *Science*, 322, 545-551.
- Karsenti, T., Collin, S., & Harper-Merrett, T. (2012). *Pedagogical integration of ICT: Success and challenges from 100+ African schools* (3rd ed.). Ottawa, Ontario: IDRC.
- Keengwe, J., Onchwari, G., & Wachira, P. (2008). Computer technology integration and student learning: Barriers and promise. *J. Sci. Educ. Technol.*, 17(6), 560-565.
- Kerr, R. (2013). *Comparing levels of school performance to science teachers' reports on knowledge/skills, instructional use and student use of computers*. (Doctor of Philosophy), Florida Atlantic University, Boca Raton, Florida.
- Kim, C., Kim, M. K., Lee, C., Spector, J. M., & DeMeester, K. (2013). Teacher beliefs and technology integration. *Teaching and Teacher Education*, 29, 76-85.
- Kim, J. W. (2004). Education reform policies and classroom teaching in South Korea. *International Studies in Sociology of Education*, 14(2), 125-145.
- Klieger, A., Ben-Hur, Y., & Bar-Yossef, N. (2010). Integrating laptop computers into classroom: Attitudes, needs, and professional development of science teachers - A case study. *Journal of Science Education and Technology*, 19, 187-198.
- Klopfer, E. (2008). *Augmented learning: research and design of mobile educational games*. MIT Press, Cambridge: Mass.

- Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, 9(1), 60-70.
- Kok, A. (2006). ICT integration into classrooms - A literature review. *European Association of Distance Learning*, 2(1), 1-19.
- Kolikant, Y. B.-D. (2012). Using ICT for school purposes: Is there a student-school disconnect? *Computers & Education*, 59, 907-914.
- Kopcha, T. J. (2012). Teachers' perceptions of the barriers to technology integration and practices with technology under situated professional development. *Computers & Education*, 59, 1109-1120.
- Kozma, R. (2003). Technology and classroom practices: An international study. *Journal of Research on Technology in Education*, 36(1), 1-14.
- Kozma, R., & Surya Vota, W. (2014). ICT in developing countries: Policies, implementation, and impact. In J. M. Spector, M. D. Merrill, J. Elen & M. J. Bishop (Eds.), *Handbook of Research on Educational Communications and Technology* (4th ed., pp. 885-894). New York: Springer Science+Business Media.
- Kukulska-Hulme, A. (2010). Learning cultures on the move: Where are we heading? *Educational Technology & Society*, 13(4), 4-14.
- Kusano, K., Frederiksen, S., Jones, L., & Kobayashi, M. (2013). The effects of ICT environment on teachers' attitudes and technology integration in Japan and the U.S. *Journal of Information Technology Education*, 12, 29-43.
- Lambert, C. (2012). Twilight of the lecture. Retrieved 20 May, 2016, from <http://harvardmagazine.com/2012/03/twilight-of-the-lecture>
- Lawless, K. A., & Pellegrino, J. W. (2007). Professional development in integrating technology into teaching and learning: Knowns, unknowns, and ways to pursue better questions and answers. *Review of Educational Research*, 77(4), 575-614.
- Leadership, A. I. f. T. a. S. (2011). *Australian professional standards for teachers*. Melbourne: Education Services Australia.
- Legrís, P., Ingham, J., & Collette, P. (2003). Why do people use information technology: A critical review of the technology acceptance model. *Information & Management*, 40(3), 191-204.
- Lens, W. (2006). Personal computers in the learning environment and student motivation. *Scandinavian Journal of Educational Research*, 38(3-4), 219-236.

- Li, K. C., & Wong, B. T.-M. (2014). Readiness development of open educational resources in Hong Kong. *International Journal of Continuing Education and Lifelong Learning*, 7(1), 119-137.
- Li, K. C., Yuen, K. S., & Cheung, S. K. S. (2013). *Open educational resources in Hong Kong*. Paper presented at the Knowledge Sharing through Technology, Hong Kong.
- Li, Y. (2013). *Constructing and sharing open educational resources: Policy and capacity*. Paper presented at the Knowledge Sharing through Technology, Hong Kong.
- Lim, C. P. (2007). Effective integration of ICT in Singapore schools: Pedagogical and policy implications. *Education Tech Research Dev*, 55, 83-116.
- Lloyd, M. (2005). *Towards a definition of the integration of ICT in the classroom*. Paper presented at the Education Research - Creative Dissent: Constructive Solutions, Parramatta, NSW.
- Lloyd, M., & Mukherjee, M. (2013). Tell me what you see: Pre-service teachers' recognition of exemplary digital pedagogy. *Australian Educational Computing*, 27(3), 85-94.
- Lowman, J. (1996). Characteristics of exemplary teachers. *New Directions for Teaching and Learning*, 65, 33-40.
- Lowther, D. L., Inan, F. A., Strahl, D., & Ross, S. M. (2008). Does technology integration "work" when key barriers are removed? *Educational Media International*, 45(3), 195-213.
- Lubega, J. T., Annet, M. K., & Muyinda, P. B. (2014). Adoption of the SAMR model to assess ICT pedagogical adoption: A case of Makerere University. *International Journal of e-Education, e-Business, e-Management and e-Learning*, 4(2), 106-116.
- Manji, F. (2015). The pan-African community inventing the future. In H. Elletson & A. Burgess (Eds.), *The eLearning Africa Report 2015* (pp. 1-132). Addis Ababa, Ethiopia: ICWE GmbH.
- Mansour, N. (2009). Science teachers' beliefs and practices: Issues, implications and research agenda. *International Journal of Environment and Science*, 4(1), 25-48.
- Marcinkiewicz, H. R., & Welliver, P. W. (1993). *Procedures for assessing teachers' computer use based on instructional transformation*. Paper presented at the 15th Convention of the Association for Educational Communications and Technology, New Orleans, Louisiana.
- Marshall, J. M. (2002). *Learning with technology evidence that technology can, and*

does, support learning. Cable in the Classroom. California.

- Martin, M. O., Mullis, I. V. S., Foy, P., & Hooper, M. (2016). TIMSS 2015 International Results in Science. Retrieved 8/4/17, 2017, from <http://timssandpirls.bc.edu/timss2015/international-results/>
- Martin, S., & Vallance, M. (2008). The impact of synchronous inter-networked teacher training in Information and Communication Technology integration. *Computers & Education, 51*, 34-53.
- Masters, J., & Yelland, N. (2002). Teacher scaffolding: An exploration of exemplary practice. *Education and Information Technologies, 7*(4), 313-321.
- Mazur, E. (1997). *Peer instruction: A user's manual*. New Jersey: Prentice Hall.
- Mazur, E. (2009). Farewell, lecture? *American Association for the Advancement of Science, 323*, 50-51.
- McCall, M. J. (2008). *Qualities of effective secondary science teachers : Perspectives of university biology students*. (Ed. D.), Baylor University, Waco, Texas. Retrieved from https://beardocs.baylor.edu:8443/xmlui/bitstream/handle/2104/5244/madelon_mccall_edd.pdf?sequence=1
- McNamara, D. E. (2010). *The exemplary teacher joyfully improving teaching mastery in all learning environments*
- Menchaca, M., Bischoff, M., & Dara-Abrams, B. (2003). *A model for systemic change management in education*. Paper presented at the International Conference on Education and Information Systems: Technologies and Applications, Orlando, Florida.
- Miniwatts Marketing Group. (2014, 14 October 2014). Top 50 Countries with the highest internet penetration rates. *Internet World Stats*. Retrieved 30 September, 2015, from <http://www.internetworldstats.com/top25.htm>
- Miniwatts Marketing Group. (2015). World internet user statistics. Retrieved 30 September, 2015, from <http://www.internetworldstats.com/stats.htm>
- Mirzajani, H., Mahmud, R., Fauzi, A., Ayub, M., & Wong, S. L. (2016). Teachers' acceptance of ICT and its integration in the classroom. *Quality Assurance in Education, 24*(1), 26-40.
- Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054.
- Morrissey, J., Hume, M., Baker, S., Ryan, S., Galvin, C., Ryan, T., . . . Turpin, F. (2008). *Investing effectively in Information and Communications Technology*

in schools, 2008-2013.

- Morrone, M. H. (2012). *Social and cultural impediments to the adoption of ICT for language learning in Japan*. Paper presented at the ICT for Language Learning, Florence, Italy.
- Mueller, J., Wood, E., Willoughby, T., Ross, C., & Specht, J. (2008). Identifying discriminating variables between teachers who fully integrate computers and teachers with limited integration. *Computers & Education, 51*, 1523-1537.
- Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2016). TIMSS 2015 International Results in Mathematics. Retrieved 8/4/17, 2017, from <http://timssandpirls.bc.edu/timss2015/international-results/>
- Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: A review of the literature. *Journal of Information Technology for Teacher Education, 9*(3), 319-343.
- Nachmias, R., Mioduser, D., & Forkosh-Baruch, A. (2010). ICT use in education: Different uptake and practice in Hebrew-speaking and Arabic-speaking schools in Israel. *Journal of Computer Assisted Learning, 26*, 492-506.
- Nager, N., & Shapiro, A. K. (2007) A progressive approach to the education of teachers: Some principles from Bank Street College of Education. *Vol. 18. Occasional Paper Series: Bank Street College of Education.*
- Nelson, B. C., Erlandson, B., & Denham, A. (2011). Global channels of evidence for learning and assessment in complex game environments. *British Journal of Educational Technology, 42*(1), 88-101.
- Newhouse, C. P., Trinidad, S., & Clarkson, B. (2002). *Quality pedagogy and effective learning with Information and Communications Technologies (ICT): A review of the literature*. Perth: Specialist Education Services.
- Ng, D. E. H. (2008). Ministry of Education, Singapore, speeches. Retrieved 24 November 2011, 2011, from <http://www.moe.gov.sg/media/speeches/2008/08/05/opening-address-by-dr-ng-eng-h-1.php>
- Ng, W. (2015). *New Digital Technology in Education: Conceptualizing Professional Learning for Educators*. Cham, Switzerland: Springer International Publishing.
- Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teach. Teach. Educ., 21*(5), 509-523.
- Nkohkwo, Q., & Islam, M. (2013). Challenges to the Successful Implementation of e-Government Initiatives in Sub-Saharan Africa: A Literature Review.

Electronic Journal of E-Government, 11(2), 253-267.

- Noeth, R. J., & Volkov, B. B. (2004). *Evaluating the effectiveness of technology in our schools ACT policy report*. ACT Office of Policy Research.
- November, A. (2012). *Who owns the learning? Preparing students for success in the digital age*. Bloomington, IN: Solution Tree Press.
- NSW Institute of Teachers. (2013). *Professional teaching standards*.
- O'Connell, J., & Groom, D. (2010). *Connect, communicate, collaborate Learning in a changing world*. Melbourne: ACER Press.
- OECD. (2015). Students, computers and learning: Making the connection *PISA*.
- Oliver, K. (2010). Integrating web 2.0 across the curriculum. *Tech Trends, 54(2)*, 50-60.
- Oliver, R. (2008). Engaging first year students using a web-supported inquiry-based learning setting. *High. Educ., 55(3)*, 285-301.
- Ormiston, M. (2011). *Creating a digital-rich classroom teaching & learning in a web 2.0 world*. Bloomington, IN: Solution Tree Press.
- Ottenbreit-Leftwich, A. T., Brush, T. A., Strycker, J., Gronseth, S., Roman, T., Abaci, S., . . . Plucker, J. (2012). Preparation versus practice: How do teacher education programs and practicing teachers align in their use of technology to support teaching and learning? *Computers & Education, 59(2)*, 399-412.
- Ottenbreit-Leftwich, A. T., Glazewski, K. D., Newby, T. J., & Ertmer, P. A. (2010). Teacher value beliefs associated with using technology: Addressing professional and student needs. *Computers & Education, 55*, 1321-1335.
- Page, T. M. (2014). Common pressures, same results? Recent reforms in professional standards and competences in teacher education for secondary teachers in England, France and Germany. *Journal of Education for Teaching, 41(2)*, 180-202.
- Paul, R., & Elder, L. (2007). *The thinker's guide to the art of socratic questioning*. Dillon Beach, CA: The foundation for critical thinking.
- Pearson, J. (2003). Information and communications technologies and teacher education in Australia. *Technology, Pedagogy and Education, 12(1)*, 39-58.
- Peeraer, J., & Van Petergem, P. (2012). Information and communication technology in teacher education in Vietnam: From policy to practice. *Educational Research Policy and Practice, 11*, 89-104.
- Pelgrum, W. J. (2001). Obstacles to the integration of ICT in education: Results from

- a worldwide educational assessment. *Computers & Education*, 37, 163-178.
- Perrone, C., Clark, D., & Reppenning, A. (1996). WebQuest: Substantiating education in edutainment through interactive learning games. *Computer Networks and ISDN Systems*, 28(7-11), 1307.
- Philomina, M. J., & Amutha, S. (2016). Information and communication technology awareness among teacher educators. *International Journal of Information and Education Technology*, 6(8), 603-606.
- Pierce, C. A., Block, R. A., & Aguinis, H. (2004). Cautionary note on reporting eta-squared values from multifactor ANOVA designs. *Educational and Psychological Measurement*, 64(6), 916-924.
- Pierson, M. E. (2001). Technology integration practice as a function of pedagogical expertise. *Journal of Research on Computing in Education*, 33(4), 413-430.
- Plano Clark, V. L. (2010). The adoption and practice of mixed methods: U.S. trends in federally funded health-related research. *Qualitative Inquiry*, 16(6), 428-440.
- Plomp, T., ten Brummelhuis, A., & Pelgrum, W. J. (1997). New approaches for teaching, learning and using information and communication technologies in education. *Prospects*, 27(3), 427-443.
- Plomp, T., & Voogt, J. (2009). Pedagogical practices and ICT use around the world: Findings from the IEA international comparative study SITES2006. *Educ Inf Technol*, 14, 285-292.
- Proctor, M. D., & Marks, Y. (2013). A survey of exemplary teachers' perceptions, use, and access of computer-based games and technology for classroom instruction. *Computers & Education*, 62, 171-180.
- Project, N. (2008). National educational technology standards for teachers. Retrieved 14 April, 2016, from <http://www.iste.org/standards/iste-standards/standards-for-teachers>
- Puentedura, R. R. (2010). SAMR and TPCK: intro to advanced practice. Retrieved 15 October, 2015, from http://hippasus.com/resources/sweden2010/SAMR_TPCK_IntroToAdvancedPractice.pdf
- Pulkkinen, J., & van Wyk, T. (2013). The challenges of the information society for South African teachers. *TelE-Learning: The challenge for the third millenium*(102), 121-124.
- Ra, S., Chin, B., & Lim, C. P. (2016). A holistic approach towards Information and Communication Technology (ICT) for addressing education challenges in Asia and the Pacific. *Educational Media International*, 53(2), 69-84.

- Rajiv, M. L. (2011). Web 3.0 in education & research. *International Journal of Information Technology*, 3(2), 16-22.
- Richards, C. (2004). From old to new learning: global imperatives, exemplary Asian dilemmas and ICT as a key to cultural change in education. *Globalisation, Societies and Education*, 2(3), 337-353.
- Richards, C. (2005). The design of effective ICT-supported learning activities: Exemplary models, changing requirements, and new possibilities. *Language Learning and Technology*, 9(1), 60-79.
- Richardson, W. (2010). *Blogs, wikis, podcasts, and other powerful web tools for classrooms*. California: Thousand Oaks, California: Corwin Press.
- Rickards, T., & Fisher, D. (1999). Teacher-student classroom interactions among science students of different sex and cultural background. *Research in Science Education*, 29(4), 445-455.
- Ritchhart, R. (2015). *Creating cultures of thinking The 8 forces we must master to truly transform our schools*. San Francisco, CA: Jossey-Bass.
- Robinson, K. (2011). *Out of our minds*. West Sussex: Capstone Publishing Ltd.
- Romine, W. L., & Banerjee, T. (2011). Customization of curriculum materials in science: Motives, challenges, and opportunities. *Journal of Science Education and Technology*, 21(1), 38-45.
- Runge, A., Spiegel, A., Pytlik Z., L. M., Dunbar, S., Fuller, R., Sowell, G., & Brooks, D. (1999). Hands-on computer use in science classrooms: The skeptics are still waiting. *Journal of Science Education and Technology*, 8(1), 33-44.
- Sahlberg, P. (2010). The secret to Finland's success: Educating teachers. *Stanford Centre for Opportunity Policy in Education*, 8.
<https://edpolicy.stanford.edu/sites/default/files/publications/secret-finland%E2%80%99s-success-educating-teachers.pdf>
- Sanchez, J., Salinas, A., & Harris, J. (2011). Education with ICT in South Korea and Chile. *International Journal of Educational Development*, 31(2), 126-148.
- Schibeci, R., MacCallum, J., Cumming-Potvin, W., Durrant, C., Kissane, B., & Miller, E.-J. (2008). Teachers' journeys towards critical use of ICT. *Learning, Media and Technology*, 33(4), 313-327.
- Schleicher, A. (2016). PISA 2015 Result in focus *PISA*.
- Schoepp, K. W. (2004). *Technology integration barriers in a technology-rich environment: A CBAM perspective*. (Master of Arts), University of Calgary, Calgary, Alberta.

- Schoolnet, S. A. (2016). SchoolNet SA. Retrieved 29 July, 2016, from <http://www.schoolnet.org.za/>
- Sciences, I. o. E. (2012). Program for International Student Assessment. Retrieved 30 September, 2015, from <https://nces.ed.gov/surveys/pisa/index.asp>
- Searcy-Hudson, J. Y. (2005). *The effect of school structure and size on developing a professional learning community: An embedded case study*. (Ph.D.), University of Phoenix, Arizona.
- Sherer, M., Maddux, J. E., Mercandante, B., Prentice-Dunn, S., Jacobs, B., & Rogers, R. W. (1982). The self-efficacy scale: Construction and validation. *Psychological Reports, 51*, 663-671.
- Smith, H., Underwood, J., Fitzpatrick, G., & Luckin, R. (2009). Classroom e-Science: Exposing the work to make it work. *Educational Technology & Society, 12*(3), 289-308.
- So, H.-J., Choi, H., Lim, W. Y., & Xiong, Y. (2012). Little experience with ICT: Are they really the net generation student-teachers? *Computers & Education, 59*, 1234-1245.
- Solomon, G., & Schrum, L. (2007). *Web 2.0 new tools, new schools*. Washington DC: International Society for Technology in Education.
- Spiezia, V. (2011). Does computer use increase educational achievements? Student-level evidence from PISA. *OECD Journal: Economic Studies, 7*(1), 1-22.
- Squire, K. D., & Jan, M. (2007). Mad City mystery: Developing scientific argumentation skills with a place-based augmented reality game on handheld computers. *Journal of Science Education and Technology, 16*(1), 5-29.
- Steinkuehler, C., & Duncan, S. (2008). Scientific habits of mind in virtual worlds. *Journal of Science Education and Technology, 17*, 530-543.
- Stern, L., Barnea, N., & Shauli, S. (2008). The effect of a computerized simulation on middle school students' understanding of the kinetic molecular theory. *Journal of Science Education and Technology, 17*, 305-315.
- Stork, C., Calandro, E., & Gillwald, A. (2013). Internet going mobile: internet access and use in 11 African countries. *info, 15*(5), 34-51.
- Sulla, N. (2013). *Students taking charge inside the learner-active, technology-infused classroom*. New York: Routledge
- Swan, K., Holmes, A., Vargas, J. D., Jennings, S., Meier, E., & Rubinfeld, L. (2002). Situated professional development and technology integration: The CATIE mentoring program. *Journal of Technology and Teacher Education, 10*(2), 169-190.

- Tobin, B. (2006). Resources for connecting science and literature. In K. Tobin (Ed.), *Teaching and Learning Science A Handbook* (pp. 579). Maryland, USA: Rowman & Littlefield Publishers, Inc.
- Tobin, K., Treagust, D. F., & Fraser, B. J. (1988). An investigation of exemplary biology teaching. *The American Biology Teacher*, 50(3), 142-147.
- Tondeur, J., van Keer, H., van Braak, J., & Valcke, M. (2008). ICT integration in the classroom: Challenging the potential of a school policy. *Computers & Education*, 51(1), 212-223.
- Twining, P. (2002). ICT in schools: Estimating the level of investment. 28. Retrieved from Academia website:
http://www.academia.edu/9262449/ICT_in_Schools_Estimating_the_level_of_investment
- Umeasiegbu, G. O., & Esomonu, N. P.-M. (2012). E-learning in global education: Challenges and prospects for science and physical education in Nigeria. *Journal of Education and Practice*, 3(14), 44-48.
- Vaughan, W. (2002). Professional development and the adoption and implementation of new innovations: Do teachers concerns matter? . *International Journal for Leadership in Learning*, 6(5), 1-11.
- Volman, M. (2005). A variety of roles for a new type of teacher educational technology and the teaching profession. *Teaching and Teacher Education*, 21, 15-31.
- Wallace, R. M. (2004). A framework for understanding teaching with the internet. *American Educational Research Journal*, 41(2), 447-488.
- Wang, C.-h., Ke, Y.-T., Wu, J.-T., & Hsu, W.-H. (2012). Collaborative action research on technology integration for science learning. *J. Sci. Educ. Technol.*, 21, 125-132.
- Wastiau, P., Blamire, R., Kearney, C., Quittre, V., Van de Gaer, E., & Monseur, C. (2013). The use of ICT in education: a survey of schools in Europe. *European Journal of Education*, 11-27.
- Webb, M. E. (2005). Affordances of ICT in student learning: Implications for an integrated pedagogy. *International Journal of Science Education*, 27(6), 705-735.
- Webster, T. E., & Son, J.-B. (2012). Implementing proactive maintenance policies to address problems with access to technology at Korean Universities. *International Journal of Pedagogies and Learning*, 7(2), 109-121.
- Westbury, I., Hansen, S.-E., Kansanen, P., & Bjorkvist, O. (2007). Teacher education for research-based practice in expanded roles: Finland's experience.

Scandinavian Journal of Educational Research, 49(5), 475-485.

- Wilson, K. L., & Boldeman, S. U. (2012). Exploring ICT integration as a tool to engage young people at a flexible learning centre. *J. Sci. Educ. Technol.*, 21, 661-668.
- Wiseman, A. W., & Anderson, E. (2012). ICT-integrated education and national innovation systems in the Gulf Cooperation Council (GCC) countries. *Computers & Education*, 59, 607-618.
- Wood, S., & Romero, P. (2010). Learner centred design for a hybrid interaction application. *Educational Technology & Society*, 13(3), 43-54.
- Woodbridge, J. (2003). *Technology integration as a teaching strategy*. (PhD), Walden University, Ann Arbor MI.
- Wycliffe, J., & Muwanga-Zake, F. (2007). Evaluation of an educational computer programme as a change agent in science classrooms. *Journal of Science Education and Technology*, 16(6), 473-490.
- Yang, J. (2010). Faculty adopters of podcasting: Satisfaction, university support and belief in podcasting. *International Journal of Information and Communication Technology Education*, 6(4), 74-88.
- Zhang, D., & Liu, L. (2016). How does ICT use influence students' achievements in Math and Science over time? Evidence from PISA 2000 to 2012. *Eurasia Journal of Mathematics, Science & Technology Education*, 12(9), 2431-2449.
- Zhao, J., & Xu, F. (2010). The state of ICT education in China: A literature review. *Front. Educ. China*, 5(1), 50-73.
- Ziya, E., Dogan, N., & Kelecioglu, H. (2010). What is the Predict Level of Which Computer Using Skills Measured in PISA for Achievement in Mathematics. *The Turkish Online Journal of Educational Technology*, 9(4), 185-191.
- Zucker, A. A., & Hug, S. T. (2008). Teaching and learning physics in a 1:1 laptop school. *Journal of Science Education and Technology*, 17, 586-594.

Every reasonable effort has been made to acknowledge the owners of copyright material. I would be pleased to hear from any copyright owner who has been omitted or incorrectly acknowledged.

Appendices

Appendix A: Keys to subject identifiers for personal quotes

Appendix B: Email approach to professional organisations

Appendix C: Email to secondary principals

Appendix D: Online survey – Participant consent page

Appendix E: Online survey – Demographic data

Appendix F: Online survey – Personal and professional computer usage

Appendix G: Online survey – Reflection on computer usage

Appendix H: Online survey – Level of computer use

Appendix I: Online survey – Specific applications for instruction

Appendix J: Online survey – Microcomputer Utilisation in Teaching Efficacy Beliefs Instrument

Appendix K: Email follow up for qualitative interviews

Appendix L: Qualitative consent form and interview questions

Appendix A Keys to subject identifiers for personal quotes

Key for Qualitative Quotes from online survey

FD# – Female Director of Teaching and Learning (a unique number follows)

FE# – Female eLearning or Computer Coordinator (a unique number follows)

FH# – Female Head of Department (a unique number follows)

FL# – Female Teacher Librarian (a unique number follows)

FP# – Female Principal (a unique number follows)

FT# – Female Classroom Teacher (a unique number follows)

MC# – Male Consultant (a unique number follows)

MD# – Male Director of Teaching and Learning (a unique number follows)

ME# – Male eLearning or Computer Coordinator (a unique number follows)

MH# – Male Head of Department (a unique number follows)

MP# – Male Principal (a unique number follows)

MT# – Male Classroom Teacher (a unique number follows)

Key for Quotes from recorded Qualitative Interviews

EIH# - Exemplary Integrator of Technology, Head of Department (a unique number follows)

EIT# - Exemplary Integrator of Technology, Classroom Teacher (a unique number follows)

CUH# - Competent User of Technology, Head of Department (a unique number follows)

CUT# - Competent User of Technology, Classroom Teacher (a unique number follows)

MAT# - Minimum Adopter of Technology, Classroom Teacher (a unique number follows)

Appendix B Email Approach to Professional Organisations

Hello,

My name is Col Harrison. I am currently completing a piece of research for my Doctor of Philosophy at Curtin University of Technology, Perth in Western Australia. I am also the Coordinator of Science at The Pittwater House School in Collaroy, NSW.

The purpose of this email is to request your assistance in gathering participants in an online survey about exemplary practice in ICT integration.

There has been considerable research data gathered focusing on the potential barriers to successful ICT integration. However after 35 years of computers in education, I believe it is time to turn the focus onto the characteristics of successful ICT integrators and what common practices can be identified across school districts and national borders.

The purpose of the survey is to gather information from Secondary teachers of Science, Technology and Mathematics about their personal and professional use of computer technology and the factors that may be associated with exemplary practice. This survey is a component of a PhD study through Curtin University in Western Australia, titled: An Investigation of Exemplary ICT Integration: Enablers and Inhibitors of Best Practice

I am interested in gathering data from individual Principals and exemplary ICT integrators in Science, Mathematics and Information Technology from Australian schools to produce a comprehensive picture of exemplary ICT integrators in Secondary education.

I would like to find out whether there is a set of common qualities, characteristics and practices of exemplary, technology-integrating, teachers.

I am interested in finding out which particular qualities and practices Principals are ideally looking for in prospective teachers, particularly regarding their ICT expertise

and pedagogy.

The survey will take around 20 minutes and can be found at the following url:

https://www.surveymonkey.com/r/Exemplary_ICT_2015

Regarding the online survey, the first page outlines the purpose of the study and requests consent from participants to use their responses. Clicking the button and proceeding to the rest of the survey will indicate consent. At the end of the survey, there is a request for volunteers to participate in a follow up interview in order to expand on some of the issues identified in the survey. These interviews may be face-to-face or via Skype. Respondents wishing to participate in this qualitative component, will be asked for separate contact details.

The survey tool will be available for a period of 6 weeks. Following this period, the data will be collated and the volunteers for the qualitative follow up contacted within one month of the closing date for the survey.

The information provided will be kept separate from personal details, and only myself and the Curtin University supervisor, Dr Tony Rickards, will have access to this. Any interview transcripts will not have names or any other identifying information on it and in adherence to university policy, the interview tapes and transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

All participants in the survey will receive a written report outlining the findings from the survey once the data has been analysed.

I believe the results of this research will inform teacher profession development activities and significantly impact on teaching and learning and would greatly value your support in disseminating the survey URL to your members. I would ensure this report is made available to the Australian Association of Mathematics Teachers to be disseminated as desired. I am also happy to make a contribution to The Australian Mathematics Teacher or the Australian Senior Mathematics Journal to update members about this important research and its impact on Mathematics Teachers.

This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval Number SMEC-30-13). If you would like further information about this study, please feel free to contact me on 0400 999847, or by email colin.harrison@postgrad.curtin.edu.au. Alternately you can contact my supervisor, Dr Tony Rickards on T.Rickards@exchange.curtin.edu.au or the Secretary, HREC, as follows:

Linda Teasdale

Manager HREC, Manager, Research Ethics

R&D – Administration & Finance

Research & Development

Building 100 – Chancellory

Room 108

Bentley Campus

(+618) 9266 2784 or (+618) 9266 3793

L.Teasdale@curtin.edu.au

Thank you very much in anticipation for your assistance with this research, it is greatly appreciated.

Kind regards,

Col Harrison

PhD Candidate

colin.harrison@postgrad.curtin.edu.au

Appendix C Email to Secondary Principals

Dear Principal,

Have you any exemplary ICT integrators in your Science or Mathematics Departments? Would they be willing to contribute to some important research designed to improve Professional Development in this area? If so, would you be able to forward this email to your chosen representative(s)?

My name is Col Harrison. I am the Coordinator of Science at The Pittwater House School and am currently completing a piece of research for my Doctor of Philosophy through Curtin University of Technology, Perth in Western Australia.

The purpose of this email is to invite you, and/or selected members of your staff, to participate in an online survey about exemplary practice in ICT integration. There has been considerable research data gathered focusing on the potential barriers to successful ICT integration. However after 35 years of computers in education, I believe it is time to turn the focus onto the characteristics of successful ICT integrators and what common practices can be identified across school districts and national borders.

One purpose of the survey is to gather information from Secondary teachers of Science, Technology and Mathematics about their personal and professional use of computer technology and the factors that may be associated with exemplary practice. This survey is a component of a PhD study through Curtin University in Western Australia, titled: An Investigation of Exemplary ICT Integration: Enablers and Inhibitors of Best Practice in New South Wales Schools

I would like to find out whether there is a set of common qualities, characteristics and practices of exemplary, technology-integrating, teachers. I am interested in finding out which particular qualities and practices Principals, such as yourself, are ideally looking for in prospective teachers, particularly regarding their ICT expertise

and pedagogy. I am requesting that you and/or your nominees complete an online survey. The survey will take around 15-20 minutes of your time and can be found at the following url: https://www.surveymonkey.com/r/Exemplary_ICT_2015

Participant involvement in the research is entirely voluntary. Participants have the right to withdraw at any stage without it affecting their rights or my responsibilities.

Regarding the online survey, the first page outlines the purpose of the study and requests consent from participants to use their responses. Clicking the button and proceeding to the rest of the survey will indicate consent. Please read this information carefully before proceeding. Within the survey is a request for volunteers to participate in a follow up interview in order to expand on some of the issues identified in the survey. These interviews may be face-to-face or via Skype. Should staff wish to participate in this qualitative component, they will be asked for separate contact details.

The survey tool will be available for a period of 6 weeks. Following this period, the data will be collated and the volunteers for the qualitative follow up contacted within one month of the closing date for the survey.

The information provided will be kept separate from personal details, and only myself and my supervisor will have access to this. Any interview transcripts will not have names or any other identifying information on it and in adherence to university policy, the interview tapes and transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

All participants in the survey who indicate their interest, will receive a written report outlining the findings from the survey once the data has been analysed. I believe the results of this research will inform teacher professional development activities and significantly impact on teaching and learning and I would greatly value your input.

This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval Number SMEC-30-13).

If you would like further information about this study, please feel free to contact me on 0400 999 847, or by email to the university colin.harrison@postgrad.curtin.edu.au or school (colin.harrison@tphs.nsw.edu.au). Alternately you can contact my supervisor, Dr Tony Rickards on T.Rickards@exchange.curtin.edu.au or the Secretary, HREC, as follows:

Linda Teasdale

Manager HREC, Manager, Research Ethics

R&D – Administration & Finance

Research & Development

Building 100 – Chancellory

Room 108 Bentley Campus

(+618) 9266 2784 or (+618) 9266 3793

L.Teasdale@curtin.edu.au

Thank you very much for taking the time to read this email, and for any contribution you can make to this research. Your participation is greatly appreciated.

Kind regards,

Col Harrison

PhD Candidate

colin.harrison@postgrad.curtin.edu.au

Appendix D Online Survey – Participant Consent Page

Exemplary ICT Integration

An Investigation of Exemplary ICT Integration Survey Consent

This purpose of this survey is to gather information from Secondary teachers of Science, Technology and Mathematics about their personal and professional use of computer technology and the factors that may be associated with exemplary practice.

This survey is a component of a PhD study through Curtin University in Western Australia, titled:

An Investigation of Exemplary ICT Integration: Enablers and Inhibitors of Best Practice in New South Wales Schools

This survey is being administered by Colin Harrison. Any questions about any aspects of the survey can be directed to colin.harrison@postgrad.curtin.edu.au or the

Secretary of the Curtin University Human Research Ethics Committee on 61 8 9266 2784.

Participant Consent Statements

I understand the purpose and procedures of the study.

I have been provided with the required participant information as outlined above.

I understand that the data collected may not benefit me.

I understand that my involvement is voluntary and I can withdraw from the process at any time without problem.

I understand that no personal identifying information like my name and address will be used in any published materials.

I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.

I have been given the opportunity to ask questions about this research.

I agree to participate in this study as outlined to me.

I understand that clicking the 'I accept' button is an acknowledgement that I have read and accept the above conditions and risks associated with participation in this survey.

1. I have read through the information above and give my consent to participating in this survey and having my responses used for the purposes outlined above.

- I accept
- I do not accept

Appendix E Online Survey – Demographic Data

Exemplary ICT Integration

Part 1 of 6 Some information about your background

In the first two Parts, we are gathering information about ICT use by teachers. Most questions will only require the ticking of one or more boxes.

Thank you for undertaking this survey.

2. I would describe my school as . .

- Primary School
- High School
- Combined Primary and High School
- Senior School
- Government School
- Independent School
- Catholic School
- Other (please specify)

3. I would describe my school's affiliation as . .

- Non denominational
- Catholic
- Christian
- Jewish
- Islamic
- Buddhist
- Non religious
- Other (please specify)

4. My school emphasises the importance of

- Aboriginal and Torres Strait Islander culture and heritage
- French culture and heritage
- German culture and heritage
- Jewish culture and heritage
- Islamic culture and heritage
- Japanese culture and heritage
- Australian culture and heritage
- All cultures and heritage are equally represented
- Other (please specify)

5. My current role in the school is primarily . .

- Classroom teacher
- Head of Department
- Head of Administration
- Director of Teaching and Learning
- Deputy Head of School
- Head of School
- Deputy Principal
- Principal
- Other (please specify)

6. The main subjects I teach are . . .

- Year 7-8 Mathematics
- Year 7-8 Science
- Year 7-8 Technology or Applied Studies
- Year 9-10 Mathematics
- Year 9-10 Science
- Year 9-10 Technology or Applied Studies
- Year 11 Mathematics
- Year 11 Science
- Year 11 Biology
- Year 11 Chemistry
- Year 11 Earth Science
- Year 11 Physics
- Year 11 Technology and Applied Studies
- Year 11 Software Design
- Year 11 Information Processing
- Year 12 Mathematics
- Year 12 Science
- Year 12 Biology
- Year 12 Chemistry
- Year 12 Earth Science
- Year 12 Physics
- Year 12 Technology and Applied Studies
- Year 12 Software Design
- Year 12 Information Processing
- Other (please specify)

7. I teach the following year Levels

- Pre-Year 1, eg Kindergarten, Preparatory
- Year 1
- Year 2

- Year 3
- Year 4
- Year 5
- Year 6
- Year 7
- Year 8
- Year 9
- Year 10
- Year 11
- Year 12
- Year 13

8. In what year were you born? (enter 4-digit birth year; for example, 1976)

9. My sex is . .

- Female
- Male

10. My highest academic qualification is . .

- Diploma
- Bachelor Degree
- Graduate Diploma
- Bachelor Degree with Honours
- Master Degree
- Master Degree with Honours
- Doctor of Philosophy
- Other (please specify)

11. I have been teaching for . . .

- 1-2 years
- 3-5 years
- 6-10 years
- 11-15 years
- 16-20 years
- 21-25 years
- 26-30 years
- Over 30 years

Appendix F Online Survey – Personal and Professional Computer Usage

Exemplary ICT Integration

Part 2 of 6 Your Personal and Professional Computer Usage

Thank you for completing Part 1.

In this Part, we are interested in your computer experience and expertise.

12. How many years have you been using computers for personal use, eg gaming, keeping personal accounts, tax records, email, social networks, etc?
- 1-2 years
 - 3-5 years
 - 6-10 years
 - 11-15 years
 - 16-20 years
 - 21-25 years
 - 26-30 years
 - Over 30 years
13. How many years have you used a personal computer at home for professional purposes, eg lesson preparation, preparing worksheets or notes, keeping marks, etc?
- 1-2 years
 - 3-5 years
 - 6-10 years
 - 11-15 years
 - 16-20 years
 - 21-25 years
 - 26-30 years
 - Over 30 years
14. Thinking about Question 13, which applications have you used primarily for professional purposes?
15. Please rank the following sources of learning about the effective use of computers in education from your experience. Use number 1 for the most effective and continue numbering with 2 being the next most effective up to 12 being the least effective. Only number as many as a relevant, eg. if you have only used 5 methods, feel free to stop at 5.

- Educator conferences
- University course work
- State/district/school level workshops
- Non-school sponsored workshops
- Private vendors, including eBook publishers
- Learned on my own (reading, trial and error, videos, etc)
- Learned from my peers
- Learning from my students
- Web-based instruction
- Software help files
- List servers
- User Forums

16. In the last 3 years, how many hours of professional development, specifically relating to the use of ICT in the classroom, have you undertaken?

Formally eg Conference, Workshop, etc

Informally, eg self-paced, online forum, etc

17. Thinking about a typical week during the school year, how many hours would you spend using or incorporating computers for

	<input type="text"/>	

18. Where are you most often when you use the internet?

19. For the ICT devices listed, rank only the devices you use either for personal or work related uses in order of preference of use. Please list 1 as your preferred device for that job, 2 for your second choice, and so on. List only the devices you use, so do not use all the numbers from the drop down if you don't need them.

	Games and Entertainment	Personal Admin	Educational Admin	Teaching and Learning
Desktop				
Laptop				
PC Tablet				
Smart Phone				
Apple iPad/Mini				
Other				

20. Please provide your contact information; (name, email address) if you would be willing to participate in further studies involving the use of computers in education and/or receive a copy of the findings from this research. If you would prefer not to participate, nor receive a copy of the results, please leave the question blank.

Name:

School:

City/Town:

State/Province:

ZIP/Postal Code:

Country, if outside Australia

Email Address:

Appendix G Online Survey – Reflection on Computer Usage

Exemplary ICT Integration

Part 3 of 6 Reflection on Computer Usage

Thank you for your responses. There are only 2 parts remaining.

In reflecting on your own personal experiences, please answer the following questions as honestly and completely as possible.

Thanks.

21. 1. I feel my use of computers in the classroom would be more effective if
22. I feel my use of computers in the classroom is less effective than it could be because
23. In order to do my job efficiently in the current age of technology, I think the minimal amount of technology use I can get away with is
24. In order to do my job more efficiently in the current age of technology, I would like to be able to improve my knowledge and/or skills in
25. In relation to the use of technology in the classroom, I think I would personally benefit most from professional development activities which
26. In relation to the use of technology in the classroom, I think the teaching staff in my school would personally benefit most from professional development activities which
27. In thinking about the use of technology in the classroom, in your opinion, what sorts of activities best identifies the following types of teachers in terms of technology use in the classroom?
 - a. Technophobic teacher
 - b. A minimum adopter of technology for teaching
 - c. Technologically competent teacher
 - d. An exemplary integrator of technology in the classroom

28. In thinking about the four categories described above, in relation to classroom practice, I would best describe myself as

- a) Technophobic
- b) A minimum adopter
- c) Technologically competent
- d) An exemplary integrator of ICT in the classroom

Appendix H Online Survey – Level of Computer Use

Exemplary ICT Integration

Part 4 of 6 Technology Use in Education

Thank you for completing Part 3. There are 3 parts remaining.

The following is a set of four statements in different combinations. Wherever the word ‘computer’ appears, this can be interpreted to mean desktop, laptop or tablet, unless specified otherwise. Many of these statements may appear quite similar. This has been written deliberately.

29. Identify one answer (A or B) in each combination that best represents you and your opinion.

A. in my instruction, the use of the computer is supplemental

B. the computer is critical to my instruction

30. Identify one answer (A or B) in each combination that best represents you and your opinion.

A. the use of the computer is not essential in my instruction

B. for my teaching, the use of the computer is indispensable

31. Identify one answer (A or B) in each combination that best represents you and your opinion.

A. the computer is critical to my instruction

B. the use of the computer is not essential in my instruction

32. Identify one answer (A or B) in each combination that best represents you and your opinion.

A. for my teaching, the use of the computer is indispensable

B. in my instruction, the use of the computer is supplemental

Appendix I Online Survey – Specific Applications for Instruction

Exemplary ICT Integration

Part 5 of 6 Specific Applications for Instruction

Thank you. You have almost completed the survey.

In this Part, we would like you to compare your use of technology with your students' use of technology.

33. For each category listed below, rate the frequency with which you undertake these tasks and the frequency with which your students undertake these tasks.

	My students use of technology for this purpose	My use of technology for this purpose
Simulation & Ed Games		
Imaging		
Communication		
Publishing		
Drill & Practice		
Information Retrieval		
Datalog and Analysis		

**Appendix J Online Survey – Microcomputer Utilisation in Teaching
Efficacy Beliefs Instrument**

Exemplary ICT Integration

Part 6 of 6 Teaching with Technology

Thanks for your assistance. This final part of the survey involves a series of statements, for which we are seeking your opinion.

34. Please indicate the degree to which you agree or disagree with each statement below by selecting the appropriate box to the right of each statement. Respond to each item with respect to your own teaching.

Scale:

SA= Strongly Agree A= Agree UN= Uncertain D= Disagree SD= Strongly Disagree

	SA	A	UN	D	SD
When a student shows improvement in using the computer, it is often because the teacher exerted a little extra effort.	<input type="radio"/>				
When a student's attitude toward using computers improves, it is often due to their teacher having used the classroom computer in more effective ways.	<input type="radio"/>				
If students are unable to use the computer, it is most likely due to their teachers' ineffective modelling.	<input type="radio"/>				
The inadequacy of a student's computer background can be overcome by good teaching.	<input type="radio"/>				
The teacher is generally responsible for students' competence in computer usage.	<input type="radio"/>				

Students' computer ability is directly related to their teacher's effectiveness in classroom computer use.	<input type="radio"/>				
If parents comment that their child is showing more interest in computers, it is probably due to the performance of the child's teacher.	<input type="radio"/>				
I am continually finding better ways to use the computer in my classroom.	<input type="radio"/>				
Even when I try very hard, I do not use the computer as well as I do other instructional resources.	<input type="radio"/>				
I know the steps necessary to use the computer in an instructional setting.	<input type="radio"/>				
I am not very effective in monitoring students' computer use in my classroom.	<input type="radio"/>				
I generally employ the computer in my classroom ineffectively.	<input type="radio"/>				
I understand computer capabilities well enough to be effective in using them in my classroom.	<input type="radio"/>				
I find it difficult to explain to students how to use the computer.	<input type="radio"/>				
I am typically able to answer students' questions which relate to the computer.	<input type="radio"/>				
I wonder if I have the necessary skills to use the computer for instruction.	<input type="radio"/>				
Given a choice, I would not invite the principal to evaluate my computer based instruction.	<input type="radio"/>				
When students have difficulty with the computer, I am	<input type="radio"/>				

usually at a loss as to how to help them.					
When students use the computer, I usually welcome student questions.	<input type="radio"/>				
I do not know what to do to increase student interest in using computers as part of their learning.	<input type="radio"/>				
Whenever I can, I avoid using computers in my classroom.	<input type="radio"/>				

Exemplary ICT Integration

Thank You

Thank you for your valuable contribution to this research. If you have previously provided your details for follow up, or a copy of the final report, we will be in touch with you soon.

Col Harrison.

Appendix K Email follow up for Qualitative Interviews

This is a general email contact as you agreed to one of the following in a recent survey:

a) you would be willing to participate in further studies involving the use of computers in education

and/or

b) you would like to receive a copy of the findings from this research.

This study has a qualitative component as well as the quantitative data you have already completed. The qualitative follow up involves a Skype interview (or other suitable media) with myself. I anticipate this will take the form of a number of questions related to the answers you have already provided to allow additional detail or clarification of several points. Again, I anticipate this interview will take around 20 minutes. I would like your permission to record the interview which will be transcribed and stored at Curtin University. Responses will only be used for the purpose of this study. If you choose to participate in this component of the course, I shall email you the questions prior to the interview. I hope to carry out these interviews over the next few weeks.

Could you please indicate by replying to this email:

yes, I am happy to be involved in the qualitative component of the research,

or

no, I would like to receive a copy of the final report but do not wish to participate in the qualitative component.

Either way, please accept my deepest gratitude for the generous assistance you have already given to this research.

Kind regards,

Col Harrison

PhD Candidate

colin.harrison@postgrad.curtin.edu.au

Appendix L Qualitative Consent Form and Interview Questions

Qualitative Survey Statement of Consent

This purpose of the qualitative survey is to gather additional information from consenting Secondary teachers of Science, Technology and Mathematics about their personal and professional use of computer technology and the factors that may be associated with exemplary practice.

This survey is a component of a PhD study through Curtin University in Western Australia, titled: An Investigation of Exemplary ICT Integration: Enablers and Inhibitors of Best Practice in New South Wales Schools.

This survey is being administered by Colin Harrison.

Participant Consent Statements

-  I understand the purpose and procedures of the study.
-  I have been provided with the required participant information as outlined above.
-  I understand that the data collected may not personally benefit me.
-  I understand that the interview will be recorded and transcribed for the purposes of the research project.
-  I understand that my involvement is voluntary and I can withdraw from the process or refuse to respond to any questions at any time without problem.
-  I understand that no personal identifying information like my name and address will be used in any published materials.
-  I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.
-  I have been given the opportunity to ask questions about this research.
-  I agree to participate in this study as outlined to me.
-  I understand that my verbal acceptance is an acknowledgement that I understand and accept the above conditions and risks associated with participation in this survey.

Do you have any questions before we begin?

Are you prepared to give your consent to the above statements?

Questions for further discussion:

As the interview progresses, I shall ask each of these questions one at a time. I may ask for additional clarification at some point.

1. How would you describe your preferred teaching style? Please discuss one example.
2. How would you describe your use of technology in your classroom? Please provide one example.
3. What do you think is your greatest need in terms of improving your integration of technology in your classroom? Why have you identified this particular need?
4. How would you describe yourself in terms of technology integration and specifically the use of computers in your classroom? Why?
5. What level of student autonomy exists within your classrooms generally? Please provide an example.
6. If it was critical that you learned how to use a new piece of hardware and software for educational purposes, how would you prefer to learn?
7. How do you see your classes operating in 5 years time? Will they be much as they are now or will they change? If so, can you describe how they might change?