Evaluating the Impact of 1:1 Laptops on High School Science Students and Teachers

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I dedicate this thesis to Julianna, James and Patrick – you to me are everything.

Statement of originality

I declare that the research presented here is my own work and has not been submitted to any other institution for the award of a degree.

I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged.

Simon Crook,
August 2016

Abstract

This thesis is the culmination of a 6-year-long longitudinal study into the impact of 1:1 laptops on the experiences and achievements of high school science teachers and students. Set in the context of 16 Sydney high schools during the Australian Digital Education Revolution, this thesis explores the practices of teachers and students with 1:1 laptops in the sciences, the impact of the 1:1 laptops on student attainment in standardised external examinations, and ultimately investigates the reasons behind the findings.

As a thesis-by-publication, this thesis consists of two introductory chapters, five journal papers (four of which have been published in peer-reviewed journals, with the fifth under review) making up five chapters, an overall discussion and a self-reflection.

The first paper explores teachers' and students' perceptions of laptop use in grade 10 science. A variable, the *Misalignment Index*, is developed and calculated to help differentiate the alignments of perceptions between teachers and their students. *Bubble graphs* are also created as visual representations to help identify relative misalignment.

The second paper ultilises Bloom's Digital Taxonomy as a theoretical framework to label various laptop activities as higher- or lower-order. Using questionnaire data, the self-reported practices with 1:1 laptops of teachers and students are presented, compared and contrasted in terms of higher- and lower-order activities.

The third paper is the pinnacle of this thesis. Responding to the paucity of quantitative research into the impact of 1:1 laptops (and other technologies) on student attainment in standardised external examinations, multiple regression analyses are performed to determine if using 1:1 laptops is a predictor of academic attainment. Within the context of this study, I found that using 1:1 laptops has statistically significant positive correlations with attainment in biology, chemistry and physics, with small effect sizes in biology and chemistry and a medium effect size in physics. This paper was very well received by the national media; featuring in various newspaper articles, The Conversation and on the radio.

Building on the substantial findings of the third paper, the fourth paper seeks to explain the different effect sizes for biology and physics. Using TPACK as a conceptual framework, along with analyses of teacher and student exit questionnaires in terms of higher- and lower-order uses, thematic analyses of teacher and student comments, and an analysis of the respective curriculum documents, physics teachers and students are found to engage in more higher-order

activities, such as simulations and spreadsheets, than those in biology. This disparity is found to be reflected in the curriculum documents. *Explosion charts* are created and utilised as visual representations to assist with the analysis.

The fifth and final paper is a longitudinal case study of four science teachers; one for each of biology, chemistry, physics and senior science. This paper records the evolving experiences and skills of the teachers and their students with using 1:1 laptops in the study of their respective science subjects. Common themes are identified and differences in practices over time are compared and contrasted.

Ultimately, this thesis provides a detailed, mixed methods commentary of the experiences of schools, teachers and students over the five years of the much maligned Digital Education Revolution, something that is missing in the national public domain. Within the larger sphere of educational technology research globally, this thesis contributes to filling in some of the gaps existing in the extant literature, particularly in terms of quantitative analysis and statistically significant findings. Future research would benefit from the methodologies, visual representations and overall findings contained within this thesis. In fact, several recent eminent literature reviews and meta-analyses include some of the papers that make up this thesis.

Acknowledgements

An enormous amount of thanks must first of all go to my supervisor Professor Manju Sharma from the School of Physics. Manju, you backed me all the way, taking on a mature-age, full-time employed, part-time, thesis-by-publication student, when experience had shown you that this was a high-risk venture, yet you believed in my research and in me. It's funny to recall that you first approached me about postgraduate study back in 2006 whilst I was still a physics teacher and well before the Digital Education Revolution was even thought of. You were very patient while I had to wait for permanent residency before I could even apply to study. Thus in 2010, after lots of build-up, we landed with our feet running and it has been a blast in the six years since. Manju, I am humbled that you invited me to study and believed in and enjoyed my work all along the way. It has been an absolute pleasure to work under your guidance; your intelligent, pastoral and flexible approach was perfect for me to succeed. You are more widely appreciated than you know.

I would also like to profoundly thank my co-supervisor Dr Rachel Wilson from the Faculty of Education and Social Work. Rachel, I wish you were there at the start; it would have saved me from a lot of dead ends. Your expertise in quantitative analysis and writing have been invaluable. Your no-nonsense approach combined with your humorous incredulity at the educational world around us has made for many a fun conversation and much better work from myself.

To the aptly named SUPER (Sydney University Physics Education Research) group, thank you for all of your support over the years even though I was very much part-time on campus. Particular thanks to Helen Georgiou, Matthew Hill, Alexandra Yeung, Gabriel Nguyen, Christine Lindstrøm and Tom Gordon for your ongoing support, friendship and examples to follow. Thanks also to Derek Muller of Veritasium fame for my initial foray into developing multimedia resources, contributing to my first paper and daring to dream. To the School of Physics, many thanks for your administrative support, particularly Alexis George, and for the encouragement from my annual performance reviewers over the past six years.

My studying would not have been possible without the support, scholarship and study leave provided by my former employers, Catholic Education Office (CEO) Sydney, thank you! In particular, I would like to thank all of the teachers and students who supported my research by completing many questionnaires and being interviewed. A very special mention must go to my former boss Mark Turkington for his unwavering support, belief and interest in my research.

Mark, you posed the original question “what will these laptops do to our exam results?”. Well, we found out. Thank you for helping guide my initial inquiry and for your never ending encouragement. I would also like to thank Dan White, Michael Bezzina, Seamus O’Grady, Doug Ashleigh, Michael Krawec plus the Southern Region study group for their support and encouragement. Many, many thanks also to Kevin Trimble for sourcing, providing and expertly assisting with chunks of the data.

There are several other individuals who have also helped me, particularly at the beginning. Many thanks to David Gow from UQ and ACSPRI for your expert tuition around regression analysis and your interest in my studies, John DeCourcy from CEO Parramatta for your expert advice with data and Louise Sutherland from USyd education for your initial ideas.

I would like to thank all of my friends and colleagues and the researchers who have shown interest in my work and offered encouragement along the way.

Sincere gratitude to my parents Peter and Frances and my brothers Martin, Jonny and Nick. Although we are miles apart, you all continue to be great inspirations to my study and my life.

Finally, and most importantly, I would like to thank from the bottom of my heart my wife Julianna and my sons James and Patrick. Thank you for being so adaptable and understanding. Beginning a PhD when James was only 13 months old has probably been the second hardest thing I have ever done. Finishing, since the arrival of the whirlwind that is Patrick, has probably been the hardest! Thank you for keeping everything together Jules and supporting me through this wonderful opportunity to study. Your turn next.

The work of this thesis was supported by the University of Sydney and the Catholic Education Office Sydney. The work in this thesis has been approved by the Human Ethics Research Committee at The University of Sydney and the Catholic Education Office Sydney Human Ethics Committee.

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Nil satis nisi optimum

Included publications and attribution

Each chapter in the body of the thesis (Chapters 2-6) is an individual self-contained article, written for a scientific journal. Together in this one document they form a consistent thesis with an evolving narrative. The first four papers, Chapters 2-5, have already been published in peer-reviewed journals, most of them already cited in the work of other academics and most of them republished with permission or as synopses in other journals and media. Chapters 4 and 5, arguably the most important chapters, particularly Chapter 4, have also featured in several national newspaper articles and a live radio interview. Chapter 6 is a journal article that has been submitted to a peer-reviewed journal, and is currently under review. Additional material is provided at the end of each of Chapters 2-6 to provide further background and/or commentary that is missing from the original journal publications.

Chapter 2

Crook, S. J., Sharma, M. D., Wilson, R., & Muller, D. A. (2013). Seeing Eye-to-Eye on ICT: Science Student and Teacher Perceptions of Laptop Use across 14 Australian schools. *Australasian Journal of Educational Technology, 29*(1), 82-95. doi:10.14742/ajet.72.

My contribution

I conceived the idea of surveying teachers and students about their use of laptops in teaching and learning. I created, distributed, collated and analysed the questionnaires and the data within. In presenting the results I anonymised the participants. I came up with the concept of a *Misalignment Index* and wrote the paper with feedback and suggestions on my drafts being provided by Professor Manjula Sharma and Rachel Wilson as my supervisor and co-supervisor respectively. Manju suggested the AJET journal and also suggested the creation of the bubble graphs, which I duly did. Derek Muller, from our research group, SUPER, also provided some feedback and suggestions, including the title.

Citations of note

Being my first paper and therefore in existence the longest, *Seeing eye-to-eye on ICT* has been the mostly widely cited of my publications. The most notable citations are:

Beckman, K., Bennett, S., & Lockyer, L. (2014). Understanding students' use and value of technology for learning. *Learning, Media and Technology, 39*(3), 346-367. doi:10.1080/17439884.2013.878353

This paper comes from the School of Education at the University of Wollongong, one of the premier Australian research groups regarding educational technology. As such, academics from this group were commissioned to report on the Digital Education Revolution in New South Wales (NSW) by the NSW Department of Education and Communities. The paper references my study of students' perspectives regarding technology.

White, G. (2013). *Forward thinking : three forward, two back : what are the next steps?* : Extended version of a presentation given to the Australian College of Educators National Conference, Melbourne.

This paper was written by a Principal Research Fellow from the Australian Council for Educational Research (ACER) as an extended version of a keynote presentation given at the Australian College of Educators National Conference in 2013. ACER is one of the world's leading educational research centres and regularly publishes papers on educational technology, drawing on the international literature. This keynote presentation and subsequent paper from ACER both referenced *Seeing eye-to-eye on ICT* three times.

Zheng, B., et al. (2016). Learning in One-to-One Laptop Environments: A Meta-Analysis and Research Synthesis. *Review of Educational Research*, 1-33. doi: 10.3102/0034654316628645.

Only recently published, this paper appeared in the highest ranked journal for education and educational research. The first and second authors, Binbin Zheng and Mark Warschauer, are two of the most notable academics globally regarding the use of laptops in education. Importantly, their paper is a meta-analysis and research synthesis of the seminal literature on 1:1 laptops. Flatteringly, my research is included within.

Chapter 3

Crook, S. J., & Sharma, M. D. (2013). Bloom-ing Heck! The Activities of Australian Science Teachers and Students Two Years into a 1:1 Laptop Program Across 14 High Schools. *International Journal of Innovation in Science and Mathematics Education, 21*(1), 54-69. http://openjournals.library.usyd.edu.au/index.php/CAL/article/view/6674/7661

My contribution

This paper came about from analysing some of the additional data collated from the first round of questionnaires. It was my idea to use Bloom's Digital Taxonomy as a theoretical framework to help differentiate the activities from lower- to higher-order. I analysed the data, collated the results and wrote the paper, drawing on the feedback and suggestions from Professor Manjula Sharma.

Chapter 4

Crook, S., Sharma, M., & Wilson, R. (2015). An Evaluation of the Impact of 1:1 Laptops on Student Attainment in Senior High School Sciences. *International Journal of Science Education, 37*(2), 272-293. doi:10.1080/09500693.2014.982229

My contribution

My original conception for this thesis hung on the research for this paper. I created, conducted, collated and analysed the questionnaires for this paper. I also accessed the required examination, socioeconomic, demographic, school and technological data, which I then aggregated into an overall database whilst anonymising the participants. I wrote this paper with the assistance of Professor Manjula Sharma and Dr Rachel Wilson. Due to the importance of the findings, this paper has been the subject of several newspaper articles, republications, synopses and interviews.

Citations of note

Haßler, B., Major, L., & Hennessy, S. (2016). Tablet use in schools: a critical review of the evidence for learning outcomes. *Journal of Computer Assisted Learning, 32*(2), 139-156. doi:10.1111/jcal.12123

Written by members of the Faculty of Education at the esteemed University of Cambridge Cambridge, one of the premier research groups in this field, and appearing in a leading journal in educational technology, this paper makes mention of our findings in my *IJSE* paper.

Maxwell, A. L. (2015). The impact of one-to-one laptop initiatives on K-12 math and science pedagogy and achievement: A literature review. University of Texas at Austin.

This literature review written as a postgraduate thesis from the University of Texas at Austin references my IJSE paper 9 times. In fact, the IJSE paper is unpacked as one of the 18 extant international studies pertaining to one-to-one laptop initiatives in science (and mathematics).

Zheng, B., et al. (2016). Learning in One-to-One Laptop Environments: A Meta-Analysis and Research Synthesis. *Review of Educational Research*, 1-33. doi: 10.3102/0034654316628645.

Also mentioned when outlining Chapter 2, this paper appeared in the highest ranked journal for education and educational research. The first and second authors, Binbin Zheng and Mark Warschauer, are two of the most notable academics globally regarding the use of laptops in education. Importantly, their paper is a meta-analysis and research synthesis of the seminal literature on one-to-one laptops. Flatteringly, two articles of my research are included within.

Chapter 5

Crook, S. J., Sharma, M. D., & Wilson, R. (2015). Comparison of Technology Use Between Biology and Physics Teachers in a 1:1 Laptop Environment. *Contemporary Issues in Technology and Teacher Education, 15*(2), 1-23. http://www.citejournal.org/vol15/iss2/science/article1.cfm

My contribution

This paper was an extension of the previous paper (Chapter 4). It was my idea to use TPACK as the theoretical framework. I performed the extensive literature review, analysed the student and teacher data, analysed the curriculum documents, presented my findings including the creation of explosion charts, analysed the results and wrote the paper drawing on the feedback of Professor Manjula Sharma and Dr Rachel Wilson.

Chapter 6

Crook, S. J., Sharma, M. D., & Wilson, R. (in review). Teachers' transition into a 1:1 Laptop Environment: A Longitudinal Case Study of Four Science Teachers over 5 years.

My contribution

This paper relied upon finding teachers from the extensive study who could shed light on their experiences of 1:1 laptops in a meaningful way. I analysed teacher and student data to find four science teachers. Finding the four teachers, as is often the case with research, relied upon a bit of chance, luck, serendipity and the benefit of a good plan and foresight. I developed the interview questions in collaboration with Professor Manjula Sharma and Dr Rachel Wilson. I then contacted the four teachers and their respective schools, conducted the interviews and organised the transcription of the interviews. Analysis of the interview transcriptions and ultimately the writing of the paper were conducted by myself in collaboration with Professor Manjula Sharma and Dr Rachel Wilson.

Republications and synopses

Crook, S. J. (2013). Seeing eye-to-eye on ICT: Student and Teacher Perceptions of Laptop use across 14 NSW Secondary Schools. *Science Education News, 62*(3), 149-150.

This 700-word synopsis of my first paper, Chapter 2, was written by myself for the journal of the Science Teachers' Association of NSW (STANSW).

Crook, S. (2015). An evaluation of the impact of 1:1 laptops on student attainment in senior high school sciences. *Curriculum & Leadership Journal, 13*(4).

This 1000-word article is a synopsis of the first four of my papers, Chapters 2-5.

Crook, S., Sharma, M., & Wilson, R. (2015). Students with laptops did better in HSC science. *The Conversation*.

This synopsis of Chapters 4 and 5 was written for *The Conversation*. It has been accessed by 4000 registered readers and precipitated 17 comment threads.

Crook, S., Sharma, M., & Wilson, R. (2015). Students with laptops did better in HSC science. *Science Education News, 64*(4), 29-30.

This article was a republication with permission of *The Conversation* article above.

Newspaper and media features

Arlington, K. (2015, October 17). How using a laptop can help you get a better HSC science mark. *Sydney Morning Herald*.

This feature by the *Sydney Morning Herald* covered the findings from Chapters 4 and 5. It included excerpts of interviews with myself and also Professor Manjula Sharma.

Arlington, K. (2015, October 17). How using a laptop can help you get a better HSC science mark. *The Age*.

This article in *The Age* was a replication of same article published in the *Sydney Morning Herald*.

Crook, S. (2015, September 2) */Interviewer: P. Clarke*. 666 ABC Canberra - Breakfast.

This three-and-a-half-minute live radio interview on *ABC Canberra* was regarding the findings from Chapters 4 and 5. The interview was sought by the ABC and arranged after they read the article published in *The Conversation* the day before (see *Republications and synopses*).

Ferrari, J. (2014, December 12). Technology turns science of schooling on its head. *The Australian*.

This feature in *The Australian* appeared after Chapter 4 was first published online in late 2014, prior to appearing in print in early 2015. It featured the findings from Chapters 4 and 5.

Conference presentations, posters and invited talks

Crook, S. (2012, 14th-15th June). *Nil satis nisi optimum.* Workshop run at the Second National ITL Masterclass, Adelaide.

Crook, S., & Sharma, M. D. (2012, 26th-28th September). *Initial data analysis of teachers' and students' reported and type of use of laptops in science in 14 Sydney secondary schools.* Paper presented at the Australian Conference on Science and Mathematics Education, Sydney.

Crook, S. (2012, 10th-11th November). *Interactive and collaborative teaching methods using ICT.* Talk presented at the Science Teachers' Workshop, Sydney.

Crook, S. (2013, 24th April). The Digital Education Revoltion: Initial data analysis of teachers' and students' reported and type of use of laptops in year 10 science. Paper presented at the CoCo Seminar Series, Sydney.

Crook, S. (2013, 1st-2nd June). *How technology is breaking down traditional barriers.* Paper presented at the Edutech, Brisbane.

Crook, S. (2013, 13th-14th June). *Nil satis nisi optimum.* Workshop run at the Third National ITL Masterclass, Sydney.

Crook, S. (2013, 6th September). *What does it mean to live in a technology-rich world?* Talk presented at the ABC Splash Live: Digital ideas for the classroom, Sydney.

Crook, S., Sharma, M. D., & Wilson, R. (2013, 19th-21st September). Early multiple regression analysis of high school sciences examination data: Assessing the impact of laptop use on student performance. Poster presented at the Australian Conference of Science and Maths Education, Canberra.

Crook, S. (2013, 2nd-4th October). *The future of technology in education.* Paper presented at the ACEL National Conference: The future is now, Canberra.

Crook, S., Sharma, M. D., & Wilson, R. (2014, 29th September-1st October). *An evaluation of the impact of 1:1 laptops on student attainment in senior high school sciences.* Paper presented at the Australian Conference of Science and Maths Education, Canberra.

Crook, S. (2015, 13th July). *eLearning @ Hennessy.* Workshop run at the Hennessy College staff development day, Young.

Crook, S. (2015, 14th August). *The pros and cons of laptops*. Talk presented at the Shore Professional Learning Forum, Sydney.

Crook, S., Sharma, M., & Wilson, R. (2016, 11th-13th January). *An evaluation of the impact of 1:1 laptops on student attainment in senior high school sciences.* Paper presented at the American Association of Physics Teachers Winter Meeting, New Orleans.

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Chapter 1
What will these laptops do to our exam results?

1.1 The issue

The impact, positive or negative, of technology on student learning is a vexed issue. There are many differing opinions out there ranging from zealous technophiles to equally zealous technophobes (Selwyn, 2010). Even now, there is still commentary in the national media (Bita, 2016) about the impact of 1:1 laptops from the Digital Education Revolution (which finished in 2012), the context for this thesis. The problem is that the various opinions tend to be grounded in personal experiences and biases; they are not based on in-depth research and quantitative statistical analyses. A major contributory factor to this is the paucity of research which has examined the impact of laptop computers on student academic achievement (Kposowa & Valdez, 2013), particularly quantitative research (Crook, Sharma, & Wilson, 2015b). The purpose of this thesis is to fill this void, particularly within an Australian context.

1.2 The Digital Education Revolution

In 2008, Australia embarked on its *Digital Education Revolution* (DER). As part of the election campaign ahead of the general election in late 2007, the then Labor opposition headed by Kevin Rudd announced its intentions to equip every Australian secondary school with world class information and communication technology (ICT) as part of its proposed education reforms in the *A Digital Education Revolution* policy document (Rudd, Smith, & Conroy, 2007). In fact, during an ABC *7.30 Report*, it was revealed that the intention was to provide every student with a laptop (Australian Broadcasting Corporation, 2007) i.e. 1:1 laptops. A political party providing schools with laptops at massive public expense only added to the hyperbolic opinions in various quarters about the merit or detriment of laptops on learning. Yet, where was the evidence, and who was going to analyse the success or not of the DER?

Large-scale 1:1 laptop initiatives are not a new phenomenon internationally. One of the earliest, and certainly the most famous, implementation was the Maine Learning Technology Initiative (MLTI), when in 2002 the state of Maine began issuing a laptop to every seventh- and eighth-grade student and their teachers (Silvernail & Lane, 2004). There have also been 31 recent 1:1 laptop initiatives across 19 countries in Europe (Balanskat et al., 2013). However, as is discussed later, very few of the various initiatives have been scrutinised through in-depth quantitative analyses (Kposowa & Valdez, 2013).

1.3 The opportunity

At the time of the official launch of the DER following Labor's success in the federal election, I had just been employed as *eLearning Adviser* to 16 secondary schools in southwest Sydney and the Sutherlandshire by the Catholic Education Office (CEO) Sydney[1]. My role was to work with all of the teachers, from all of the schools, in all subject areas on how to manage classrooms of students using laptops, how to use laptops in teaching and learning and in some cases simply how to use a laptop. With the variety of wild opinions about the impact of laptops on student learning, I immediately had school principals and district administrators asking me what would be the impact of the laptops on their examination results? With the University of Sydney inviting me to undertake some postgraduate study in physics education research and CEO Sydney encouraging research and requiring answers, I had both an academic and professional question that needed researching and answering.

1.4 A focus on the sciences

Having previously helped develop multimedia resources for Higher School Certificate (HSC) physics with the University of Sydney's physics education research (SUPER) group (Muller et al., 2008), namely a flash interactive simulation of *Thomson's Experiment* to assist those Australian secondary schools (almost all of them) that did not have access to the equipment and/or expertise to perform Thomson's Experiment, I was keen to embark on my own research within the research group. Evaluating the impact of laptops on student attainment seemed the perfect challenge. With my background as a physics and science teacher, and my relationship with the SUPER group, I naturally decided to focus my research on school teachers and students in the sciences.

1.5 The mechanics of the Digital Education Revolution

The aim of the DER was to create a 1:1 computer-to-student ratio for grades 9-12 in all Australian secondary schools within 5 years (Dandolopartners, 2013). Obviously, the logistics

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[1] Within Australia, there are three different school sectors: (1) government schools; (2) Catholic systemic schools, such as those governed by CEO Sydney; and (3) independent schools. Catholic systemic schools are non-selective, catering for students across the full range of socioeconomic status.

for achieving this in every secondary school, budgeted at AU$2.1 billion, needed careful coordination; the responsibility falling on then Deputy Prime Minister Julia Gillard who had responsibility for the education portfolio.

It was decided that in order to implement this successfully, schools would be split into two rounds, *Round 1* and *Round 2*, with Round 1 schools receiving technology to issue to grade 9 students every year for four years from 2008 to ultimately achieve the desired ratio, and Round 2 schools doing the same starting from 2009. Thus, the DER was to run from 2008 to 2012.

1.6 A unique dichotomy

Locally, schools from CEO Sydney were to be split across Rounds 1 and 2. The split was ostensibly based on need following a federal audit of technology in the schools, but in fact was somewhat arbitrary with equivalence across both groups in terms of the socio-demographic and technological profiles for the 16 schools I worked with (Crook et al., 2015b). With about half of the schools in Round 1 and half in Round 2, this created a very fortuitous, unique and crucial dichotomy: when the grade 9 students from 2008 sat for their statewide external standardised HSC examinations in 2011, those from Round 1 had been schooled for three and half years with individual laptops and those from Round 2 without. This created a one-off, natural, non-researcher-influenced experiment for me to investigate (Murnane & Willett, 2011).

1.7 1:1 laptops

One-to-one, or 1:1, laptops refer to when students are issued with laptops, one laptop per student, to use at school and usually at home too (Zheng, Warschauer, Lin, & Chang, 2016). Back in 2008 and 2009, whereas some schools provided extra desktop computers to achieve the desired 1:1 ratio for the DER and others provided laptops locked away in trolleys that could only be used in school, CEO Sydney provided one laptop for every child to use at school and at home i.e. 1:1 laptops in the true sense of the word (Bebell & O'Dwyer, 2010). This was very much in the spirit of the original 2007 announcement (Australian Broadcasting Corporation, 2007). The laptops issued in CEO Sydney schools were either Apple MacBooks® or HP laptops (at the schools' discretion). The type of laptop issued varied elsewhere, with some schools issuing lower-order netbooks, thereby making funds available for wireless infrastructure.

Ubiquitous computing means an *anywhere, anytime* learning environment (Wurst, Smarkola, & Gaffney, 2008). Within education it is synonymous with (though not exclusive to) 1:1 laptops, which students can take with them anywhere, anytime i.e. school and home. Ubiquitous computing relies upon the proliferation of wireless networking, as does any success with 1:1 laptops. Much of the literature about *1:1 laptops* comes under the moniker of, or interchanges with *ubiquitous laptops* (Penuel, 2006; Valiente, 2010).

The generic term 1:1 laptops should not be confused with *One Laptop Per Child* (OLPC). OLPC is a specific term used for a non-profit initiative established to empower the world's poorest children through technology and education by distributing low-cost, low-power laptops (OLPC, 2008). These OLPC laptops have been issued to 2.5 million children and teachers in 40 countries. In Australia, when OLPC laptops have been given out, most of the children involved have been Indigenous, although not by design (Howard & Rennie, 2013). OLPC is a separate initiative and should not be confused with the DER.

1.8 1:1 laptops in the literature

There is substantial extant literature about 1:1 laptop initiatives in schools, much of which is discussed within Chapters 2-6. Of note, in the most prominent synthesis of 1:1 laptop initiatives, by Penuel (2006), it was found that "outcome studies with rigorous designs are few, but those studies that did measure outcomes consistently reported positive effects on technology use, technology literacy, and writing skill" (p. 329). However, as Kposowa and Valdez point out, only one of the twelve studies Penuel examined was in a peer-reviewed journal (2013). Despite the large number of studies into the impact of 1:1 laptops, "there is a paucity of research that examines their effectiveness, especially their impact on student academic achievement" (Kposowa & Valdez, 2013, p. 348). While there are many studies reporting on broad themes, such as impact on motivation, very few focus on learning outcomes. Within this paucity, there is even less research using in-depth quantitative analysis. One of the prime purposes of this thesis is to fill this void in the literature.

1.9 Contribution to the literature

This thesis aims to contribute to the literature in three novel ways:

1. performing a quantitative analysis of the impact of 1:1 laptops on student attainment in the sciences, thereby filling the identified void by providing a robust statistical

argument to the ongoing debate regarding the efficacy of technology in teaching and learning;

2. incorporating a variety of innovative graphical representations to help communicate the data and findings;
3. providing the academic commentary and quantitative analysis that have been missing to date to what was a multi-billion dollar Australian Federal Government initiative i.e. the DER.

1.10 Sample of schools

As is discussed within the various chapters, a sample of schools that I had ready access to was studied in this research. Reading the chapters in sequence, there may appear to be inconsistencies in the sample. However, this is simply to do with the different age ranges of the students studied in the various papers and can be explained easily by providing an initial overview of the sample of schools.

Table 1.1: Sample of schools studied

School	DER round[2]	Gender	SES[3]	Grades taught	Chapter inclusions
1	1	boys	low	7-12	2, 3, 4, 5
2	1	co-ed	low	7-12	2, 3, 4, 5, 6
3	1	boys	high	7-10	2, 3
4	1	co-ed	low	11-12	4, 5
5	1	boys	low	7-12	2, 3, 4, 5
6	1	boys	low	7-10	2, 3
7	1	co-ed	high	7-12	2, 3, 4, 5
8	1	girls	low	7-12	2, 3, 4, 5, 6
9	2	girls	high	7-10	2, 3
10	2	co-ed	high	11-12	4, 5
11	2	co-ed	high	7-12	2, 3, 4, 5
12	2	co-ed	low	7-12	2, 3, 4, 5, 6
13	2	girls	low	7-10	2, 3
14	2	co-ed	high	7-12	2, 3, 4, 5, 6
15	2	boys	low	7-12	2, 3, 4, 5
16	2	co-ed	low	7-12	2, 3, 4, 5

The overall sample of schools studied was every one of the then 16 high schools from CEO Sydney Southern Region, located in the southwest of Sydney and the Sutherlandshire. In Chapter 2, schools are named with codes. In providing a description of the full sample of

[2] Schools were split into two rounds: Round 1 schools starting DER in 2008; Round 2 schools in 2009

[3] Socio-economic status: numerical values obtained from the Australian Bureau of Statistics (ABS) then coded as low/high to maintain anonymity of schools.

schools in Table 1.1, the coding convention from Chapter 2 is ignored and the order is randomised so as to maintain the anonymity of the schools and ultimately their teachers, which could otherwise be derived from the combined information.

Looking at the end column of chapter inclusions, it can be seen that 14 of the 16 schools were studied in Chapters 2 and 3 i.e. those schools that contain grade 10. Chapters 4 and 5 studied 12 of the 16 schools i.e. those schools with grade 12. Chapter 6 studied teachers from four of the schools.

1.11 By publication

Given that I was in full-time employment with a young family, it was agreed that my postgraduate study would be part-time. In theory this would draw out the timeline to roughly six years. Six years is a long time in such a quickly evolving field like technology, particularly when associated with political agenda. Consequently, with this in mind plus the need for milestones and the desire to publish whilst still relevant, it was agreed that this thesis would be *by publication*. Accordingly, along with this introductory chapter and the concluding chapters, this thesis is made of five published papers each making their own chapter i.e. Chapter's 2-6. The merits of this manner of study are discussed in the concluding chapter, Chapter 8.

1.12 Longitudinal study

Taking six years to complete this study had a specific benefit: this length of time allowed for the research to be longitudinal. I thus was able to collect questionnaire data, collate examination results and perform interviews over the course of the DER to help provide a more complete narrative for the schools, teachers and students as they progressed through the DER.

1.13 Outline of the thesis

1.13.1 Phase 1: Measuring the alignment of teacher and student perceptions of laptop use

The first part of this thesis used the data from questionnaires to determine if teachers' use of laptops and what they perceived of their students' use of laptops aligned or not with the students' self-reported use in grade 10 science. It was hypothesised that alignment of perceptions might be a predictor of student attainment. Phase 1 is recorded in Chapter 2 with the paper entitled *Seeing eye-to-eye on ICT: Science student and teacher perceptions of laptop use across 14 Australian schools* (Crook, Sharma, Wilson, & Muller, 2013).

1.13.2 Phase 2: Identifying teacher and student self-reported activities on laptops in terms of higher- and lower-order practices

The questionnaires utilised in Phase 1 provided a plethora of additional information. Building on Bloom's Digital Taxonomy, I set out in Phase 2 to determine the relative frequencies of laptop use in grade 10 science in terms of higher- and lower-order activities. This analysis was performed for both teachers and students. The findings are presented in Chapter 3 with the paper entitled *Bloom-ing heck! The activities of Australian science teachers and students two years into a 1:1 laptop program across 14 high schools* (Crook & Sharma, 2013).

1.13.3 Phase 3: Quantitative analysis of examination and socio-demographic data to determine if using a laptop was a predictor of student attainment in the sciences

The third phase is the most important part of this thesis. With most research into the impact of educational technology, including into 1:1 laptops and including in the sciences, being qualitative with general statements about motivation and engagement, I really wanted to perform a quantitative analysis to ascertain if 1:1 laptops had any measurable impact within the context of the sample studied. This was achieved by combining examination data for nearly one thousand students in the sciences at HSC with socio-demographic data and performing a multiple regression analysis. In the event, statistically significant correlation coefficients were found with effect sizes calculated for biology, chemistry and physics. I subsequently used questionnaire data to help explain the findings. This phase of the study is captured in Chapter 4 with the paper entitled *An evaluation of the impact of 1:1 laptops on student attainment in senior high school sciences* (Crook et al., 2015b).

1.13.4 Phase 4: Analyses of exit questionnaires and curriculum documents to further explain the findings from Phase 3

Following on from the success of Phase 3, I wanted to investigate further the reasons for the difference in effect sizes calculated between HSC physics and biology. To achieve this, further analysis was performed of the exit questionnaires, using TPACK as a conceptual framework, and involving a thematic analysis of comments by teachers and students in both subjects. In addition, an analysis of the respective curriculum documents was performed to determine if they correlated with the findings. Phase 4 is presented in Chapter 5 with the paper entitled *Comparison of Technology Use Between Biology and Physics Teachers in a 1:1 Laptop Environment* (Crook, Sharma, & Wilson, 2015a).

1.13.5 Phase 5: Case studies of four science teachers in their use of laptops in teaching and learning

To complete the longitudinal narrative of this thesis, I wanted to perform case studies of four science teachers: one from each of biology, chemistry, physics and senior science. Each of the teachers was interviewed, with the transcriptions analysed to find common themes and individual differences. The commentary provides coverage of the teachers' experiences and evolving skills and opinions over the course of the DER. These case studies form Chapter 6 with the paper entitled *Teachers' transition into a 1:1 Laptop Environment: A Longitudinal Case Study of Four Science Teachers over 5 years* (in review).

1.13.6 Note on the thesis structure

Since Chapters 2-5 have already been published in academic journals, and Chapter 6 is in review, they are presented in this thesis with the same words and overall format as were accepted through the journals' peer-review and editorial processes. Accordingly, the way that this thesis is arranged is less common. Rather than having one overall literature review and reference list for the thesis, each chapter has its own literature review and references, although obviously there are overlaps. However, any appendices to the papers are included in the overall appendix to this thesis rather than individually to each chapter.

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Chapter 2:

Seeing eye-to-eye on ICT: Science student and teacher perceptions of laptop use across 14 Australian schools

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2.1 Abstract

As schools start investigating and investing in the idea of 1:1 iPads and tablets, are there any lessons that can be learnt from recent 1:1 laptop deployments? In Australia, since 2008, 1:1 laptops have been introduced into every secondary school. This study reports on a survey designed to investigate frequency and type of laptop use, and the alignment of teacher and student perceptions of that use. Data was obtained from 14 secondary schools from the Catholic Education Office Sydney, involving responses from 1245 grade 10 science students and 47 science teachers. As part of the analysis, *bubble graphs* are used to visually represent a teacher's alignment/misalignment with their students' self-reported practices. Results show student and teacher perceptions of use were usually relatively aligned though sometimes very contrasting. The alignment was measured with the use of a *Misalignment Index*. Three distinct types of teacher/student alignment or misalignment emerge from a graphical analysis of the data. Of the teachers and students sampled, some 30% of teachers were highly aligned, 55% had medium alignment and 15% were badly misaligned with their respective students. Potential uses of the Misalignment Index and analysis tools are discussed.

2.2 Introduction

In November 2007, *A Digital Education Revolution Policy* Document was released stating an intention to "provide world class information and communications technology (ICT) for every secondary student in years 9 to 12", (Rudd, Smith, & Conroy, 2007, p. 1) "ideally equipping every student with a laptop" (Australian Broadcasting Corporation, 2007). In February 2008, all secondary schools were informed that they could apply to participate in the Digital Education Revolution (DER) (DEEWR, 2008a; Gillard, 2008a).

The Catholic Education Office (CEO) Sydney is responsible for the management of the 147 systemic Catholic schools which educate more than 65,000 students in the Archdiocese of Sydney (CEO Sydney, 2012). Following DER guidelines, CEO Sydney decided to issue a laptop to every grade 9 student for 4 years. The first CEO Sydney school issued their grade 9 students with laptops in September 2008, with the other Round 1 schools (DEEWR, 2008b; Gillard, 2008b) doing likewise shortly after. The Round 2 schools received their first machines in mid-2009 (Gillard, 2009). Overall, for CEO Sydney, this meant laptops would be provided to over 4,500 students per year for 4 years i.e. over 18,000 students. Whereas the students' laptops were paid for by Federal Government funding, the teachers' laptops were paid for (unexpectedly) by the individual schools.

The students and teachers in this sample would have had 1:1 laptops for either one or two years at the time of data collection. This paper reports on the perceptions of science students and teachers on the use of the laptops.

2.3 Research context and purpose of study

Several studies and meta-analyses have investigated the effect of 1:1 laptops on teaching and/or learning. Studies looking primarily at teacher use of laptops have found a variety of benefits and challenges (Donovan, Hartley, & Strudler, 2007; Garthwait & Weller, 2005; Owen, Farsaii, Knezek, & Christensen, 2005; Windschitl & Sahl, 2002; Zucker & McGhee, 2005). Some of the studies around the impact on teaching and learning have reported positive impacts (Bebell & O'Dwyer, 2010; Greaves, Hayes, Wilson, Gielniak, & Peterson, 2010; Gulek & Demirtas, 2005; Ingram, Willcutt, & Jordan, 2008; Lin & Wu, 2010; Silvernail & Lane, 2004; Zucker & McGhee, 2005). Similarly, some meta-analyses have reported overall positive effects of 1:1 laptops on teaching and learning (Penuel, 2006).

Investigating the impact of technology in general there have been various studies and meta-analyses. Several studies report positive impacts on teaching and learning (Chowdry, Crawford, & Goodman, 2009; O'Dwyer, Russell, Bebell, & Seeley, 2008; OECD, 2010). Similarly, several meta-analyses report overall, if somewhat minor, positive impacts of technology on teaching and learning (Goldberg, Russell, & Cook, 2003; Kulik, 2003; Moran, Ferdig, Pearson, Wardrop, & Blomeyer, 2008; U.S. Department of Education, 2010; Warschauer & Matuchniak, 2010).

However, a few studies have highlighted negative impacts of technology on student performance (Vigdor & Ladd, 2010) and some meta-analyses state that the various studies conducted raise more questions than provide answers (Valiente, 2010; Weston & Bain, 2010). Increasing student access through 1:1 laptop ratios does not necessarily increase student usage (Larkin & Finger, 2011).

In his synthesis of meta-analyses, Hattie (2009) states, regarding the various studies of the impact of technology on student performance:

> *the majority of studies in this area are about teachers using computers in instruction and there are fewer studies about students using them in learning. That is, often the studies compare teaching in classes with and without computers (of some variant) rather than comparing students learning in different ways when using computers (p. 221).*

Elaborating on this theme, Fullan (2011) states:

> *The notion that having a laptop computer or hand-held device for every student will make her or him smarter is pedagogically vapid ... Without pedagogy in the driver's seat there is growing evidence that technology is better at driving us to distraction, and that the digital world of the child is detached from the world of the school (p. 15).*

None of the papers, in our search to date, have examined students' reported use of laptops and how this compares with their teachers' practices and perceptions of the students' use. However, Niles (2006) did compare teacher and student perceptions of the impact of 1:1 laptops and Burgad (2008) investigated teacher, student and parent perceptions of 1:1 laptops and academic performance. Niles found that there was a paradigm shift in terms of classroom dynamics, communication and belief around the impact of 1:1 laptops from both teachers and students. Burgad found that students, teachers, and parents all perceived increased student engagement, motivation, and organisation, along with improved research, writing, and editing skills. In fact, these laptop students also experienced significant gains in mathematics though significant dips in reading and language arts.

A fundamental question underpinning this paper is *do teachers need to bring their own laptop to class?* The authors would argue *yes*. The provision of staff laptops has been demonstrated to empower teachers to move from "didactic instructional approaches toward more student-centred, project-based lessons" (Windschitl & Sahl, 2002, p. 178). A teacher's laptop is a hub for learning in the classroom (Parr & Ward, 2011). Similarly:

> *teachers with laptops are integrating ICT into their pedagogy and offering students a more varied and accessible curriculum (Cowie, Jones, & Harlow, 2011, p. 253).*

In his meta-analysis of 52 studies on the effects of computer-assisted instruction versus traditional instruction on students' achievement, Liao (2007) found that the mean effect size was 0.55 i.e. more effective. Regarding the local context, since many of the science laboratories and classrooms in the schools surveyed have interactive whiteboards, the mobility of a teacher's laptop would allow for the inclusion and individualised use of this technology, particularly as teachers move between classrooms.

The aim of this study was to consider the various facets of the self-reported frequency of laptop use to determine the relative alignment or misalignment between the practices and requirements of teachers and their respective students' reported practices and laptop use. Rather than simply measure and focus on teacher and student efficacies with using laptops and technology as in previous studies, we wanted to see if there was merit in measuring the relative alignment of the teachers' practices and requirements of their students, and the students' reported practices and use. The motivation for this was to accommodate those teachers and occasional students that state "my current methods work, why should I change?; if it ain't broke, don't fix it". That is, how would classes where the teachers do not require students to use their laptops (and the students comply) compare with those classes of high teacher requirement and high student use? Also, can we identify the instances of teachers requiring that their students use laptops a lot and the students self-reporting that they do not, and vice versa? Do students really use the laptops as often as teachers require them to for particular tasks? Are teachers *in tune* with their students?

2.4 Method

2.4.1 Sample

The sample of 14 schools reported on in this study was drawn from the 16 secondary schools of the Southern Region of CEO Sydney. These schools range from the lowest socio-economic status (SES) with significant fractions of students within the English as a Second Language

(ESL) program to some of the highest SES with low ESL secondary schools in CEO Sydney. All 14 schools are comprehensive and non-academically-selective. Eight schools are single-sex and six are co-educational schools. Four schools cater for grades 7-10 and ten schools cater for grades 7-12. In terms of the size of schools, in 2010, the grade 10 cohorts ranged in size from 108 to 218 with the number of practicing grade 10 science teachers ranging from 4 to 8 per school.

2.4.2 Questionnaire design

The questionnaire (see Appendix A) was constructed for this particular study around the *use* of laptops rather than how they were used or how best they could be used. In this research, *use* refers to frequency of use. This is considered the first step prior to probing *how* they are used which will be discussed in a follow up report. Draft questions were developed by the authors in view of extant literature. The draft questions were then critiqued by a group of six educational experts, two with several years of experience and the others with more than 20 years of experience each. The draft questions were modified slightly and the final questions are shown below.

The teacher questions read:

- T1 How often do you bring your laptop to School?
- T2 How often do you bring your laptop to your Year 10 Science class?
- T3a How often do you use your laptop in this Science class?
- T3b How often do you require your students to use their laptop in this Science class?
- T4 How often do you require your students to use their laptop for Science homework?
- T5 How often do you do you require your students to use their laptop in Science assessments?

The student questions read:

- S1 How often do you bring your laptop to School?
- S2 How often do you bring your laptop to this Science class?
- S3 How often do you use your laptop in this Science class?
- S4 How often do you use your laptop during Science homework?
- S5 How often do you use your laptop during Science assessments?

Both teacher and student respondents had to answer using a 5-point Likert scale: 1=never to 5=always.

The survey items were almost identical for purpose of comparison i.e. T1↔S1; T2↔S2; T4↔S4 and T5↔S5. It is important to note that the comparisons T1↔S1 and T2↔S2 contrast the self-reports of the behaviours (practices) of both teachers and students. However, it is also important to note that comparisons T3b↔S3, T4↔S4 and T5↔S5 contrast the requirements (expectations) by teachers on student use with the self-reported student use. (Since a fundamental focus of this study was to compare the requirements of teachers on student use with the reported use by the students themselves, T3b (rather than T3a) was compared with S3).

2.4.3 Procedure

The questionnaires were administered online via *Google Docs Forms* for simplicity. This eliminated the cost, time and errors involved in transcription, while maintaining confidentiality of the data. The questionnaires were administered to grade 10 science teachers and students from the participating secondary schools in August/September 2010 ahead of the 2010 statewide School Certificate examinations. The timing was such that there was a window of opportunity providing access to both students and teachers.

The overall return rate was 47 teachers (64%) and 1245 students (60%). However, the number of students whose teachers also responded was 815 (39%). In addition, due to some non-Year 10 teachers responding or minimal responses from a teacher's students, some 40 teachers (55%) are considered in this paper. Given the normal response rates from online surveys of around 25% (Kaplowitz, Hadlock, & Levine, 2004), the response rates in this study of over 60% combined with the large sample sizes and range of schools mean that diversity in the sampling is captured.

2.4.4 Results and discussion

The profile of a particular class' laptop use was compared with that of the class teacher using *bubble* graphs; see Figure 2.1(a-c).

Figure 2.1 shows the students in patterned bubbles and the teacher as a solid bubble for each question on the survey (1 to 5 on the x-axis). The y-axis represents the Likert scale responses. Bigger bubbles mean more students for particular responses. Figure 2.1(a) shows that the students in school 1A with teacher 2 (that is teacher 1A2), bring their laptops to school (first column of patterned bubbles) anywhere from about half of the time to all of the time, with the majority bringing all of the time. Likewise, the teacher (small solid bubble) brings her laptop all of the time to school. This teacher appears well aligned with her students in all aspects except with regard to use of laptops for assessments. Compare this with her two corresponding colleagues from the same school, teacher 1A4 in Figure 2.1(b) and teacher 1A3 in Figure 2.1(c).

(a)

(b)

(c)

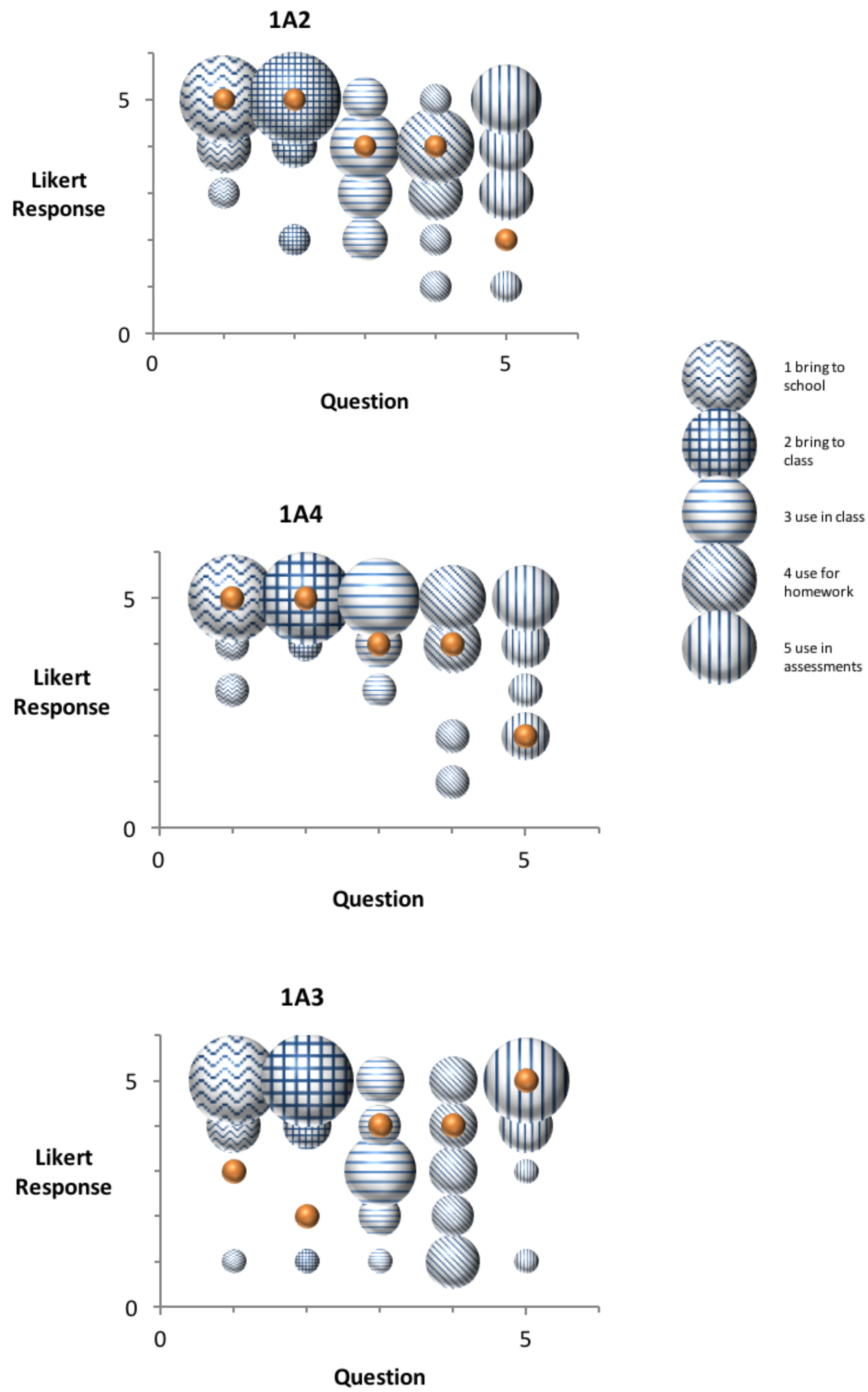

Figure 2.1: Bubble graphs for teachers 1A2, 1A4 and 1A3 and their classes showing Likert response versus question.

Teacher 1A4 has an identical profile to 1A2. Though his students use their laptops even more frequently, particularly in class and for homework, teacher 1A4 is still very aligned if not more so than teacher 1A2. However, as can be seen in Figure 2.1(c), the practices and requirements of use by teacher 1A3 do not coincide with his students' practices and self-reported use, particularly with regard to bringing their laptops to school and science class in the first place.

One could argue that teachers do not necessarily need to bring their laptops to class in order to facilitate the students' learning with their own laptops. However, as was highlighted in the introduction and research context presented earlier in this paper, whereas the student laptops were paid for by Federal Government funding the teacher laptops were paid for by the individual schools. As such there is the expectation that teachers both bring their laptops to school for their own administration e.g., checking email and daily notices, plus bring them to class to model good practice to the students and offer a more varied and accessible curriculum. Essentially the underlying philosophy is that laptops are integral components rather than add-ons. A "school community deliberately and systematically uses its rules to embed its big ideas, values, aspirations, and commitments in the day-to-day actions and processes of the school" (Weston & Bain, 2010, p. 12) e.g. around bringing one's laptop to school and class. To ensure that the DER worked in its schools, CEO Sydney provided every secondary school with wireless access plus provided substantial professional development opportunities for teachers as a system and more locally within individual schools. Ultimately, explicit expectations were given by CEO leadership and principals to teachers regarding the integration of laptop use in the daily teaching and learning practices to capitalise on opportunities provided by the DER. Teacher 1A3 could be deemed non-compliant with such practices and expectations. It should be noted however, that despite this the students of teacher 1A3 are very compliant with school expectations on bringing their laptops to school and class. It can also be observed that the students of teacher 1A3 have greater variance in their use, particularly in class and for homework, than the students of teachers 1A2 and 1A4.

Such bubble graphs were generated for all 40 teachers considered. An observation of all bubble graphs demonstrated that patterns emerged for questions 1 to 4. Question 5, regarding student laptop use for assessments, had substantial, somewhat random variations, thereby appearing anomalous. It was decided that this question was ambiguous due to a lack of agreement on what constitutes an assessment. For example, some assessments would actually have been examinations without laptops yet many students and some teachers stated they always used laptops in assessments. As such, when the *Misalignment Index* (MI) was generated, Question 5 was excluded.

The MI was created to measure the variations between teacher practices and requirements, and student practices and use that could be observed in the bubble graphs. The simple calculation summed the moduli of the differences between a teacher and his/her students for similar questions as shown in Equation 2.1.

$$MI = \Sigma|T-S| \quad (2.1)$$

The MIs ranged from 1.0 to 6.1 with an average of 2.7 and a standard deviation of 1.3. Of the 40 classes, some 30% showed high alignment of laptop use (MI of 0-1.9; essentially the lowest third of the range), 55% were moderately aligned (MI of 2.0- 3.9; middle third of the range) and 15% of classes were quite misaligned (MI of 4.0+ i.e. the equivalent of a disparity of at least 1 in each of the 4 questions; top third of the range). A graph of the teachers' MIs versus their average Likert responses can be seen in Figure 2.2 (coded by how many years' experience they have of teaching students with laptops).

As can be seen in the trend line (for all teachers) in Figure 2.2, those teachers with the highest average Likert response tended to have the lowest MI. This implies that those teachers that exhibited high usage and required high usage by their students are most aligned with their students i.e., their students report similarly high usage. Whereas, those with lower average Likert responses tended to have higher MIs. This would imply the teachers that report lesser use and have lower required student use are less aligned i.e., the students report greater use than the teacher.

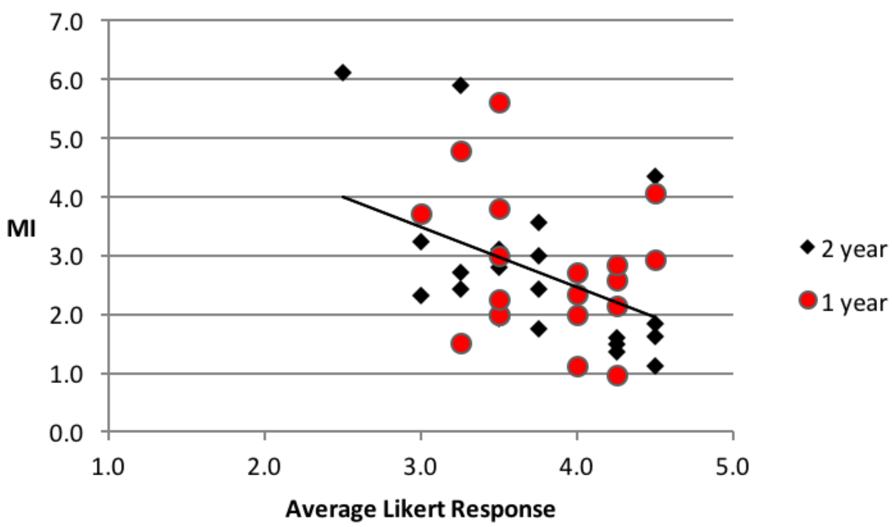

Figure 2.2: A graph to show MI versus Average Likert Response for all teachers.

It should be noted that only one teacher gave an average Likert response less than 3 (at 2.5) i.e. less than the median Likert response. Consequently, though we hypothesised the existence of relatively lower use teachers, these teachers in fact report semi-regular use as a minimum. This is important since it demonstrates in fact no teachers reported minimal use throughout.

It should be noted that the laptops were deployed over a couple of years. Round 1 teachers would have had two years' experience of teaching students with laptops at the time of sampling (denoted as circles in Figure 2.2). Round 2 teachers would have had one year's experience at the time of sampling (denoted as diamonds in Figure 2.2). The distributions for the two rounds appear quite similar with no obvious difference in trend between MI and average Likert responses within this small timeframe. Also, considering MI specifically, there are similar numbers of Round 1 and 2 teachers within each of the low (0-1.9), medium (2.0-3.9) and high misalignment (4.0+) ranges. This would appear to indicate that an extra year's experience and possible embedding of practice, even at such an early stage, might have little impact on teacher practice and perception. Although technology necessitates that "teachers change their pedagogy for learning to become relevant and meaningful for students" (Fullan & Smith, 1999), some teachers buy into new paradigms with vigour immediately and some refuse, or only move on their own terms.

The reduction to a single value given by the MI removes information but does provide a mechanism for comparison. As already mentioned, finer detail can be observed in the bubble graphs. Bubble graphs for two of the teachers with the highest alignment (lowest MI) have already been given in Figures 1(a) and 1(b). The bubble graphs for the two most misaligned teacher/students with the highest MI (aside from 1A3 in Figure 2.1(c)) can be seen in Figure 2.3.

Regarding the misaligned teacher/students it is interesting to note in Figure 2.3(a) that teacher 1H3 rarely brings her laptop to school or class but her students do so most if not all of the time. In Figure 2.3(b), the most misaligned teacher 2J1, always brings his laptop to school but never brings it to science class. This raises the question, does teacher 2J1 only use his laptop for administration rather than teaching and learning (Cuban, 2001). Somewhat ironically, 2J1 expects his students to use their own laptops every lesson, whereas they state they only use it half of the time! With the requirement asked of the students at odds with the disposition of the teacher it is not surprising that the self-report of student laptop use is less than expected (Vannatta & Fordham, 2004).

Further analysis of the results was achieved by plotting the average student response against the respective teacher's response for each question. The results can be seen in Figure 2.4(a-d). Every graph in Figure 2.4 includes a solid line for y = x, i.e., the line of alignment for teachers and students. In addition, 2 dashed lines are present to border student responses within ± 1 of the line of alignment with their respective teachers. Falling beyond ± 1 of the line of alignment would be considered misaligned. There are therefore two regions of misalignment: the top-left triangle bordered by the +1 dashed line and the y-axis; and the bottom-right triangle bordered by the -1 dashed line and the x-axis (see Figure 2.5).

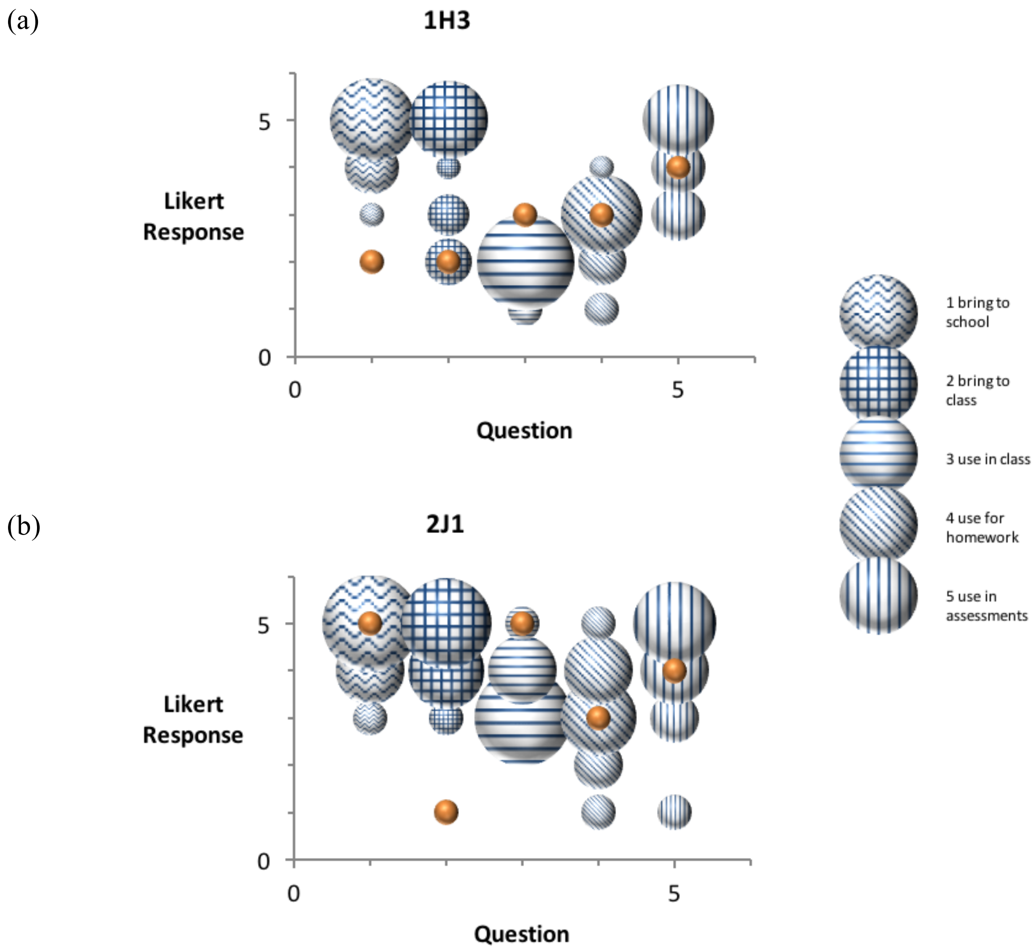

Figure 2.3: Bubble graphs showing high misalignment.

As can be seen in Figure 2.4(a), every teacher apart from 3 brings their laptop to school all of the time. Every class of students by and large brings their laptop to school nearly all of the time apart from one outlier. It can be observed that despite most teachers and students bringing their laptops to school all of the time it is a different story when bringing their laptops to science class (see Figure 2.4(b)). This is particularly the case for teachers. All data points within the top-left triangle bordered by the +1 dashed line and the y-axis are where the class teachers are far less compliant than the students within their classes. In the instance of bringing laptops to science class this accounts for 13 or 33% of the teachers. There are no points in the bottom-right triangle that would have indicated relatively non-compliant students. The question regarding the practice of bringing laptops to science classes demonstrates the greatest misalignment.

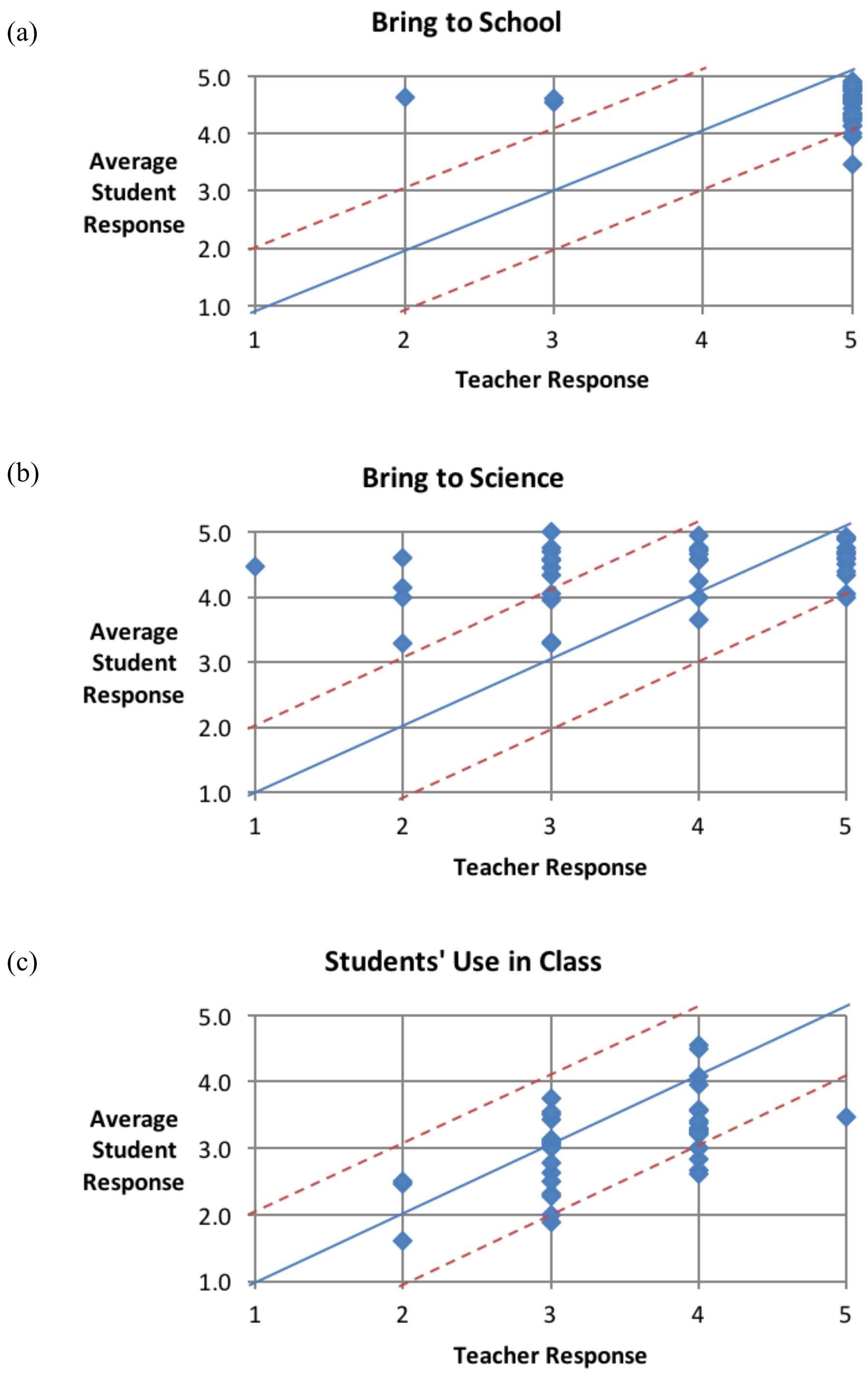

Figure 2.4(a-c): Comparing student and teacher responses.

(d)

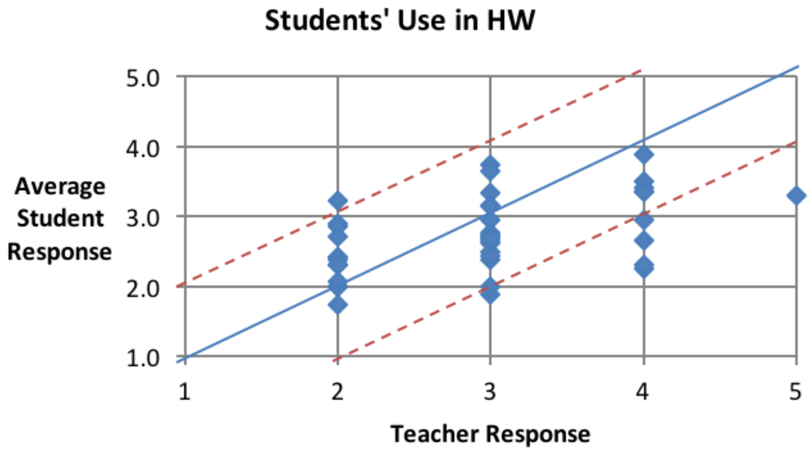

Figure 2.4(d): Comparing student and teacher responses.

Figure 2.4(c) shows that in terms of use of laptops in class, the relative frequency of use by the students and the required use by the teachers have the greatest alignment. There are many that fall within high-use alignment (T=4, S=4±1), many within medium range (T=3, S=3±1) and interestingly three within low-use alignment (T=2, S=2±1). There are no points within the top-left triangle meaning there are no instances of low teacher requirement paired with high reported student use. There are 5 points in the bottom-right corner indicating that these teachers require far greater student use of laptops in their class than is actually the case according to the students themselves.

Figure 2.4(d) looks very similar to Figure 2.4(c) though there is a tendency towards lesser required use of laptops for homework by teachers and reported use by students. There is one outlier in the top-left triangle indicating a much lower requirement by the teachers compared to the students' reported experience of using laptops for homework. There are 6 points in the bottom-right triangle where the teacher requirement is far greater than the self-report by students.

2.4.5 Implications

The question of how the above analysis methods can be used and what utility they offer emerges. The answer is at two levels. First, the analysis methods provide resolution and detail that can be used at the school management level to identify and learn from good practice. Highly aligned teachers (in terms of both behaviour and expectations) can be identified and hence observed. It is hypothesised that one might learn from the highly aligned teachers' classroom management and pedagogical skills with (and without) technology. Further research must be undertaken to observe such teachers and discover if this is in fact the case. The second level is obtained by taking the analysis a step further. As in Figure 2.4, every class of students can be plotted against their respective teachers on a graph for any variable that might be investigated. Figure 2.5 provides an empirical graph highlighting the different areas of alignment and misalignment, applicable for any context that might be surveyed. The teachers could be colour-coded to represent e.g. schools, years of practice or other categorical features. Broader patterns might then emerge in terms of which schools and/or categorical features need addressing to improve teacher-student synergy and ultimately student learning outcomes.

The ability to map teacher/student alignment, as measured by this relatively easy and transparent (to both the teacher and policy maker) mechanism at the very basic level of *use*, provides a powerful tool for the assessment of professional development initiatives and classroom culture (Supovitz & Turner, 2000).

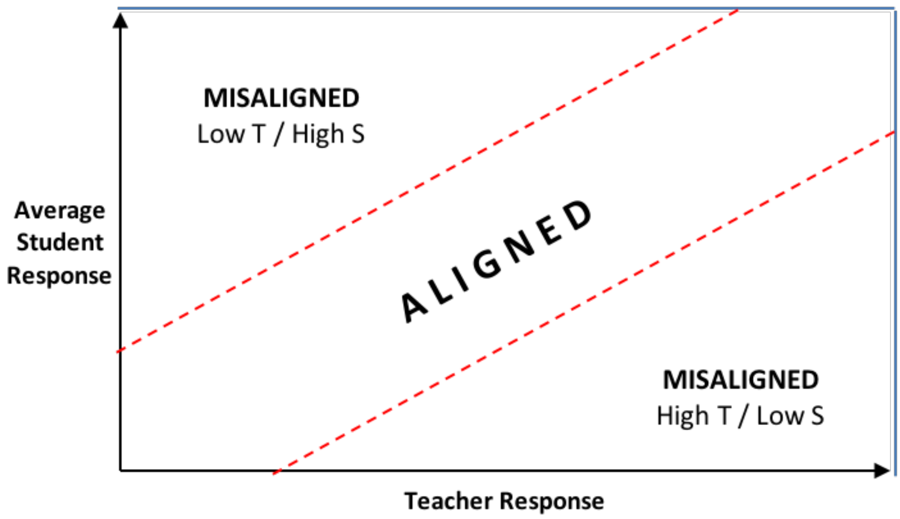

Figure 2.5: Graph demonstrating 3 distinct zones of student/teacher alignment.

In the case of the Australian Government's substantial investment in the Digital Education Revolution and CEO Sydney's deployment of this initiative, analyses such as those described in this paper would assist policy makers and educators in assessing the level of classroom cultural change (Hargreaves, 1994) taking place and identifying where further support is required such as targeted and personalised professional development for specific teachers. In some cases, the misaligned teachers (in terms of behaviour and expectations) may have good practices that are not captured by this study. On the other hand, the underlying philosophy to integrate laptops into classroom practices starts with good use of computers. Strategic programs to couple good practices with optimum use and hence integration of laptops can then be designed and implemented to suit local regional and school contexts.

Other questions that arise include how does any misalignment between teacher practice and requirement, and student reported practice and use impact on teaching and learning? Do teachers that think students rarely use (or need to use) laptops rarely plan lessons with them? These are aspects that could be investigated in future work.

This research should add a nuance to the body of literature around how teacher attitudes and use of technology affect student use (Miller, 2008; Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010; Vannatta & Fordham, 2004; Windschitl & Sahl, 2002).

2.5 Future work

The obvious extension of this study is to investigate how the students of the highly aligned and misaligned teachers performed i.e., investigate any possible relationship between laptop usage, MI and educational outcomes. With the first external examination data in the DER 1:1 laptop context obtained for the 2009 School Certificate (SC) and 2011 Higher School Certificate (HSC) examinations there is a unique opportunity to assess the impact of 1:1 laptops on student performance. Each of these epochs has the unique dichotomous scenario where half of the candidature will have sat having been schooled with laptops and half without. Trend and value-added data will be available as students involved in the DER perform these examinations over subsequent years with the final 2012 DER grade 9 cohort undertaking its HSC in 2015 allowing for longitudinal study. (However, in August 2011 it was announced that the School Certificate would be discontinued after 2011 (Piccoli, 2011)). More appropriately, using the survey data, further study could examine type of use e.g. high/low-order activities, professional development and calculate teacher and student efficacies. Ultimately, by comparing the reported use by students and teachers to generate respective efficacies and Misalignment Indices then cross-referencing these with standard examination results, coherent data should ultimately be obtainable to perform a multiple regression to assess the impact of 1:1 laptops on student performance.

2.6 Conclusion

We set out to investigate the reported use of laptops in 14 schools in Sydney by science teachers and students. Patterns of use and variation in the alignment between teacher and student practices and perceptions were identified using a Misalignment Index developed in this context. It was found that some 30% showed high alignment of practices and perceived laptop use, 55% were moderately aligned and 15% of classes were quite misaligned. The study provides methods of identifying high alignment of teachers and students. This may aid schools in identifying and learning from highly aligned staff and also identifying where there is significant misalignment and hence where strategic support may be required.

Some 15% of teachers would appear to be quite out of touch with their students regarding laptop use. This raises the question of what does this mean for the education of these students? The answer is that further study is needed to investigate if such misalignment (or alignment) has any bearing on lesson planning, teaching, learning and ultimately student performance.

2.7 Acknowledgements

This project has human ethics approval from CEO Sydney and The University of Sydney. We are extremely grateful for the support, participation and openness from the teachers and students of the participating schools and the cooperation and support of CEO Sydney.

2.8 Additional material

The additional material for this chapter is to further explain how to interpret bubble graphs and discuss their merit.

Consider Figure 2.1 on page 17. The brown dots represent the Likert scale responses (y-axis) from the particular teacher for each question (x-axis) of the questionnaires. The sizes (areas) of the patterned bubbles represent the frequency of the student responses for each integer response on the Likert scale for each question. Different questions have different patterned bubbles as shown in the key. The nature of the bubble graphs allows the reader to firstly observe the spread of responses and the frequencies of each Likert response for the students for every question. This is particularly useful and easy to observe when considering only five integer responses on a Likert scale. Secondly, for any individual class, superimposing the brown teacher responses over the patterned student responses allows for an immediate sense of whether or not the teacher's practices and perceptions of the students' practices align with the students' self-reported practices. The bubble graphs assist one to report on the overall spread of student responses and the alignment or misalignment of the class teacher. As discussed in the paper, the overall principle of bubble graphs and the misalignment index could be applied to any comparison of a teacher with their students for Likert scale responses in questionnaires.

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Chapter 3:

Bloom-ing Heck! The activities of Australian science teachers and students two years into a 1:1 laptop program across 14 high schools

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3.1 Abstract

This study examines the responses of 1245 science students and 47 science teachers from 14 Catholic high schools in Sydney, Australia, 2010. Two years into a 1:1 laptop program, the types of activities engaged in with laptops as self-reported by teachers and students are analysed. The activities are differentiated from lower- to higher-order using Bloom's Digital Taxonomy. Though the shift has been to use pen and paper less and laptops more, it is found that the modal practice for students is the lower-order paradigm of note-taking and working from textbooks through electronic means by word processing and electronic textbooks, plus simple online searching. Students enjoy engaging in higher-order activities such as blogging and video editing but teachers do not favour these. Data logging and databases, despite being encouraged or even mandated by the Board of Studies NSW, are rare experiences. Most science teachers report using simulations but students do not report the same experience. Investment must be made in the professional development of teachers to empower and encourage them to integrate higher-order tasks and to capitalise on the opportunities offered by 1:1 laptops.

3.2 Australian context

In Australia 2008, the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) released the Melbourne Declaration on Educational Goals for Young Australians. High on the list of priorities, MCEETYA stated that "young people need to be highly skilled in the use of ICT" (2008, p.5) and that over the next decade, schools need to significantly increase the effectiveness of technologies in learning. This complemented the

Digital Education Revolution (DER), launched in 2008 (Gillard, 2008) to ultimately achieve a computer-to-student ratio of 1:1 over four years (DEEWR, 2008).

Prior to the DER, the average computer-to-student ratio in Australian schools was about 1:3 in 2006 (OECD, 2010). Based on the PISA (Programme for International Student Assessment) data, OECD also report that for Australian students in 2006, 96.3% used a computer for schoolwork at home and 91.9% had access to the internet at home.

Following DER guidelines, the Catholic Education Office (CEO) Sydney, opted to roll out laptops to every grade 9 student (14 to 15 years old) over 4 years, with the students taking the laptops home every evening after school for a complete 1:1 experience (Knezek & Christensen, 2004). The first CEO Sydney school issued its grade 9 students with laptops in September 2008, with the other schools following suit. For CEO Sydney this has meant the provision of laptops to over 4,500 students per year for 4 years i.e. over 18,000 students. To ensure that the DER worked in its schools, CEO Sydney provided every high school with wireless connectivity, technician support plus provided a laptop and substantial professional development opportunities to teachers as a system and more locally within individual schools. This paper examines data collected from grade 10 science students and teachers from CEO Sydney schools in 2010.

3.3 Research context

The paradigm of 1:1 laptops is not a new phenomenon, particularly in Australia (Grasso & Fallshaw, 1993; Johnstone, 2003; Rowe, Brown, & Lesman, 1993). However, there are still many schools, school districts and even countries looking to adopt this model. Looking at the present and to the immediate future, there are also many schools and districts investigating and adopting the idea of 1:1 iPads (DEECD, 2011) and personal mobile devices in general. The high profile and much acclaimed Horizon Reports (Johnson, Adams, & Haywood, 2011; Johnson, Adams, & Cummins, 2012; Johnson, Adams Becker, Cummins, Estrada, Freeman & Ludgate, 2013) identify mobile devices as emerging technologies likely to have a large impact on teaching and learning within a year. These reports critically assert that mobile devices are compelling tools for learning; to ignore these claims would be to miss out on one of the primary ways students interact with and learn from each other. Research and understanding gained regarding the impact of 1:1 laptops in the classroom and how teachers adapt (or not) should be directly applicable to future 1:1 technology deployments.

Questions around how the laptops are used by teachers and students and their impact, if any, need to be investigated. This is being addressed through a comprehensive study in which the alignment between teacher and student self-reports of usage has been analysed as the first step (Crook, Sharma, Wilson & Muller, 2013), and this paper, investigating the types of activities, is the second of perhaps five papers. In addition, formal evaluation of the DER and 1:1 laptop implementation within New South Wales (NSW) state schools is being conducted by the University of Wollongong and NSW Department of Education and Communities over the next few years (Howard & Carceller, 2010, 2011; Howard, Thurtell, & Gigliotti, 2012).

3.4 Existing research

Various studies have reported positive impacts of 1:1 laptops on teaching and learning (Bebell & Kay, 2010; Bebell & O'Dwyer, 2010; Greaves, Hayes, Wilson, Gielniak, & Peterson, 2010; Gulek & Demirtas, 2005; Ingram, Willcutt, & Jordan, 2008) as have some meta-analyses (Penuel, 2006). However, some studies have reported negative impacts of technology, including laptops, on student performance (Fried, 2008; OECD, 2011; Vigdor & Ladd, 2010) and some meta-analyses highlight that the various studies conducted raise more questions than provide answers (Hattie, 2009; U.S. Department of Education, 2010; Valiente, 2010; Weston & Bain, 2010). Wellington (2005) predicted that the uncertainties and questions around the impact of technology on learning are likely to be perennial and recurring.

Literature around the use of technology in science tells us that "the use of technology in the pedagogy of learning science is important" (Elliott & Paige, 2010, p.13). Online learning environments have been found to result in higher student achievement for students studying physics and chemistry (Preston, 2008; Frailich, Kesner, & Hofstein, 2007). Technology-rich science classrooms have been found to be essential to gains in inquiry pedagogy (Songer, Lee, & Kam, 2002). In fact, new pedagogies are emerging, using for example simulations, that enhance conceptual understanding in chemistry (Khan, 2010).

However, to the contrary, OECD (2010) split students into nine different profiles based on leisure and educational ICT (Information and Communications Technology) use. These profiles were found to relate differently to performance in science (as well as gender and socio-economic status (SES)) such that, interestingly, higher performance in science is related to lower educational use of computers (in all bar four countries, one of which is Australia, discussed below).

With regard to science teachers specifically and their use of technology, Van Rooy working with Biology teachers notes that "if professional development opportunities are provided where the pedagogy of learning and teaching of both the relevant biology and its digital representations are available, then teachers see the immediate pedagogic benefit to student learning" (2012, p.65). Policy makers and principals can improve the quality of technology integration of science teachers by creating robust professional development opportunities for innovative technology- enhanced science instruction (Shen, Gerard, & Bowyer, 2009; Higgins & Spitulnik, 2008).

Regarding assessment, computer-based assessment has been identified as having the potential to more broadly assess the objectives of scientific literacy education (Martin, 2008). The use of handheld technology has been demonstrated as supporting more frequent assessment practices in science (Yarnall, Shechtman, & Penuel, 2006).

Considering specifically 1:1 laptop use in science, embedding laptop use in the science classroom has been shown to make schools more engaging, relevant, modern, and effective institutions (Zucker & Hug, 2007). Science classrooms with 1:1 laptops have been found, amongst other things, to increase student motivation, engagement, interest, self-directed learning and student interaction with teachers (Zucker & McGhee, 2005). In the study of high school physics, 1:1 laptop programs have presented teachers and students with more opportunities and higher quality tools to explore scientific concepts (Zucker & Hug, 2008).

Regarding the use of technology in science in Australia specifically, it has been reported that "Australia is well placed to take advantage of the opportunities provided through ICT in education" (Ainley, Eveleigh, Freeman & O'Malley, 2010, p.v). In fact, they highlight that in 2007, Australian science teachers were relatively high users of ICT compared to their counterparts in other countries. An observation across all countries including Australia is that the use of ICT is greater when teachers have a higher level of confidence in ICT (Australia had the second highest level of confidence following Singapore out of 18 countries studied). However, about one quarter of Australian teachers cited their own knowledge of using ICT in pedagogy as a limiting factor. In terms of science teaching at grade 8, Ainley et al conclude that Australian science teachers are leaders in the use of ICT with a significantly greater percentage of Australian grade 8 science teachers using ICT in teaching (particularly simulations, 63% compared to an average of 41%) than in all the other 18 countries studied (c.f. OECD (2010) ranking Australia 9th of the 40 countries studied for overall computer use at school in 2006). Interestingly, Ainley et al also find within Australia that the use of ICT is higher for science than mathematics but that this is not associated with age or gender. Bucking the trend internationally, OECD identified Australia as one of only four countries where the effect of increased frequency of computer use, at home or at school, is systematically positive for general value of science, general interest in science and science related activities.

These studies show that computers are being used in Australian science classrooms and have been for some time (though historically on an ad hoc basis (Ng & Gunstone, 2003)). The next question is how are 1:1 laptops specifically being used by teachers and students? Is the usage higher- or lower-order? This study examines students' and teachers' self-reports of laptop use in science. Future research to further support assertions in this study should also include student and teacher interviews as well as classroom observations.

3.5 Theoretical framework

The study described in this paper examines both teacher and student use of laptops in the classroom and whether new pedagogies have evolved (Khan, 2010) or traditional pedagogical practices have remained (Cuban, 2001) albeit within a new medium.

The types of use considered in this study are aligned to Bloom's Digital Taxonomy (BDT) in terms of lower- through to higher-order activities (Churches, 2009) as in Figure 3.1. Bloom's Digital Taxonomy is an adaptation of the long established Bloom's Taxonomy (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956), which classified learning objectives in a hierarchy. In 2001, the hierarchy was revised to place *creating* at the top (Anderson & Krathwohl, 2001).

A key aspect of BDT is that it is a hierarchy of verbs or processes rather than nouns (Love, 2009). That is, rather than ordering technologies (nouns), it is a hierarchy of what one does with a technology (verbs). That being said, certain processes are synonymous with certain technologies e.g. blogging and blogs, wiki-ing and wikis, googling and internet search. Bower et al state that whilst BDT "does relate thinking processes to digital technologies, it does not provide a means of relating these processes to the types of pedagogies" (Bower, Hedberg, & Kuswara, 2010, p.182). This is particularly important in this study when we later consider actions such as word processing. Word processing could refer to very low order, almost passive activities such as copying notes from the board, through to designing and publishing (i.e. creating). This is demonstrated by Churches (2009) in Figure 3.2.

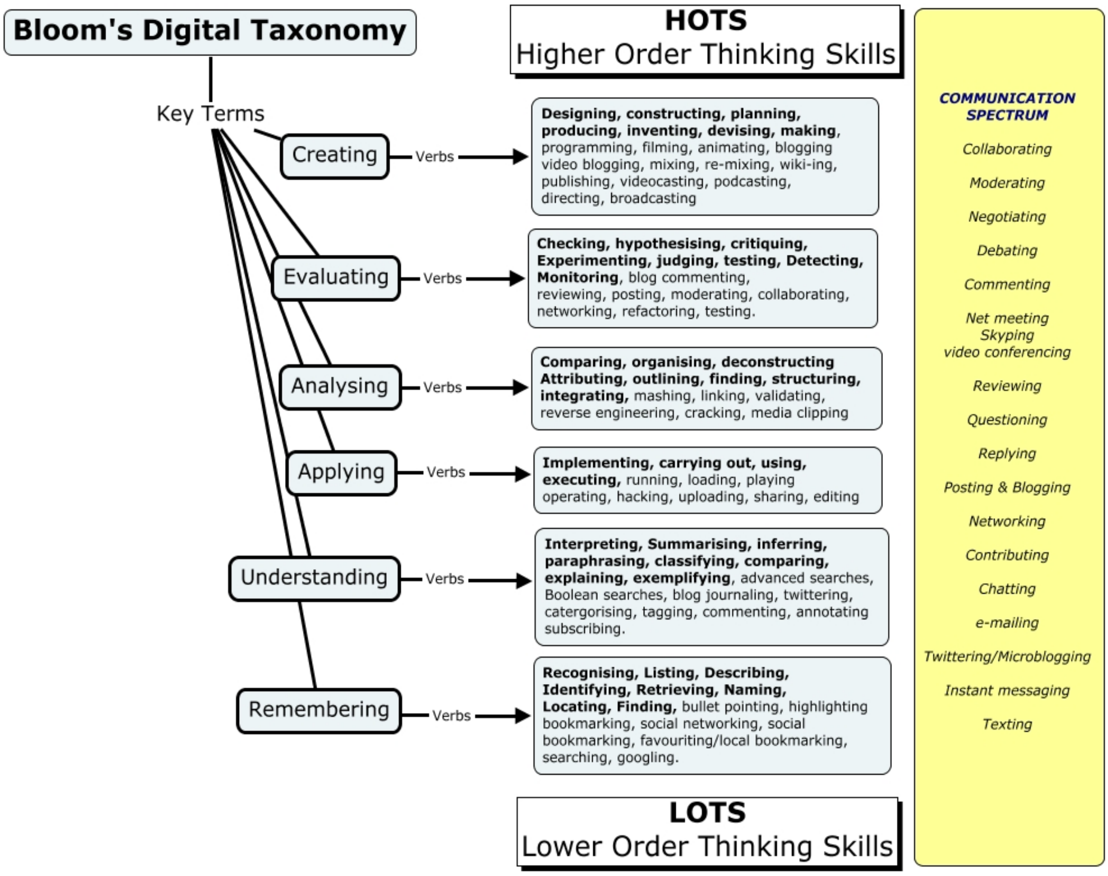

Figure 3.1: Bloom's Digital Taxonomy (reproduced with permission from A. Churches)

In the context of this study and the teachers surveyed, it must be highlighted that Bloom's Digital Taxonomy is part of the vernacular used in eLearning professional development within CEO Sydney schools and would be familiar to many if not most teachers. Examples of the explicit reference to BDT within CEO Sydney professional development are found in the CEO Web 2.0 Course (CEO Sydney, 2009), iLE@RN Ning (CEO Sydney, 2011) and Catholic Schools Leadership Program (CEO Sydney, 2009-2011).

Figure 3.2: Bloom's & Word Processing (reproduced with permission from A. Churches)

3.6 Methodology

In this study, a sample of 14 high schools were issued an online survey in late 2010 to examine the activities of science teachers and students, two years since the 1:1 laptop program had begun. (The first author works with 14 high schools with grade 10. All 14 schools are used in the sample). The schools range from the lowest socio-economic status (SES) with significant fractions of students within the English as a Second Language (ESL) program to some of the highest SES with low ESL high schools in CEO Sydney. All 14 schools are comprehensive and non-academically-selective. Eight schools are single-sex and six are co-educational schools. Four schools cater for grades 7-10 and ten schools cater for grades 7-12. In terms of the size of schools, in 2010, the grade 10 cohorts ranged in size from 108 to 218 with the number of practicing grade 10 science teachers ranging from 4 to 8 per school.

Online surveys (see Appendix A) were issued to grade (Year) 10 science teachers and students from the participating schools. The surveys were administered online via Google Docs Forms for ease, removing the need, cost, time and errors involved with transcription, whilst retaining security (128-bit encryption). As well as collecting meta-data plus responses to be used in further studies, teachers and students were, for the purpose of this study, asked the same three questions around the types of activities they use their laptops for (see Table 3.1).

In total, 47 teachers (64% of all grade 10 science teachers) and 1245 students (60% of all grade 10 science students) completed the online surveys. The response rates in this study of over 60% each exceed the normal response rates of online surveys of around 25% (Kaplowitz, Hadlock, & Levine, 2004). Furthermore, the sample size is large and there is a range of schools involved.

The data collected were first analysed to compare the teacher and student frequencies for each question and secondly to compare between questions. The importance of comparing enjoyment with modal practices has been highlighted by Baylor and Ritchie (2002), who found a correlation between teacher enjoyment of technology and students learning content and increasing their higher-order thinking skills, and Li (2007), who reported that students related their enjoyment of technology to increased motivation, confidence and consequently their learning. The data were analysed such that we could draw conclusions on relative use of activities in terms of higher- or lower-order. Similarly, the comparisons were used to provide indicators for the presence of student- or teacher-centred learning.

Table 3.1: Questions asked of teachers and students

	Which activities/applications do you utilise in your Year 10 Science class?	Which activities/applications do you MOST ENJOY utilising in your Year 10 Science class?	Which activities/applications do you utilise MOST OFTEN in your Year 10 Science class?
	tick all applicable boxes	tick up to 3 boxes maximum	tick up to 3 boxes maximum
Word Processing (e.g. Word, Pages)			
Spreadsheets (e.g. Excel, Numbers)			
Presentations (e.g. PowerPoint, Keynote)			
Simulations			
Science software			
Textbook resources (e.g. CD, online)			
Wikis/Nings/Google Site			
Blogs			
Internet Research			
Learning Management System *(MyClasses)*			
Video-editing (e.g. Windows Movie Maker, iMovie)			
Podcasting (e.g. Audacity, Garageband)			
Databases			
Email			
Data logging			
Other (please list)			

3.7 Results and discussion

The frequencies of responses as percentages were found and compared for teachers and students (see Figures 3.3-3.5).

There are two noteworthy features from Figure 3.3. Firstly, regarding all applications/activities, every option was selected within the total samples of teachers and students. However, given the option to tick as many boxes as possible, teachers selected more options (48%) compared to students (39%). This would indicate that teachers use a greater variety of applications than students. Secondly, the four applications used most by teachers, in order, are: internet research (96%), word processing (94%), presentations (83%) and textbook (68%).

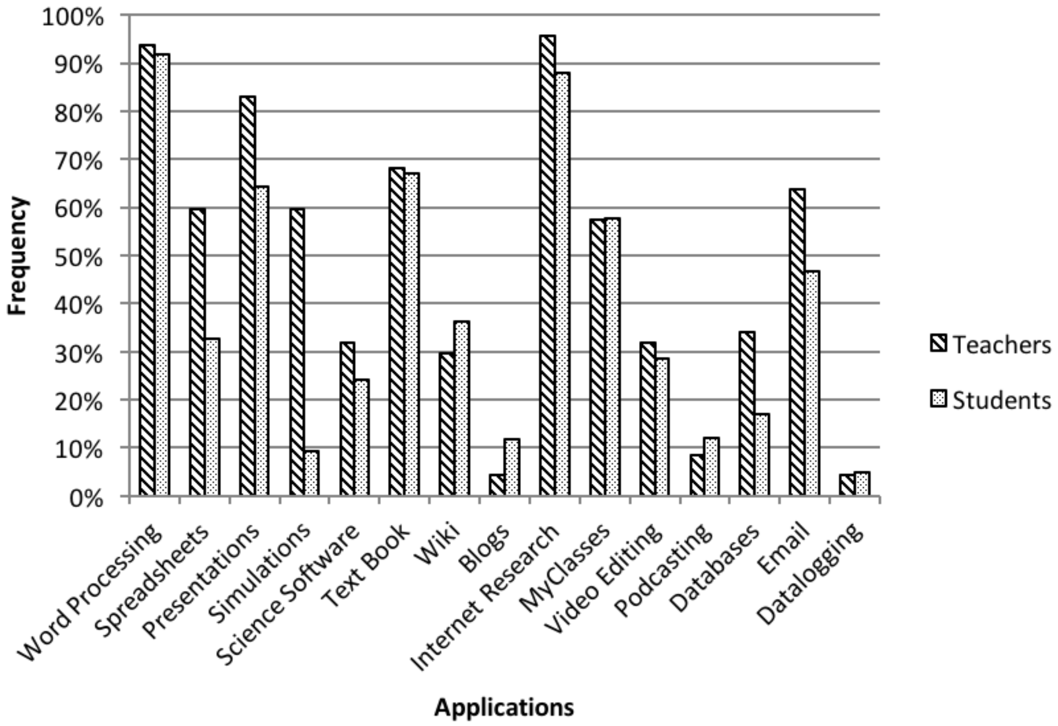

Figure 3.3: Frequencies of Use for All Applications

For students they are: word processing (92%), internet research (88%), textbook (67%) and presentations (64%). The teachers report the same as the students, adding validity to the results, but in a slightly different order. Comments obtained by the survey from the individual students e.g. *"not a lot of application to science unless it's taking notes in class"*, plus anecdotal evidence would suggest that the word processing was primarily taking notes on the part of the students plus answering questions from the textbook. This, along with internet searching and using the textbook would be considered lower-order in BDT. However, to verify the comments and anecdotal evidence, classroom observations and interviews would be desirable to view activities as they are happening and to "gain a full range and depth of information" (Mertens, 2010, p.352). Of note, many more teachers report using presentations (e.g. PowerPoint®) than students. Students report enjoying using presentations (39% in Figure 3.4) but only get to use them infrequently (22% in Figure 3.5). This would indicate more teacher-centred delivery than student presentation creation and delivery.

Regarding the three applications most enjoyed (see Figure 3.4), for teachers these are internet research (51%), simulations (51%) and presentations (49%). For students these are internet research (57%), word processing (41%) and presentations (39%). Again, with the exception of simulations (discussed later), these are lower-order activities. In both cases internet research, essentially googling (Rieger 2009), ranked the highest.

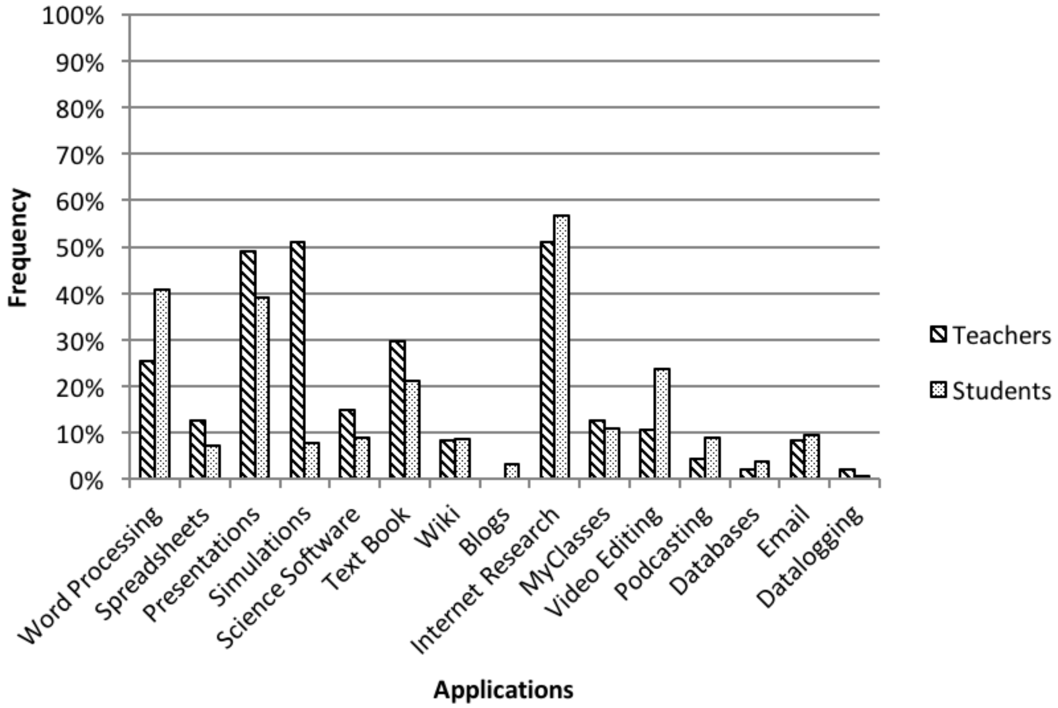

Figure 3.4: Frequencies of the 3 Most Enjoyable Applications

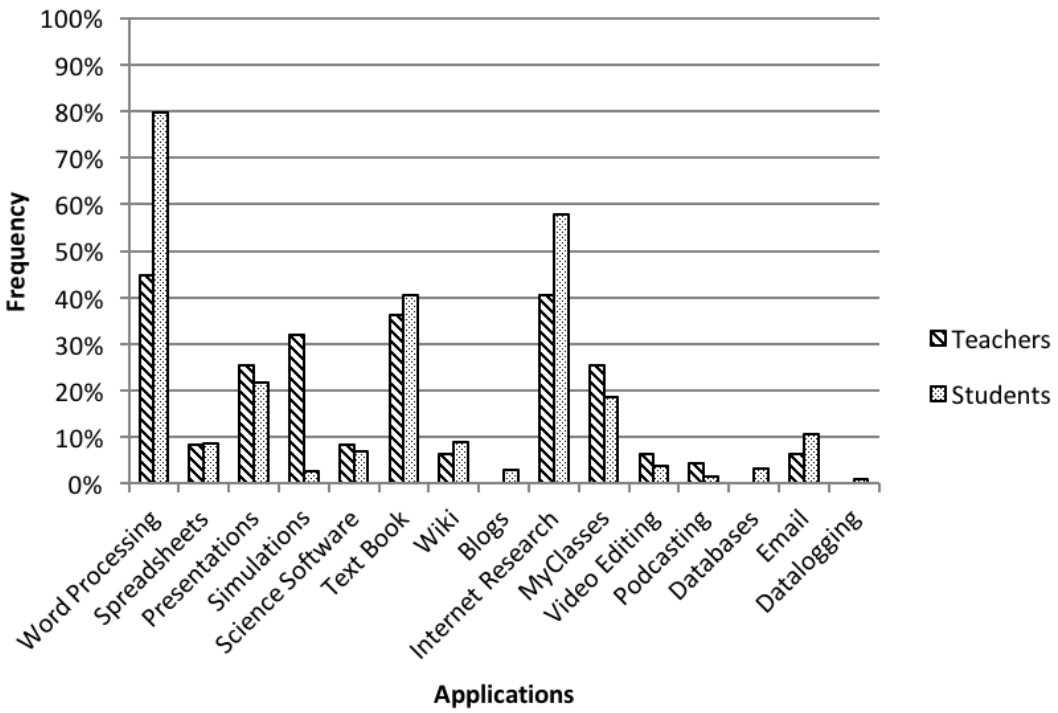

Figure 3.5: Frequencies of the 3 Applications Used Most Often

Perhaps of most interest are the results of the three most utilised applications/activities (see Figure 3.5). These results essentially paint a picture of what is actually taking place in the classroom. Teachers most often use word processing (45%), internet research (40%) and an electronic textbook (36%) i.e. lower-order activities. Students report most often using word processing (80%), internet research (58%) and an electronic textbook (40%) i.e. the same three applications in the same order as identified by the teachers, again adding validity to the results. These results would suggest that the students are mostly taking notes by typing into their laptops (whereas previously this would have been the same exercise but writing into a book). Even if the students were involved in higher-order word processing, it would still be a digital replication of the pedagogy of pen and paper (with the exception of publishing). Equally, students are now using an electronic textbook where they would previously have been using an actual textbook. (In a few exceptional cases electronic textbooks include interactive simulations (Zucker & Hug, 2008) but in many cases they are not much more than the original textbooks now in PDF or HTML format). It is perhaps surprising that teachers do not rank presentations higher (25%). It would appear then that students are taking notes from the textbook, the board and perhaps dictation more than *death by PowerPoint*. The only new classroom practice that appears to be taking place in any sizeable frequency is internet research, usually performed in a lower-order manner (Churches, 2009).

Of particular interest are the asymmetries between what teachers and students most enjoy and what they report using most often. Most strikingly, whereas 80% of students report doing word processing most often only 41% report actually enjoying it. Taking notes is very much a teacher- centred knowledge delivery activity rather than student-centred knowledge creation activity. Research indicates that the prevalence of such practices will lead to disengagement and decreased motivation (Guthrie & Davis, 2003). Similarly, 40% of students report using an electronic textbook most often in class whereas only 21% enjoy using it.

Regarding middle order activities, comparing across the three figures, it is interesting to note that almost twice as many teachers (60%) report using spreadsheets (*analysing* in BDT) as students (33%). This would imply spreadsheets are used more for class administration and teacher-centred activities than student-centred learning. Spreadsheets are not enjoyable or popular for teachers (13%) or students (7%) it would appear. Given that spreadsheets can be incredibly valuable during experimentation, data analysis and interpretation in science, their full value is not being exploited, perhaps requiring constructivist learning to rectify this (Abbott, Townsend, Johnston-Wilder & Reynolds, 2009).

More students (5%) report using data logging than teachers (4%) though the frequencies are the lowest for both groups. This is perhaps surprising and of cause for concern since data logging has been the traditional application of ICT within science classrooms and has been strongly recommended within the Year 10 science syllabus since 1999 to the present day (Board of Studies NSW, 1998, 2003a). Whereas 5% of students report engaging in data logging, only 0.8% rate it in their top three. Similarly, databases are currently a mandatory part of the science syllabus (Board of Studies NSW, 2003a) and were assessed at the end of Year 10 in the School Certificate Computing Skills Test (Board of Studies NSW, 2003b) until 2011 (Piccoli, 2011). However, only 34% of teachers and 17% of students report having used them. This would appear non-compliant with Board of Studies requirements. In defence of the science teachers, it is somewhat arbitrary the way databases were designated to science in preparation for the School Certificate Computing Skills Test. Many teachers viewed databases as an add-on and left until just prior to the Computing Skills Test. (This occurred after the time of the surveys). The Computing Skills hark back to 1990's Microsoft Office®. It can be argued that the most commonplace database package, Microsoft Access®, is unintuitive. In addition, 8 of the 14 schools have Apple MacBooks® which one could argue have database packages that are even less intuitive and less familiar. This low frequency of use of data logging is backed up by Ainley et al (2010) for Australian schools across the board.

The starkest difference in reported use is with regard to simulations. 60% of teachers report using simulations at one time or another (very close to the 63% measured by Ainley et al (2010)) whereas only 9% of students report the same. Compare this with 55% of students using simulations weekly at the Denver School of Science and Technology (Zucker & Hug, 2008). It is heartening that teachers rank simulations in equal first place thereby taking advantage of science specific offerings that the laptops can access. However, the disparity between teachers and students is a dilemma, why is this so? This needs further follow up with interviews. It possibly indicates teachers checking out simulations but not implementing them. Or, perhaps more likely, teacher-centred instruction and a lack of student experimentation and exploration with simulations. This is of great surprise and perhaps disappointment as simulations are particularly engaging for science students (Khan, 2010; Baggott la Velle, Wishart, McFarlane, Brawn, & John, 2007). There are many great simulations for students to use in learning science e.g. Scootle http://www.scootle.edu.au/, PhET http://phet.colorado.edu/, Java Applets on Physics http://www.walter-fendt.de/ph14e/, Celestia http://www.shatters.net/celestia/, and AMPS http://www.hscphysics.edu.au/resource/template.swf. At first glance students do not rate simulations (8%). However, considering only 9% report using simulations in the first place, they are in fact very popular amongst users. If teachers could tap into this affinity for simulations it is arguable that students would be more motivated and engaged in science (Garrigan, 2011) when using laptops. It has been demonstrated that more interactive instruction can prompt improved understanding of science (Tanahoung, Chitaree, Soankwan, Sharma, &

Johnston, 2010). With many of these simulations, middle- to higher-order Bloom's would be possible, depending of course on how they are used.

Interestingly, despite students reporting less activities overall, they out-report teachers regarding wikis (36% v 30%), blogs (12% v 4%) and podcasting (12% v 8%). Each of these would be considered more contemporary activities/applications, pertaining to the highest order thinking skills i.e. *creating* in BDT. We speculate that these are areas where the students may be developing skills that outstrip the teachers and that the students find motivating. These activities require monitoring and further research and interviews. Wikis should be capitalised on since they foster a deeper style of learning used to create shared knowledge (Ruth & Houghton, 2009) i.e. higher-order Bloom's. No teachers at all report they enjoy using blogs. This is unfortunate as consequently teachers will be less inclined to expose students to this higher-order technology and take advantage of it. Blogs are seen as valuable assets to learning (Farmer, Yue, & Brooks, 2008). Blogs could be particularly useful for journaling in the mandatory Year 10 Student Research Project (Board of Studies NSW, 2003a). As with blogs, though relatively few students report using the higher-order technologies video-editing (28%) and podcasting (12%), most of these students enjoy using them. Surprisingly this is not the case with wikis (36% dropping to 9%). However, from the teachers' point-of-view, only 11% enjoy video-editing, 4% enjoy podcasting and 0% enjoy blogs! A lack of appreciation of activities by teachers would no doubt deny students opportunities to explore such technologies. Of the 28% of students that report they enjoy video-editing, only 4% get to engage in it often. Making students engage in lower-order activities they do not enjoy and denying them new found opportunities through the laptops to activities they do enjoy is counter-productive and counter-intuitive, potentially leading to disaffection with studying science (Elliott & Paige, 2010).

3.8 Implications for research and practice

This research provides an indication of the practices of science teachers and the experiences of science students in 1:1 laptop classrooms in Australia in 2010. This paper, along with previous complementary research (Crook et al., 2013), will contribute to a larger study assessing the impact of 1:1 laptops on student performance in science. In time, longitudinal data will emerge for the 14 schools in this study.

To further support the claims made in this study it would be beneficial to conduct interviews with teachers and students, classroom observations and analyse students' work. A particular point of focus could be to drill in on the actions and activities associated with word processing since arguably word processing can cover all levels (see Figure 3.2). Such findings would argue for or against the assertions in this paper that most word processing is around lower-order thinking skills.

Further investigation should also add to the body of research, e.g. Valanides and Angeli (2008), around what role teacher professional development plays on shifting pedagogy and which models work best with time-poor teachers. Similarly, school leadership and culture could be scrutinised to investigate how they impact on the embedding of new practices.

3.9 Conclusion

In 2010, two years into the Digital Education Revolution and 1:1 paradigm, it can be seen that the teachers and students studied are partaking in a variety of activities. However, though the shift has been to use pen and paper less and laptops more, by and large teachers are still instructing students in a lower-order, teacher-centred paradigm, albeit electronically. It is of concern that a greater shift has not occurred since 1:1 laptops have been in Australia (the first place in the world) since 1990 (Johnstone, 2003). Such shifts need to occur if schools are now to embrace the prevalence and use of mobile devices (Johnson, Adams, & Cummins, 2012).

As identified in BDT, there are many legitimate, higher-order activities students can engage in when privileged enough to experience 1:1 laptops. In fact, students identify that they enjoy such applications e.g. blogs, video-editing and podcasting. However, teachers appear to have little affinity for such technologies, thereby denying students the opportunities to explore and capitalise on the unique activities to be accessed through the laptops. Halverson and Smith back this up when they state:

> *schools seemed to pick up on affordances that reinforced institutionalized priorities. Rather than opening up new opportunities to reframe how teachers teach and students learn, it seemed as though instructionalism bent technologies to extend existing pedagogical, curriculum delivery, and assessment practices (2009, p.52).*

In Bloom's Digital Taxonomy, Churches writes "it's not about the tools; it's about using the tools for learning" (2009). That is, it is not simply about giving students laptops. Indeed, it is not even about telling students to engage in higher-order activities such as wiki-ing and blogging. What is important is that any technologies are incorporated into teaching and learning to compliment the practices and to strategically and appropriately benefit the pedagogy e.g.

through increased opportunities for interaction and feedback (Hattie, 2009). We need to get the pedagogy right in the first place, with or without the technology. We should be probing the affordances provided by new technologies for two compelling reasons: (1) the new technologies provide greater opportunities for the diverse range of students and (2) the student body is very different today and new technologies are central to their everyday lives. As the proverb goes (often credited to Rabindranath Tagore):

do not confine your children to your own learning, for they were born in another time.

We should be questioning the role of chalk-and talk and textbooks in pedagogy rather than propagating them because they were used on us; students have a right to be engaged in more contemporary, student-centred learning. We should be questioning how different tools can be integrated to support a multiplicity of learning activities and opportunities with the student at the centre. We should be questioning if and how the tools can be used to facilitate differentiated teaching and learning opportunities.

The Digital Education Revolution has provided our teachers and particularly our students with a unique opportunity to access contemporary learning activities. Given the relative readiness of many students in this study, it is evident that we need to invest further in the teachers to empower them to become more aligned with their students (Crook et al., 2013). Key to this is equipping teachers with a greater understanding of the value of technology (Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010), how this translates into practice and to provide a multiplicity of professional development opportunities.

Delivering, encouraging, even mandating professional development around the appropriate integration of e.g. Web 2.0 tools such as wikis and blogs, would assist the teachers and benefit the students. These hopes are endorsed by CEO Sydney (2008) as well as the NSW Department of Education (Howard & Carceller, 2010). Teachers need to allow students to become knowledge creators within a more student-centred environment. Importantly, with the advent of the Australian Curriculum upon us (ACARA, 2011), there is a unique opportunity, and many would argue obligation, to embed such practices in future syllabuses and hence teaching and learning.

3.10 Acknowledgements

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3.11 Additional material

In addition to the published paper that makes up this chapter, the discussion below is to benefit this chapter further by providing greater detail of the activities engaged in by science students with 1:1 laptops, particularly simulations, as they are an important and regular theme throughout this thesis.

As described in more detail later in this thesis, simulations provide students with unique opportunities to perform experiments and explore phenomena virtually. Where experiments or phenomena would be too dangerous, expensive or impossible to perform physically without a school owning the requisite apparatus, simulations allow students to individually explore these areas of the curriculum.

There are many examples of useful simulations. Some of the best can be found in Scootle http://www.scootle.edu.au/, a repository of more than 20,000 quality-assured digital learning resources aligned to the Australian Curriculum e.g. a simulation allowing a student to operate the controls of a simulated nuclear reactor to ensure safe operation and avoid a meltdown. Another excellent repository is PhET http://phet.colorado.edu/, founded in 2002 by Nobel Laureate Carl Wieman at the University of Colorado Boulder. When learning about MRI in Medical Physics, students can adjust a virtual radio frequency source and magnetic field to create and observe resonance of hydrogen nuclei in a virtual patient. They can even add a tumour to observe the increased density of hydrogen and consequent reradiated radio emission. Java Applets on Physics http://www.walter-fendt.de/ph14e/ also provides another excellent (though somewhat dated) repository of simulations for students covering all aspects of physics and science including one for time dilation where a student can adjust the relative speed of a space rocket and compare clocks in different frames of reference.

Having their own laptop through a 1:1 laptop program especially empowers students to perform such investigations at school and at home.

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Chapter 4:
An evaluation of the impact of 1:1 laptops on student attainment in senior high school sciences

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4.1 Abstract

Our study capitalised on a unique natural experiment rather than a researcher-designed, randomised experiment whereby, thanks to the Australian Government's Digital Education Revolution, half of grade 9 students in 2008 received laptops and half did not. Consequently, in late 2011, when these students sat for their grade 12 external examinations based on the same curriculum implemented across the state of New South Wales, half of them had been schooled with 1:1 laptops for over three years, and half without. With school principals and district administrators asking the question "what will these laptops do to our examination results?" this dichotomous scenario presented us with a unique opportunity to find out. The aim of this study was to evaluate if having 1:1 laptops was a predictor of success in the sciences in the external examinations. The science students (N = 967) from 12 high schools in Sydney, Australia were studied. Using socio-demographic, school and examination data, multiple regression analyses were performed to measure the impact of the 1:1 laptop provision and other variables on student attainment in biology, chemistry and physics. We found that being schooled with 1:1 laptops had statistically significant and positive standardised regression coefficients with student attainment, with a medium effect size in physics (0.38), and small effect sizes in biology (0.26) and chemistry (0.23). Upon further investigation, exploring data provided by student and teacher questionnaires, we found that the greater effect size in physics corresponded with greater use of simulations and spreadsheets by students and teachers.

4.2 Introduction

In a time when data and testing are increasingly occurring across states, nations and even internationally, for example, Trends in International Mathematics and Science Study (TIMMS) and Programme for International Student Assessment (PISA), the interrogation of these data is not necessarily occurring at a level adequate to inform strategic directions of governments and local schools. More often, such data are used to provide metrics for school and system performance, and is often presented in a highly emotive fashion and viewed as threatening. In this paper, we interrogate the high-stakes data for the Higher School Certificate (HSC) examinations in New South Wales (NSW), Australia, with the intent of distilling insights that can be used to inform practice and guide the best use of the dollars invested in technologies in schools.

Individual schools and whole school districts are currently investigating the concept of 1:1 iPads or tablets, particularly in science, technology, engineering and mathematics (STEM) education (Miller, Krockover, & Doughty, 2013; Weiss, 2013). Consequently, is there anything that can be learnt from recent 1:1 laptop initiatives that might better inform the decision-makers? Our study examines three science subjects studied in senior high school, and measures the impact of 1:1 laptops and other variables on student attainment within the different science disciplines using multiple regression analysis and effect sizes. Using student and teacher questionnaires, we drill down into the activities that give rise to the standardised regression coefficients and effect sizes calculated.

In their analysis of the criticism leveled at 1:1 laptop initiatives, Weston and Bain highlight the "naked truth" that the fact that most 1:1 initiatives provide "little or no sustained and scaled effects on teaching, learning, and achievement" is symptomatic of the failure of most educational initiatives period, aimed at change, innovation and reform (2010, p. 8). Regarding the nature of 1:1 laptop and educational technology research in general, it is argued that the "overall lack of methodological precision and validity is of particular concern . . . currently, decision makers contemplating the merits of educational technology are often forced to make decisions about the expenditure of millions of dollars with only weak and limited evidence" (Bebell, O'Dwyer, Russell, & Hoffmann, 2010, p. 47). A systematisation of the most salient evidence about 1:1 initiatives by the Organisation for Economic Co-operation and Development (OECD) found that given the limited body of evidence there are many "unsolved questions about the cost-effectiveness and educational impacts of 1:1 computing in education" (Valiente, 2010, p. 4). The study presented here addresses these criticisms by providing an analysis of a 1:1 implementation that examines the learning outcomes of laptop introduction.

4.2.1 The Digital Education Revolution

The Australian Government initiated the National Secondary School Computer Fund (NSSCF) in 2008 as part of the Digital Education Revolution (DER). The objective was to create a 1:1 computer-to-student ratio for grades 9–12 in all schools within 5 years (Dandolopartners, 2013). Schools across the nation were split into 2 groups, Rounds 1 and 2. Round 1 schools equipped grade 9 with laptops from 2008. Consequently, by the time these students finished grade 12 in 2011, they had been schooled with 1:1 laptops, that is, they had ubiquitous access to their laptops at school and at home (Wurst, Smarkola, & Gaffney, 2008), for over 3 years. However, Round 2 schools only equipped grade 9 with laptops from 2009. Accordingly, the Round 2 2008 grade 9 cohort missed out, and were schooled through to grade 12, in 2011, without laptops.

In 2011, within the state of NSW, the Catholic Education Office (CEO) Sydney system of schools had representative schools in both rounds. During this time, all students sat for statewide, high-stakes, external, standardised examinations at the end of grade 10 (School Certificate (SC) including mandatory Science) and grade 12 (Higher School Certificate (HSC) examinations including optional sciences). Consequently, in 2011, CEO Sydney had the unique dichotomous scenario where half of its candidature for the grade 12 HSC had been schooled for over 3 years with 1:1 laptops, and half without (Crook, Sharma, Wilson & Muller, 2013). With school principals and district administrators asking the question "what will these laptops do to our examination results?", this dichotomous scenario presented us with an interesting natural experiment to investigate (Murnane & Willett, 2011).

4.3 Review of the literature

4.3.1 1:1 laptop initiatives

There have been many studies across the world of the various 1:1 laptop initiatives implemented by schools, sectors, states and even whole countries. Arguably, the most famous implementation, attracting the most research, was the Maine Learning Technology Initiative (MLTI), when in 2002 the state of Maine began issuing a laptop to every seventh- and eighth-grade student and their teachers (Berry & Wintle, 2009; Muir, Knezek, & Christensen, 2004; Silvernail, Pinkham, Wintle, Walker, & Bartlett, 2011). Overall, the Maine research found that the role of the teacher in integrating the use of laptops was key to any gain in student attainment. Findings from the state of Michigan's similar Freedom to Learn (FTL) 1:1 initiative, also launched in 2002, found that FTL students performed similarly to control students, but with greater acquisition of the twenty-first century skills (Lowther, Inan, Ross, & Strahl, 2012).

A recent report from the European Commission analysed 31 recent 1:1 initiatives that involved approximately 47,000 schools and 17,500,000 students in K-12 education from across 19 European countries (Balanskat et al., 2013). Almost all of the initiatives in the European study found that motivation increased in 1:1 class- rooms. There were also inconsistent reports of improvements in student-centred learning, teaching and learning practices and parental attitudes. The majority of studies showed that there were little or no increases in learning outcomes associated with these 1:1 laptop initiatives.

The most notable synthesis of 1:1 laptop initiatives was by Penuel (2006). Penuel found that "outcome studies with rigorous designs are few, but those studies that did measure outcomes consistently reported positive effects on technology use, technology literacy, and writing skill" (p. 329). However, as Kposowa and Valdez point out, only one of the twelve studies Penuel examined was in a peer-reviewed journal (2013, p. 348).

In their commentary on various international 1:1 laptop programs, Zucker and Light (2009) emphasise that to achieve the desired impact on teaching and learning, more has to be done than simply providing laptops and the technical infrastructure; "laptop programs will be most successful as part of balanced, comprehensive initiatives that address changes in education goals, curricula, teacher training, and assessment" (p. 82). Cognizant of this, our study also inquires into pedagogical shifts at schools implementing 1:1 laptops. While it is not possible here to review research on the effectiveness of the numerous pedagogical shifts possible with a 1:1 laptop implementation, one invaluable source is Hattie's (2009) exhaustive study of over 800 meta-analyses of pedagogies, characteristics and processes associated with educational effectiveness.

4.3.2 Quantitative research: 1:1 laptop initiatives

Despite the large number of studies into the impact of 1:1 laptops, including the seminal ones outlined above, "there is a paucity of research that examines their effectiveness, especially their impact on student academic achievement" (Kposowa & Valdez, 2013, p. 348). While there are many studies reporting on broad themes, such as impact on motivation, very few focus on learning outcomes. Within this paucity, there is even less research using in-depth quantitative analysis. One of the notable exceptions to this came from Bebell and Kay (2010). Bebell and Kay compared the students and teachers of five schools participating in the 1:1 laptop Berkshire Wireless Learning Initiative with two comparison schools. Comparing student and teacher survey results with test scores, Bebell and Kay performed bivariate correlation analyses. They also developed linear regression models to determine the overall program effect on student performance in the state standardised tests for English language arts (ELA) and mathematics. The 1:1 laptop student score increases were found to be statistically greater than those in the non-1:1 setting in ELA, but not mathematics. However, nearly all of the technology use measures were not statistically significant once prior attainment was accounted for.

Using an analysis of covariance approach, Dunleavy and Heinecke (2008) used a pretest–posttest control-group design to compare mathematics and science standardised test scores for students randomly assigned to 1:1 laptop classrooms with students in classrooms without 1:1 laptops in the same middle school. They found that 1:1 laptop instruction enhanced student science attainment, but there was no significant effect observed in mathematics attainment. The reasons for these results were inconclusive.

Gulek and Demirtas (2005) analysed the data from grade point averages (GPAs), end-of-course grades, writing test scores, and state-mandated norm- and criterion- referenced standardised test scores in ELA, mathematics and writing for students (not randomly assigned) with and without 1:1 laptops in the same middle school. Using t-tests and longitudinal linear mixed-modelling, they found that students who participated in the 1:1 laptop program attained significantly higher test scores and grades for writing, ELA, mathematics and overall GPAs. However, the reasons why these significantly higher test scores occurred were not investigated since the researchers did not systematically collect information about how individual students used their laptops.

In their recent study into laptop use and standardised test scores, Kposowa and Valdez (2013) used bivariate and multiple regression analyses plus independent sample t-tests to examine data from an elementary school. Their results in general reported that students with 1:1 laptops performed significantly better than those without in ELA, mathematics and science.

Among the various extant literature, the findings regarding the impact of 1:1 laptops on student attainment are inconclusive and inconsistent. Most of the research has been around ELA and mathematics, usually within middle school. There is a need for more research around 1:1 laptops within the sciences and within senior school. In terms of a quantitative approach, studies employing multi-level modelling and/or structural equation modelling would be of benefit to the field. However, these approaches are not always possible, given the contexts (or in the case of this study, the natural experiments) presented.

4.3.3 Laptops in science

Regarding the use of laptops specifically in science, there is some extant literature. In their study of the Denver School of Science and Technology, Zucker and Hug found that 1:1 laptops provided physics students with high-quality tools to explore scientific concepts (2007, 2008). In a study of 25,000 teachers and students in grades 6–12 in Henrico County Public Schools in Virginia, Zucker and McGhee (2005) found that most of the teachers they observed "asked students to use laptops for many purposes, including cultivating the skills necessary for scientific inquiry: generating research questions; formulating hypotheses or predictions; developing models to describe or explain a phenomenon; and collecting, displaying, and analysing data" (p. 12).

As part of the MLTI research, Berry and Wintle (2009) used a variety of activities and pretest and posttest results to compare students instructed with and without laptops. They found higher levels of comprehension, retention and engagement in those students studying science with laptops. In an interesting change of emphasis, it has also been found that performing scientific inquiry on laptops and computers and providing the academic context can increase proficiency in the use of technology (Ebenezer, Kaya, & Ebenezer, 2011). However, as highlighted earlier, there is a relative void regarding 1:1 laptop research in a science context, particularly in sciences other than physics.

4.3.4 Quantitative research: Capitalising on the use of high-stakes examination data

As mentioned, quantitative research within the school setting has been summarised by Hattie (2009). However, in terms of outcomes, what the students learnt, the literature is more limited. At the international level, PISA and TIMMS provide benchmarks and comparisons (Martin & Mullis, 2013; OECD, 2010b). Large-scale national and state examinations can also provide large sample sizes that should be analysed to determine whether certain large-scale interventions or processes have impacted outcomes. For example, in NSW in Australia, the statewide examination results could be correlated against state or national initiatives such as the DER. If one had access to this large data set and could correlate with local interventions, one could analyse and establish the success or otherwise of these interventions. Furthermore, in this digital age, students and teachers can more readily provide data of practices through online means (Howard & Carceller, 2011). This has the potential to provide holistic rich quantitative data on outcomes as well as processes to better inform future policies and practices.

4.4 Purpose of the study

In view of the extant literature, this paper is positioning itself to fill some of the voids identified and provide an in-depth quantitative analysis to explore correlations between the use of 1:1 laptops and student attainment in the senior high school science subjects of biology, chemistry and physics, across a large sample size of students from a good number of schools, using data from high-stakes standardised external examinations. Data provided by the students and teachers in exit questionnaires are used to drill down into and identify any pedagogies and activities that emerge that might explain any correlations and nuances.

4.4.1 Research questions

1. Does learning within a 1:1 laptop environment affect senior high school student attainment in statewide-examined biology, chemistry and physics?
2. If there is an effect, what are the types of use of the laptops that might indicate the advantage the 1:1 laptops afford?

4.5 Methods

4.5.1 Socio-demographic and technological data for schools and students

The students from 12 comprehensive high schools in CEO Sydney of varying socio- economic, gender and grade profiles were studied. These schools were split into Round 1 (n = 7) and Round 2 (n = 5), ostensibly based on need. However, as is discussed below, the resulting split was somewhat arbitrary with equivalence across both groups in terms of their socio-demographic and technological profiles.

As can be seen in Table 4.1, both groups, schools with and without laptops, were roughly equivalent in terms of school type, socioeconomic status and their spread in prior attainment. Considering the technological data, an average of 94% of students with DER laptops reported having access to a computer other than their issued laptop (in fact, the school that reported 80% was very much an outlier with the next lowest figure being 94%), and an average of 98% reported having access to the Internet. Impressively, 100% of the students without laptops reported having access to a computer at home, and again, 100% reported having access to the Internet at home. These results are not too dissimilar to those reported for Australian students by OECD (2010a), based on 2006 data, of 96.3% and 91.9% for home computer and Internet access, respectively; and the Australian Bureau of Statistics (2012), based on 2010–2011 data, reported 94.7% and 92.6% for home computer and Internet access for families with children.

Table 4.1: Socio-demographic and technological data for schools and students

Schools with laptops	There were 7 schools with laptops: 2 boys', 1 girls' and 4 coeducational schools; the schools ranged in socio-economic status[a] from 980 to 1088; the total number of grade 12 HSC science students within these schools ranged from 65 to 201; the schools' average score for grade 10 SC Science[b] (an indicator of prior attainment) ranged from 77.9 to 84.8.
	Regarding access to technology, for the schools with laptops, the percentage of students with access to another computer at home ranged from 80% to 100%; the percentage of students with access to the internet at home ranged from 94.7% to 100%. Prior to the DER, the computer-to-student ratio[c] for the schools that did receive laptops in Round 1 ranged from 1:3 to 1:9.
Schools without laptops	There were 5 schools without laptops: 1 boys', 0 girls' and 4 coeducational schools; the schools ranged in socio-economic status[a] from 998 to 1071; the total number of grade 12 HSC science students within these schools ranged from 32 to 76; the schools' average score for grade 10 SC Science[b] ranged from 74.6 to 88.2.
	Regarding access to technology, for the schools without laptops, 100% of all students had access to a computer at home; equally, 100% of all students had access to home internet. Prior to the DER, the computer-to-student ratio[c] for the schools that did not receive laptops in Round 1 ranged from 1:2 to 1:3.
Summary	The two groups of schools, with and without laptops, are very similar in terms of gender profiles, range of socio-economic status and prior attainment as indicated by grade 10 SC Science scores. The main differences are that there was only one girls' school (they had laptops), the schools without laptops had smaller cohorts of students, the schools without laptops had greater access to a home computer and home internet and the schools without laptops already enjoyed a far better computer-to-student ratio within school.

[a]The school socio-economic status (SES) was obtained from the Index of Community Socio-Educational Advantage (ICSEA) 2011 as presented on the MySchool website (http://www.myschool.edu.au/).
[b]Grade 10 School Certificate (SC) Science score out of 100 – a measure of prior attainment.
[c]Computer-to-student ratios calculated following a 2007 audit by comparing all computers within a school, whatever age of machine, with the total number of students.

It is interesting to observe that families where the child received a DER laptop were slightly more likely to have home Internet than another home computer. It can be surmised that some families undertook to provide home Internet to capitalise on their child receiving a DER laptop. In a similar vein, with 100% of students who did not receive a DER laptop having both home computer and Internet access, it can be surmised that at least some families compensated on missing out on a DER laptop by providing a home computer and the Internet; the families were proactive in eradicating any perceived digital divide (Vigdor & Ladd, 2010; Warschauer, Zheng, Niiya, Cotten, & Farkas, 2014).

Although the Australian Government dictated the splitting of schools into Rounds 1 and 2, for this sample of 12 schools, the split was somewhat random in terms of their socio-demographic profiles and not too varied in terms of their technological profiles.

4.5.2 Procedure

A total of 759 individual students studied the various science subjects within the sample schools. With a number of students studying more than one science, this presented a total of N = 967 *students-within-subject*. The subjects were analysed separately; hence, the data for a student in two or more subjects were mutually exclusive. As a consequence, for the ease of the reader, the term *students* is used in place of *students-within-subject*. The data for every student, N = 967 (see the database in Appendix B), were collected for the 5 sciences studied in the senior years of high school in NSW: biology, chemistry, physics, senior science, and earth and environmental science. All five subjects are included when calculating the number of sciences studied. The curricula for all of the subjects are statewide (Board of Studies NSW, 2009) and followed by all students within the subjects, irrespective of access to laptops.

Within this study, a combined approach of three methods used in conjunction with each other was used: (a) multiple regression analysis of natural, non-researcher-influenced, high-stakes examination data; (b) calculation of effect sizes using the same examination data; and (c) exit questionnaires of student and teacher practices. The analysis of classroom practices as found by the questionnaires was used to help explain the significant correlations and nuances found in the multiple regressions and effect sizes.

It is important to note that this was not a researcher-designed randomised experiment. As already highlighted, the dichotomous scenario was imposed arbitrarily by external agencies (the Australian Government). As a consequence, the considerable design and methodology that would normally be present to achieve the randomisation (Murnane & Willett, 2011) were not possible in our study. However, by definition, they were superseded by the natural experiment itself.

4.5.2.1 Multiple regression of natural experiment data

The data were used to generate variables (discussed below) to be used in a multiple regression analysis: z-score of the examination mark for the respective grade 12 HSC science subject (*ZA12HSC*); z-score of the examination mark for the prior grade 10 SC science (*ZA10SC*); number of sciences studied (*NSciences*); socioeconomic status (*SES*); and dummy variables for 1:1 laptops (*Laptop*); boys' school (*BoysS*); girls' school (*GirlsS*); gender (*Gender*); and senior school (*SeniorS*). Details regarding the variables can be found in Table 4.2.

These data were historical and readily available to those with access rights, that is, they were natural data without any influence from researchers. Bivariate correlation analysis (Table 4.3) was used to examine the variables and determine an appropriate regression model.

Table 4.2 Variables used in the multiple regression

Variable	Overview for 12 schools; *N*=967 students
ZA12HSC	see Appendix B
ZA10SC	see Appendix B
Laptop	710 with laptop; 257 without
NSciences	1 subject: *n*=565; 2 subjects: *n*=360[a]; 3 subjects: *n*=42[b]
BoysS	3 boys' schools[c]; *n*=227
GirlsS	1 girls' school[c]; *n*=65
Gender	*n*=380 girls; *n*=587 boys
SeniorS	2 senior schools, grades 11-12[d]; *n*=266
SES	see Table 4.1

[a]180 students studying 2 subjects presented 360 students-within-subject
[b]14 students studying 3 subjects presented 42 students-within-subject
[c]c.f. 8 coeducational schools
[d]c.f. 10 grade 7-12 schools

The multiple regression assumptions were also checked through residual analysis to confirm that the data were appropriate for regressing.

In every subject, there were statistically significant associations of varying magnitudes between some of the variables. To treat each subject to the same initial regression, we retained the variables in all subjects. *ZA12HSC* was required as the independent variable and measure of student attainment in each subject. *ZA10SC*, as a measure of prior attainment, not surprisingly, had highly significant and sizeable correlation with *ZA12HSC* in every subject. Being the main focus of this study, Laptop needed to be included in the regression for every subject. *NSciences* provided an interesting discriminator for enculturation in the study of sciences (unpacked in Results and Discussion). *BoysS*, *GirlsS* and *SeniorS* provided discriminators, given the spread of profiles in the schools. As an educational analysis, we were obliged to include *Gender* and *SES*. Initial consideration might elicit a response of collinearity between *Gender* and *BoysS*/*GirlsS*. However, given that some students were in single-sex schools and the others in coeducational schools, it was appropriate to include all three variables.

The relationship to be regressed for each subject is described by Equation 4.1.

$$ZA12HSC = f(ZA10SC, Laptop, NSciences, BoysS, GirlsS, Gender, SeniorS, SES) \quad (4.1)$$

For each of the three sciences, a multiple regression analysis was performed, gradually removing non-significant variables ($p > 0.05$) to leave optimal regressions for each subject, that is, all variables were significant ($p < 0.05$).

Table 4.3 Bivariate Correlations of Variables

Biology	*ZA12HSC*	*ZA10SC*	*Laptop*	*NSciences*	*BoysS*	*GirlsS*	*Gender*	*SeniorS*	*SES*
ZA12HSC	1.000	0.757**	0.114*	0.290**	-0.160**	-0.108*	0.070	0.156**	0.250**
ZA10SC		1.000	0.018	0.239**	-0.268**	-0.138*	0.092	0.258**	0.311**
Laptop			1.000	0.098	0.060	0.210**	0.028	0.378**	0.051
NSciences				1.000	-0.013	-0.068	-0.135*	0.150**	0.064
BoysS					1.000	-0.183**	-0.562**	-0.329**	-0.377**
GirlsS						1.000	0.325**	-0.213**	-0.475**
Gender							1.000	0.124*	0.090
SeniorS								1.000	0.539**
SES									1.000
Chemistry									
ZA12HSC	1.000	0.558**	0.106	0.054	0.089	-0.130	-0.149*	0.045	0.075
ZA10SC		1.000	-0.217**	-0.066	-0.116	-0.082	-0.085	0.038	0.143
Laptop			1.000	0.107	-0.070	0.213**	0.199**	0.374**	-0.028
NSciences				1.000	0.052	-0.076	-0.114	0.077	-0.031
BoysS					1.000	-0.180*	-0.438**	-0.317**	-0.431**
GirlsS						1.000	0.411**	-0.180*	-0.477**
Gender							1.000	0.143	0.025
SeniorS								1.000	0.407**
SES									1.000
Physics									
ZA12HSC	1.000	0.597**	0.176*	0.418**	0.112	-0.038	0.095	0.159*	-0.019
ZA10SC		1.000	-0.048	0.290**	-0.093	0.009	0.165*	0.068	0.100
Laptop			1.000	0.084	-0.009	0.179*	0.138	0.281**	0.014
NSciences				1.000	-0.067	0.042	0.257**	0.142	-0.014
BoysS					1.000	-0.161*	-0.311**	-0.254**	-0.510**
GirlsS						1.000	0.520**	-0.101	-0.373**
Gender							1.000	0.171*	-0.092
SeniorS								1.000	0.242**
SES									1.000

* $p < 0.05$.
** $p < 0.001$.

4.5.2.2 Effect sizes of natural experiment data

Within secondary education, rather than utilising regression correlation coefficients, academics and policy-makers tend to compare effect sizes. Often, these are benchmarked against those collated by Hattie (2009) from more than 800 meta-analyses. Using the *pooled* standard deviations (Field, 2013) for the full data sets for each subject, the effect size of introducing 1:1 laptops was calculated for each science subject.

4.5.2.3 Questionnaire

For this paper, we sought student and teacher responses via questionnaires in terms of what students and teachers used their computers for (Beckman, Bennett, & Lockyer, 2014), comparing between classes where students had 1:1 laptops and those without. It should be noted that all teachers had personal laptops provided for them by their schools whether their students received laptops or not.

For the students with laptops, the questionnaire asked a variety of questions about the frequency and types of use of the laptops, in school and at home for the various sciences. For the students without laptops, similar questions were asked regarding the frequency and types of use of school computers within their science subjects. In addition, questions were asked about the frequency and types of use of any computers at home for science study. Teachers were asked near identical questions to those of the students in terms of their own practices.

The questionnaires (see Appendix A) were administered online during the last month of their HSC curriculum and two months prior to the students sitting their final examinations in 2011. The questionnaires were administered via Google Doc Forms for ease, efficiency, security (128-bit encryption), anonymity and minimising errors due to transcription.

4.6 Results and discussion

4.6.1 Multiple regression of natural experiment data

The outputs for the multiple regression analyses are presented in Table 4.4. For completeness, the standard errors are included for unstandardised coefficients; both the unstandardised and standardised coefficients are used in the discussions.

The results show some interesting consistencies and contrasts. All subject models have significance throughout ($p < 0.05$, in fact mostly $p < 0.001$, that is, highly significant, even by recent, more stringent standards (Johnson, 2013)). In biology and physics, these models account for over 50% of the variability in student attainment (R^2 = 0.61, 0.51, respectively). Similarly, the standard errors of the estimate (*SEE*) are quite respectable, that is, each model performs its predictive capacity within 0.63–0.78 standard deviations. In all three subjects, prior attainment in science (*ZA10SC*) is the greatest predictor of higher level science attainment (β is greatest for *ZA10SC* in all cases). This is to be expected from the extant literature (Martin, Wilson, Liem, & Ginns, 2013; Sadler & Tai, 2007).

Table 4.4: Multiple regression output by subject

	Unstandardised Coefficients		Standardised Coefficients	
Biology N=340 R^2=0.61 *SEE*=0.63	*B*	*Standard Error*	β	*p*
ZA10SC	0.849	0.043	0.738	<0.001
Laptop	0.330	0.085	0.146	<0.001
NSciences	0.229	0.065	0.125	0.001
SeniorS	-0.368	0.102	-0.163	<0.001
SES	0.003	0.001	0.092	0.030
Chemistry N=181 R^2=0.40 *SEE*=0.78				
ZA10SC	0.890	0.085	0.634	<0.001
Laptop	0.560	0.129	0.260	<0.001
BoysS	0.403	0.138	0.172	0.004
Physics N=178 R^2=0.51 *SEE*=0.70				
ZA10SC	0.799	0.081	0.554	<0.001
Laptop	0.424	0.112	0.205	<0.001
NSciences	0.423	0.094	0.253	<0.001
BoysS	0.486	0.118	0.221	<0.001

Of particular interest to this study is that being schooled with 1:1 laptops is significant in each of biology, chemistry and physics. Of equal importance, in each case, 1:1 laptops have a sizeable, standardised regression (β) coefficient, that is, 1:1 laptops correlate with greater student attainment in biology, chemistry and physics, in the schools studied, in 2011. In biology, chemistry and physics, the unstandardised coefficient for 1:1 laptops is B = 0.330, 0.560 and 0.424, respectively. This means that having a 1:1 laptop increased *ZA12HSC* (*z*-score of grade 12 HSC attainment) by 0.330 in biology; in other words, this increased a student's attainment in the external standardised biology examination by around one-third of a standard deviation.

In terms of raw scores (out of 100), this corresponded to an increase in 3 marks (see Table 4.5). In chemistry, having a 1:1 laptop accounts for over half of a standard deviation increase in attainment, or 5 marks. In physics, it is over 40% of a standard deviation or about 3½ marks.

Table 4.5: Examination raw score descriptives by subject

Subject	*A10SC* mean	*A10SC* SD	*A12HSC* mean	*A12HSC* SD
Biology	82.2	7.0	74.7	9.9
Chemistry	87.5	5.7	78.5	8.9
Physics	86.7	5.5	77.7	8.5

Socioeconomic status of the school (*SES*) only features in biology and with a very small standardised regression coefficient (smallest β). This goes against most extant literature (Gorard & See, 2009; Sirin, 2005). However, it is recognised that CEO Sydney has made substantial and concerted investment in low SES schools, possibly explaining this result (Australian Government, 2011; Cardak & Vecci, 2013). Similarly, student gender does not feature as being statistically significant (Hyde & Linn, 2006). However, attending a boys' school is significantly positive when studying chemistry and physics (B = 0.403, 0.486, respectively), suggesting the importance of the peer effect for boys in these traditionally male subjects rather than simply gender per se (Archer, DeWitt, & Willis, 2013). Attending a girls' school was non-significant, although given that there was only one girls' school, we cannot comment in any way conclusively.

Interestingly, attending a senior school had a negative impact on student attainment in biology (B = -0.368). This would appear to imply that in this subject, with traditionally greater female representation, both boys and girls perform less well in a new coeducational environment after attending single-sex schools for grades 7–10, as was the case here. This is in contrast to the extant literature (Lavy & Schlosser, 2011).

The number of science subjects studied (*NSciences*) was an interesting variable to include. It can be conceived of as a proxy for interest and enculturation in the sciences (Fullarton, Walker, Ainley, & Hillman, 2003; Sadler & Tai, 2007). While *NSciences* was significantly positive in biology and physics (B = 0.229, 0.423 respectively), it was non-significant in chemistry. Students often pair physics with chemistry; or biology with chemistry; rarely studying physics with biology (Fullarton et al., 2003). One speculative perspective would be that studying chemistry in parallel with either biology or physics does provide a level of enculturation in the sciences benefitting both physics and biology. However, this makes the chemistry cohort somewhat disparate resulting in *NSciences* not being significant for chemistry and a poor fit for the chemistry model as a whole (low R^2).

4.6.2 Effect sizes of natural experiment data

The effect sizes, also known as Cohen's *d* (Cohen, 1988), for the impact of 1:1 laptops on student attainment were calculated for biology (0.26), chemistry (0.23) and physics (0.38) using *pooled* standard deviations. With effect sizes of 0.26 and 0.23, respectively, the impact of 1:1 laptops in biology and chemistry would be considered small (Hattie, 2009). However, with an effect size of 0.38, the impact of 1:1 laptops in physics would be considered medium. In fact, this is very close to Hattie's average effect size of 0.40 relating to student achievement. Of particular interest are comparable effect sizes. For example, within the context of our study, studying biology or chemistry with 1:1 laptops corresponds to a slightly higher effect size than reducing class sizes ($d = 0.21$). Whereas, the use of 1:1 laptops in physics is comparable with time on task ($d = 0.38$), attitude to science ($d = 0.36$) and science curricula programs ($d = 0.40$). Of particular note and adding validity to our findings, Hattie finds that the average effect size for computer-assisted instruction is 0.37; this average effect is usually observed in experimentally controlled and targeted intensive educational interventions. Hattie remarks that most of the research examines dichotomous scenarios, that is, with or without certain technology interventions. While this study is dichotomous, an important distinction is that the dichotomy was imposed by external agencies, that is, the Australian Government, thereby creating a natural experiment rather than a researcher-designed randomized experiment (Murnane & Willett, 2011). In a meta-analysis of 61 studies from the USA, specifically regarding the effects of teaching strategies on student achievement in science, the average effect size for instructional technology (i.e. the use of computers in class- room teaching) was 0.48 (Schroeder, Scott, Tolson, Huang, & Lee, 2007).

Comparing within, it is interesting to note the substantially larger effect size of 1:1 laptops in physics compared to biology and chemistry. Finding a difference between subjects is to be expected when considering the extant literature (Bebell & Kay, 2010; Dunleavy & Heinecke, 2008). Analyses of the questionnaires shine light on this result.

4.6.3 Questionnaires

For the questionnaires, the response rate for all science students was 54% (522 out of 967). For all science teachers, the response rate was 75% (47 out of a possible 63). These response rates far exceed the average response rate for online surveys of 25% (Kaplowitz, Hadlock, & Levine, 2004). The sample size is large capturing the diversity in the sample.

Having found significant, positive standardized regression coefficients for 1:1 laptop schooling in biology, chemistry and physics (Table 4.4), we looked to the questionnaire data to see if there were any differences in practice apparent between those students with laptops and those without, similarly with the teachers of those classes, and also between subjects.

Table 4.6 shows the percentage of students who used their laptops (or school/home computers where they had no laptops) for various activities/applications by subject. We first compared with and without laptops for the subjects as presented in the differences, Δ. Biology has the greatest spread in differences of use, that is, there are many negative values as well as positive. Chemistry has almost as many negative differences as Biology, though not as large a spread. Physics has consistently positive differences. By simply observing the greyed out values, we observe that physics has most differences greyed out, with six $10 < \Delta < 20$ and six $\Delta > 20$, including the five largest differences of all of the subjects. Biology, has the next largest values with two $10 < \Delta < 20$, one $\Delta > 20$ and, interestingly, one $\Delta < -20$ for electronic text books. Chemistry has two $\Delta > 20$ and, surprisingly, one $\Delta < -20$ for simulations. These results are consistent with the effect sizes calculated from the natural data where physics has a far greater effect size, with biology slightly larger than chemistry. As mentioned earlier, finding differences between subjects is to be expected from the extant literature.

An obvious prediction might be that students with laptops would engage in much more computer-based activities than those without. However, upon inspection, this is not always the case; the students without laptops were still able to participate in a variety of computer-based activities, sometimes more, particularly in Biology and Chemistry, using school and/or home computers. Considering that the largest differences and the largest effect size were for physics, it is necessary to explore why physics is advantaged. The 3 largest differences in physics are particularly interesting: spreadsheets (38.7), simulations (30.7) and wikis (29.0). These are considered high-order activities (Crook & Sharma, 2013). Importantly, given that the access to computers for students without laptops is not as diminished as one might first think, the major differences would therefore appear to be related to classroom pedagogy (Hennessy, Deaney, & Ruthven, 2006). The use of spreadsheets and simulations in particular would be considered activities associated with higher-order thinking skills, beneficial to the study of science (Huppert, Lomask, & Lazarowitz, 2002; Khan, 2010; Lindgren & Schwartz, 2009; Smetana & Bell, 2012). This is particularly the case with physics (Tambade, 2011; Wieman, Adams, & Perkins, 2008; Zucker & Hug, 2007, 2008). Within the 1:1 laptop physics classes, it would appear that there were greater opportunities for students to experience phenomena and perform experiments individually through simulations, represent and analyse data through spreadsheets, and collaborate and co-construct knowledge through wikis (Ruth & Houghton, 2009).

Table 4.6: Percentage student use of applications with and without laptops by subject

	Biology			Chemistry			Physics		
Application	Laptop	No Laptop	Δ	Laptop	No Laptop	Δ	Laptop	No Laptop	Δ
Word Processing	93.3	93.4	-0.1	89.6	91.9	-2.3	91.9	87.1	4.8
Spreadsheets	15.7	17.1	-1.4	28.6	21.6	7.0	41.9	3.2	38.7[a]
Presentations	60.4	56.6	3.8	42.9	24.3	18.6	67.7	41.9	25.8
Simulations	18.7	21.1	-2.4	27.3	37.8	-10.5	59.7	29.0	30.7[a]
Science Software	11.2	15.8	-4.6	18.2	27.0	-8.8	32.3	12.9	19.4
Text Book[b]	62.7	82.9	-20.2[c]	72.7	78.4	-5.7	69.4	45.2	24.2
Wiki	42.5	26.3	16.2[d]	28.6	13.5	15.1	41.9	12.9	29.0[a]
Blogs	3.0	9.2	-6.2	0.0	8.1	-8.1	14.5	0.0	14.5
Internet Research	83.6	89.5	-5.9	85.7	81.1	4.6	85.5	71.0	14.5
LMS[e]	63.4	57.9	5.5	51.9	56.8	-4.9	46.8	19.4	27.4
Video Editing	30.6	13.2	17.4	9.1	0.0	9.1	29.0	9.7	19.3
Podcasting	6.0	1.3	4.7	10.4	5.4	5.0	12.9	6.5	6.4
Databases	5.2	3.9	1.3	3.9	0.0	3.9	8.1	0.0	8.1
Email	56.0	31.6	24.4	44.2	37.8	6.4	41.9	25.8	16.1
Data logging	9.7	5.3	4.4	7.8	2.7	5.1	14.5	0.0	14.5

[a]top three most sizeable differences.

[b]electronic text book.

[c]dark grey represents differences Δ < -20, Δ > 20.

[d]light grey represents differences -20 < Δ < -10, 10 < Δ < 20.

[e]LMS = Learning Management System: MyClasses®.

We must also consider that the physics teachers may have had greater readiness and stronger belief systems around using the laptops with their students (Campbell, Zuwallack, Longhurst, Shelton, & Wolf, 2014; Howard, Chan, & Caputi, 2014).

Similarly, examining Figure 4.1, we can see that in terms of percentage use of applications for all students with laptops compared by subject that students in physics greatly out-report students in biology and chemistry in the use spreadsheets and simulations.

In terms of teachers' self-reported practices, in Figure 4.2 far more physics teachers of 1:1 laptop classes report using spreadsheets than biology or chemistry teachers, and 100% of physics teachers report using simulations with their 1:1 laptop classes. Importantly, but not surprisingly, these results concur with the students' self-reported uses.

Given the evidence from student and teacher responses regarding the activities engaged in by students (and teachers) on laptops, the substantially larger use of simulations and spreadsheets in 1:1 laptop classes in physics would appear to explain the far greater effect size of 1:1 laptops in physics.

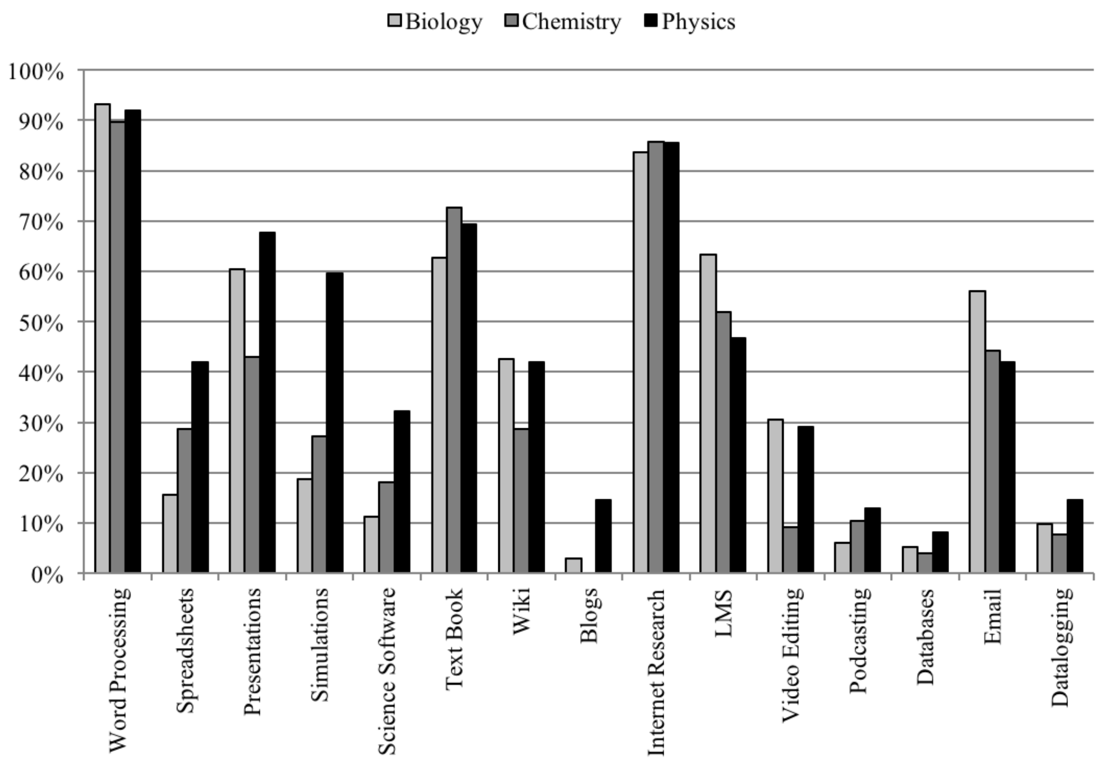

Figure 4.1: Student-reported percentage use of applications for students with laptops by subject

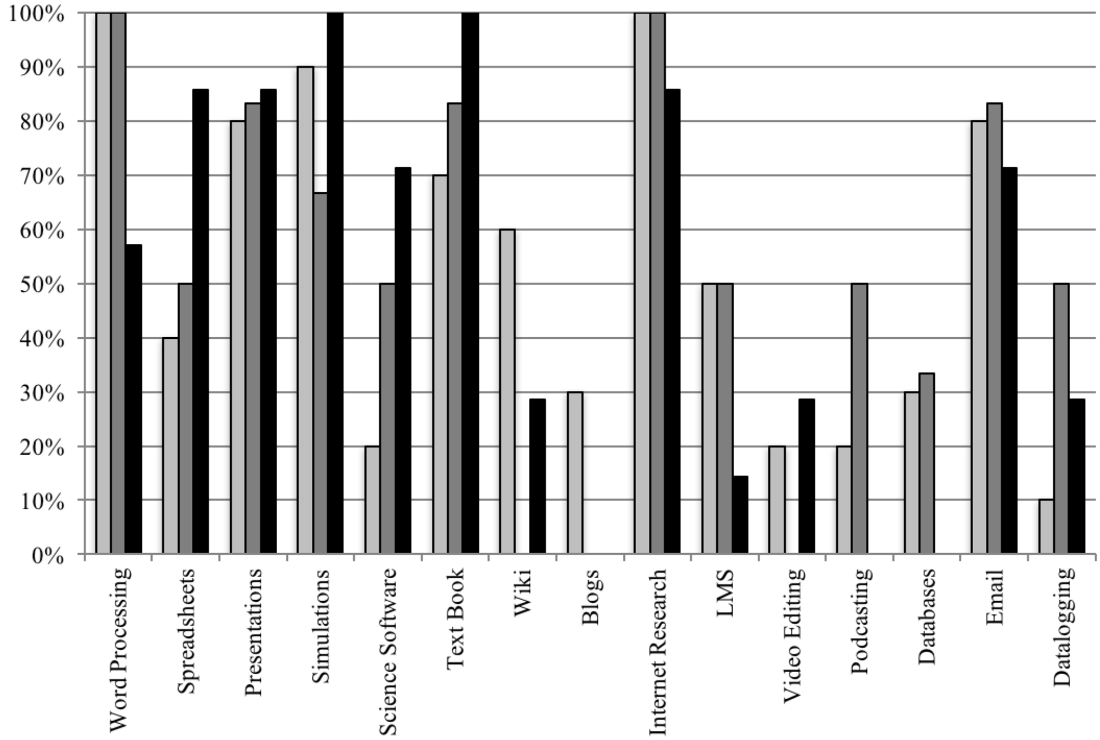

Figure 4.2: Teacher-reported percentage use of applications with classes with laptops by subject

4.7 Conclusion

Responding to the albeit blunt question at inception from school principals and district administrators, we have found that the roll out of the 1:1 laptops by CEO Sydney was certainly not detrimental to student attainment in the science subjects. In fact, there was a positive impact on student attainment in each of physics, biology and chemistry. As part of a \$2.1 billion national DER initiative, the statistically significant and substantial standardised regression coefficients and effect sizes present policymakers with some positive findings. Questions have also been asked regarding the cost-effectiveness of the DER. For the sample within this study, considering that most students already had access to computers at home and all had some level access to computers within their schools, one could argue that the DER was not cost-effective at AU\$1,000 per student. However, regarding the impact of 1:1 laptops on student attainment in the sciences, even though the effect sizes were small to medium, the average net increase in examination score of three to five marks may have had considerable impact on the futures of the students. In NSW, although the examination marks are out of 100, they are more effectively out of 50–100, with students achieving *bands* covering 10-mark ranges, that is, Band 2 (the minimum standard expected) corresponds to 50–59 marks, Band 3 corresponds to 60–69 marks; continuing in this fashion to Band 6: 90–100 marks (Board of Studies NSW, 2013). Therefore, an average increase of three to five marks could easily shift a student's band, thus increasing their employment and university entry prospects.

We are not suggesting that by simply issuing students with a laptop they will perform better (Fullan, 2011). However, we would argue that associated with this particular laptop initiative, the 1:1 laptop environment provided the catalyst for a paradigm shift (Kroksmark, 2014; Weston & Bain, 2010), providing students with the opportunities for more student-centred and personalised learning (Granger et al., 2012; Odom, Marszalek, Stoddard, & Wrobel, 2011). Specifically, in this study, it would appear that the more substantial effect size for laptops in physics is due to new pedagogies capitalising on the affordances of the 1:1 laptop environment for student-centred, personalised learning, particularly in the use of simulations and spreadsheets. This raises the need for alignment of the use of new pedagogies with curriculum and assessment to ensure that their use is valued and there is payoff in terms of student attainment (Silvernail et al., 2011) for the sizeable cost of investment (Zucker & Light, 2009). The cost of professional development in this area would also need to be factored into any assessment of cost-effectiveness.

Additional research is required to further investigate how students use laptops and how these different factors affect student attainment (Crook et al., 2013; Crook & Sharma, 2013; Howard & Rennie, 2013). Within Australia, it would be beneficial to perform both statewide and national quantitative studies of the DER, on top of those performed at a system level such as this paper. Equally, the extant literature and the findings in this study pertain primarily to physics. Further research is required to look at the similarities and differences between integrating technology in biology, chemistry and physics and how best to leverage technology in biology and chemistry as well as physics.

4.8 Acknowledgments

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4.9 Additional material

Given that this paper and indeed this thesis straddle physics, science education and educational technology, the additional discussion below is to provide further detail to the analytical techniques used in the paper that makes up this chapter. These techniques are de rigeur in educational research but less so in science.

Multiple regression analysis is a commonplace analytical technique used when examining a social or educational scenario where several predictors are studied and analysed together to measure their individual and combined impacts on an overall outcome. In this paper, we chose for predictors: the focus of this study i.e. use of 1:1 laptop or not; the mandatory sociodemographic variables such as SES and gender; plus, important educational variables for the sample such as prior attainment and the type of school. These were then analysed against the dependent variable i.e. examination performance. Equation 4.1 on page 61 shows the dependent variable as a function of all of the other variables chosen to be regressed. The actual multiple regression analyses, bivariate correlations and correlation coefficients were performed and calculated using SPSS (Statistical Package for the Social Sciences), using the standard textbook *Discovering statistics using IBM SPSS statistics* (Field, 2013) for guidance. By performing the regressions iteratively, I was able to remove the least significant ($p > 0.05$) variable each time to achieve the optimal regressions for each analysis whereby all predictors were statistically significant ($p < 0.05$) for the resultant model i.e. I reduced the hypothesised relationship in Equation 4.1 to the best fit of predictors for each subject analysed.

4.10 References

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Chapter 5:
Comparison of technology use between biology and physics teachers in a 1:1 laptop environment

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5.1 Abstract

Using a mixed-methods approach the authors compared the associated practices of senior physics teachers (n = 7) and students (n = 53) in a 1:1 laptop environment with those of senior biology teachers (n = 10) and students (n = 125) also in a 1:1 laptop environment, in seven high schools in Sydney, NSW, Australia. They found that the physics teachers and students reported more use of their laptops than did their biology counterparts, particularly in regard to higher-order, engaging activities such as simulations. This disparity is consistent with the differences between the prescribed NSW physics and biology curriculum documents. The physics curriculum specifies that students should engage with various technologies (especially simulations) frequently within the course content, while the biology curriculum makes only generic statements within the course outline. Due to the curriculum mandate, physics teachers seemed to be capitalising on the opportunities afforded by the 1:1 laptop environment, whereas the biology teachers had less of a mandate and, consequently, incorporated less technology in their teaching.

5.2 Introduction

A recent study found that senior students in a 1:1 laptop environment performed significantly better in external standardised examinations than did those without laptops in both biology and physics (Crook, Sharma, & Wilson, 2015). The effect sizes (Cohen's *d*) of being schooled with 1:1 laptops in these subjects were 0.26 and 0.38, respectively. The substantially larger effect size in physics was an interesting result. Consequently, we determined to investigate why students in physics appear to be better able to leverage the opportunities afforded by a 1:1

laptop environment compared to students in biology. Additional questions included the following:

- What were the differences in the practices of the teachers and students in physics compared to those in biology?
- Are there any differences in the mandatory and recommended uses of technology in the respective curriculum documents?
- Can this difference be related to technology, pedagogy, and content knowledge (TPACK)?
- What implications would these answers have on the preservice training and professional development of science teachers?

5.3 Background

From 2008-2012, the Australian Government implemented a $2.1 billion 1:1 laptop initiative known as the Digital Education Revolution (DER) across the whole country (Digital Education Advisory Group, 2013). The objective of the DER was to create a 1:1 computer-to-student ratio for grades 9-12 in all secondary schools within 5 years. In recent years a variety of research has been undertaken to review the DER (Crook & Sharma, 2013; Crook et al., 2015; Crook, Sharma, Wilson, & Muller, 2013; Dandolopartners, 2013; Howard & Mozejko, 2013). However, of the studies we found, none thus far have examined the role of prescribed curriculum content in the uptake and integration of technology in class, nor have any incorporated the TPACK framework.

Across the state of New South Wales (NSW), Australia, all senior students (Grades 11 and 12) within particular subjects follow the same curriculum documents created and prescribed by the Board of Studies NSW (Board of Studies NSW, 2009b). These curriculum documents or syllabuses specify detailed content that should be taught, often recommending *how* the content should be taught and specifying what students should *learn* and *do*. At the end of Grade 12 all students sit for the statewide Higher School Certificate (HSC) external standardised examinations, which ultimately determine a student's overall score and eligibility for admission into various university degree programs (Universities Admissions Centre, 2009). The curriculum documents specify the precise content that is examined in these high-stakes examinations. Furthermore, the Board of Studies NSW provides standards packages to illustrate performance in different syllabus areas in relations to standards-based assessment (Board of Studies NSW, 2006).

This study focuses on seven high schools from the Catholic Education Office (CEO) Sydney, Southern Region, that were issued laptops for every Grade 9 student in 2008, as part of the first roll out of the DER. Consequently, this first cohort of students with 1:1 laptops graduated from Grade 12 in 2011 having sat for the external, standardised NSW HSC examinations. This study examines the 2011 Grade 12 physics and biology students and teachers from these seven schools to explore their integration of technology with the 1:1 laptops and uncover any notable differences.

A particular focus of our previous studies has been on the impact of the 1:1 laptop environment on teaching and learning in the sciences. These studies have concentrated on the practices of teachers and students and comparisons between them, the activities in which they engage in terms of higher- and lower-order thinking, and multiple regression analyses to determine whether being schooled in a 1:1 laptop environment offered any advantage in external standardised examinations (Crook & Sharma, 2013; Crook et al., 2015; Crook et al., 2013). Having determined *what* happens to student attainment in a 1:1 laptop environment in the previous studies, this study determined to find out *why*.

5.4 Review of the literature

Given the context of this study, we reviewed the literature around technology in teaching, particularly science teaching; 1:1 laptops in teaching, particularly science teaching; approaches to technology integration in science curricula; and TPACK.

5.4.1 Technology in science teaching

Technology has long been a part of science instruction, with science teachers often being considered innovators and leaders in the use of technology over many decades (McCrory, 2006). In more recent times the technologies used in science teaching have been specifically digital technologies, be they online resources, software, or physical computers and devices.

Some of the latest practices and research in teaching science have been around the use of tablets (such as iPads®; Miller, Krockover, & Doughty, 2013; Wilson, Goodman, Bradbury, & Gross, 2013). The use of technology in the classroom or laboratory has been shown to increase motivation and learning and offer new opportunities through various simulations (Khan, 2010; Quellmalz, Timms, Silberglitt, & Buckley, 2012; Wieman, Adams, & Perkins, 2008), and science software (Baggott la Velle, Wishart, McFarlane, Brawn, & John, 2007; Zheng, Warschauer, Hwang, & Collins, 2014). Similarly, students who are confident with basic information and communications technology (ICT) tasks have been found to have higher scientific literacy (Luu & Freeman, 2011).

Of course, no one is suggesting that science teaching should be conducted through technology alone. The best learning outcomes are obtained through a combination of real and virtual experiences (Olympiou & Zacharia, 2012), and evidence-based effective teaching practices should be followed (Bryan, 2006). New tools are also evolving that might change the landscape of science teaching, such as those that can automatically score students work, offering personalised guidance in science inquiry (Linn et al., 2014) and effecting instructional quality through their mediation of research-proven practices and classroom instruction (Weston & Bain, 2014).

To understand the role of technology in science attainment, researchers have examined ICT access and use in relation to international attainments in scientific literacy, as assessed by PISA (e Silva, 2014; Luu & Freeman, 2011). After controlling for demographic characteristics, use of technology was found to have a modest but consistently positive impact upon scientific literacy. However, Luu and Freeman (2011) pointed out that the ways in which students use computers in schools may have a stronger effect than how often computers are accessed, and e Silva (2014) said, "What we loose [sic] in these huge statistical studies is the detail. We need now to know what works and what does not work in each situation" (p. 6).

However, the detail in implementation of innovative technology tools by science teachers is very much dependent on their personal beliefs, motivations, and contexts regarding technology and science teaching as a whole (Kim, Hannafin, & Bryan, 2007; Stylianidou, Boohan, & Ogborn, 2005). In technologically enhanced environments, student-centered approaches have been demonstrated to be more effective than teacher-guided approaches (Hsu, 2008) and to facilitate significantly higher emotional engagement in the students (Wu & Huang, 2007).

A variety of literature exists specifically around the use of 1:1 laptops in science teaching. Within a middle school context, Yerrick and Johnson (2009) found that by inserting laptops and science technology tools in the classrooms of motivated science teachers, students found their teachers to be more effective, and the teachers themselves also reported renewed vigor in their teaching with improved scores on students' attainment.

In another middle school context, Berry and Wintle (2009) noted that students learning science with 1:1 laptops experienced increased engagement, comprehension, and retention of learning. Even though learning required more effort than traditional methods, it was more fun.

Zucker and Hug (2007, 2008) provided examples of ways 1:1 laptops can be used effectively to teach and learn high school physics at the Denver School of Science and Technology. They found that the physics teachers there made use of the many affordances of the digital technology, providing their students with high-quality tools to explore scientific concepts. Again in a middle school context, a quantitative analysis by Dunleavy and Heinecke (2008) showed significant positive effects of 1:1 laptop instruction on student achievement in science.

Along with our previous work, this study will provide some much-needed research documenting and analysing the use of 1:1 laptops in senior high school science beyond middle school. Our aim is to identify practices that are reported in classrooms where 1:1 laptop use is positively associated with higher attainment.

5.4.2 Technology in science curricula

An important part of this study is the embedding (or lack thereof) of technology in the recommended and mandatory activities in science curricula. Hennessy et al. (2007) highlighted that existing pedagogical approaches and thinking are limited by "the systemic subject culture of secondary science which imposes tight curriculum time constraints" (p. 147). In a similar contemporary vein, teachers have expressed concerns about the limited connections between curricula and game-based learning (Sadler, Romine, Stuart, & Merle-Johnson, 2013). Others have noted that the success of integrating new technology into education varies from curriculum to curriculum (Becta, 2003; Bingimlas, 2009).

Braund and Reiss (2006) argued that to create a more authentic science curriculum requires learning both in and out of school, particularly capitalising on virtual worlds through information technologies. In a recent study, 48 preservice science teachers were asked, "What does technology integration mean to you?" (Green, Chassereau, Kennedy, & Schriver, 2013, p. 397). The common misconception that emerged was that many teachers see technology integration as a tool in itself but do not see how that tool can enhance the curriculum; that is, some teachers use technology for the sake of using technology rather than understanding how it can improve teaching and learning.

The Board of Studies NSW prescribes syllabuses to be followed by all students within every subject. The syllabuses not only recommend and mandate activities that teachers should employ, including the integration of technology, but also specify what students should learn and, oftentimes, how they should learn it (Board of Studies NSW, 2009b). More recently, in preparation for the new Australian Curriculum, the national Australian Curriculum, Assessment and Reporting Authority (ACARA, 2011b) has prepared curriculum documents for K-10 specifying the integration of technology in every subject through the *ICT General Capability*. In NSW, the Board of Studies has adapted the ACARA material to create syllabuses for every subject, K-10, again including the *ICT General Capability* (Board of Studies NSW, 2012). However, in the interim and at the time of this study for Grades 11 and 12, in NSW students will still follow the Board of Studies NSW HSC syllabuses (Board of Studies NSW, 2009b).

Within this context of specific and detailed curricula, our study examines classroom practice with 1:1 laptops. To analyse the complexities involved we drew on the TPACK theoretical framework in order to examine the different aspects of classroom practice reported by students and teachers.

5.4.3 TPACK

Building on Shulman's (1986, 1987) construct of pedagogical content knowledge (PCK), Mishra and Koehler described technological knowledge as a domain of a more specific *technological* pedagogical content knowledge (Koehler & Mishra, 2009; Mishra & Koehler, 2006), which later became referred to as technology, pedagogy, and content knowledge, or TPACK (Thompson & Mishra, 2007). TPACK is a conceptual framework to describe the knowledge base teachers need to teach effectively with technology (see Figure 5.1).

Prior to Mishra and Koehler describing TPCK/TPACK, Niess (2005) described an adaptation of PCK she called "technology-enhanced PCK" (and also "technological pedagogical content knowledge"). In her study, Niess examined a teacher preparation program designed to empower science and mathematics teachers to integrate technology. Of the 22 teachers studied, 17 were science teachers of various disciplines.

The study "uncovered an important consideration in the development of TPCK—the interaction of the content of science/mathematics and the content of the specific technology…[however,] only some of the students recognised the interplay of technology and science" (p. 520).

In a study of 4 in-service secondary science teachers, researchers found that "contextual constraints such as availability of technology tools and characteristics of student population had large impacts on the teachers' development of TPACK" (Guzey & Roehrig, 2009, p. 40). In another study by the same authors looking at three beginning science teachers, they found that "intrinsic motivation in conjunction with beliefs and knowledge drives teachers to use educational technology tools in their teaching…[and] that reflection is critical for sustained technology use" (Guzey & Roehrig, 2012, p. 178).

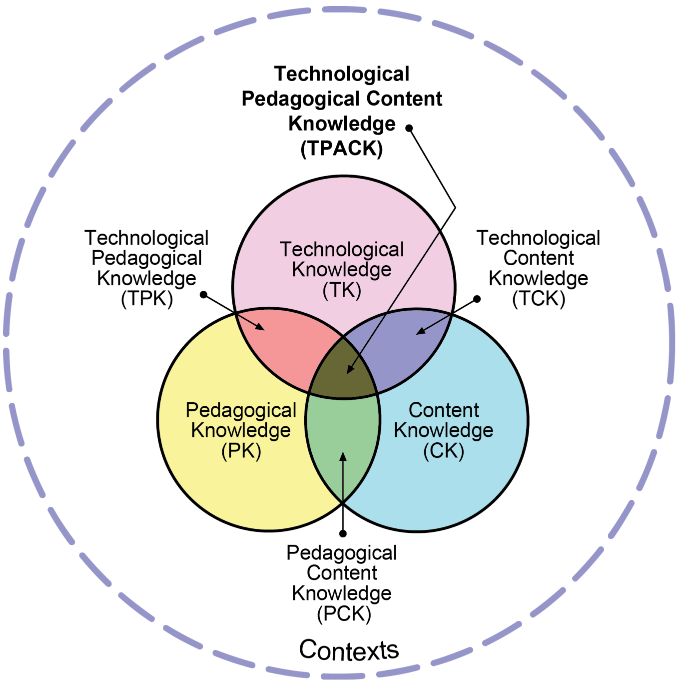

Figure 5.1: Technological pedagogical content knowledge (TPACK).
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In a case study of three preservice physics teachers, Srisawasdi (2012) recorded their respective transformation over time in PCK, technological content knowledge (TCK), technological pedagogical knowledge (TPK), and ultimately, their increased competence in TPACK. Srisawasdi was also noted that "competency of TPACK could directly impact on students' conceptual learning in physics" (p. 3243). In a study of 4 physics student teachers Alev and Yiğit (2011) found that they began with limited technological knowledge and insufficient pedagogical knowledge. However, through a process of reflection they developed transformative uses of technology through new pedagogical practices, that is, TPACK.

TPACK has also been used in the context of biology preservice teachers around using computer technology to support reforms-based science instruction (Schnittka & Bell, 2009). Recently, a study examined the development of TPACK in mathematics and science preservice special education teachers (Tournaki & Lyublinskaya, 2014). Focusing on three domains of knowledge related specifically to integrating instructional technology (i.e., TPK, TCK, and TPACK), they found significant gains with large effect sizes in teachers' knowledge in these domains due to the embedding of TPACK in their preservice course. A byproduct was a significant gain but moderate effect size in PCK.

The idea of TPACK is constantly evolving from its original PCK (Shulman, 1986) roots. Of potential use for science teachers (although yet to gain traction), Jimoyiannis (2010) took TPACK and an authentic learning approach in science to create technological pedagogical and science knowledge (TPASK); a new model for science teachers' professional development, essentially TPACK in science education (Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2013). It remains to be seen if TPASK is adopted and is of any benefit within science education.

Using TPACK as a theoretical framework, Khan (2010) examined how simulations were employed across 11 science topics in the science curriculum and enhanced conceptual understanding. Khan found that "special insights into an experienced science teacher's TPACK can reveal key heuristics and instructional patterns on effective classroom-based methods for teaching with technology" (p. 229). Using TPACK as a framework to investigate technology-enhanced scientific inquiry instruction in 27 preservice teachers, it was found that "integrating technologies such as digital images, simulations, spreadsheets, and probeware can help teachers engage their students in observational, correlational, and experimental inquiry investigations" (Maeng, Mulvey, Smetana, & Bell, 2013, p. 855).

TPACK has also been used recently as a framework in a 1:1 laptop environment, albeit in a social studies context. A recent study found that since "access to classroom technologies continues to become more ubiquitous, more novice teachers are going to be asked to teach in technology-rich environments, so it is imperative that they learn to think from a TPCK standpoint before entering the field as professionals" (Walker Beeson, Journell, & Ayers, 2014, p. 10).

Harris, Mishra, and Koehler (2009) highlighted the problems with the general approaches that dominate current and past technology integration efforts in teaching. They stated that "these approaches tend to initiate and organise their efforts according to the educational technologies being used, rather than students' learning needs relative to curriculum-based content standards, even when their titles and descriptions address technology integration directly" (p. 395). The solution they purport is TPACK: "a form of professional knowledge that technologically and pedagogically adept, curriculum-oriented teachers use when they teach" (p. 401). This work supports the use of TPACK as an organising framework to assure that technology, pedagogy and content are all included in the researcher's lens when exploring technology integration phenomena.

There are no references to TPACK within the Board of Studies NSW physics and biology syllabus documents examined in this study. This was to be expected since they were first written in 2002 and predate references to TPACK in the literature. However, with the advent of the new Australian Curriculum, there is a brief reference to TPCK by ACARA (2014), where it is stated, "Professional learning and resources that highlight suitable pedagogies, for example technological pedagogical content knowledge (TPCK) would be desirable" (p. 1). However, this occurrence is only within the curriculum area of *Digital Technologies* and not within the cross-curricula *ICT General Capability*. At the time of writing no references to TPCK/TPACK appear at all in the Board of Studies NSW materials for sciences.

5.5 Purpose of the study

In view of the extant literature, including our previous study which found that the effect size of 1:1 laptops on student attainment was greater in physics than biology, this study examined the technology uses of teachers and students in senior physics and biology in a 1:1 laptop environment and compared between these subject disciplines to provide some explanation for the greater effect size in physics. To inform this comparison we needed to consider the respective curriculum documents in terms of the integration of technology and present these findings within the framework of TPACK.

5.6 Research questions

1. Given that the effect size of the impact of 1:1 laptops on student attainment in NSW HSC physics was previously found to be significantly larger than that in biology, what are the differences in the teacher and student use of the laptops between the two subject disciplines?
2. Are there any differences in the opinions of the physics and biology teachers and students regarding the value and impact of the 1:1 laptops on their respective teaching and learning?
3. Are there any differences in the syllabus requirements for the integration of technology between the prescribed NSW HSC physics and biology curriculum documents? If so, how do these differences relate to differences in use identified in Questions 1 and 2?
4. Can any differences found in Questions 1, 2, and 3 be interpreted in terms of the TPACK framework?

5.7 Methods

Within this study we used a mixed-method approach to address the research questions sequentially:

1. A quantitative analysis of exit questionnaires for teachers and students to explore their self-reported integration of technology via 1:1 laptops in the teaching and learning of physics and/or biology.
2. A qualitative analysis of written comments from teachers and students from exit questionnaires regarding their perceived value and impact of 1:1 laptops on the teaching and learning of their subject.
3. A curriculum document analysis to identify mandatory and recommended inclusions for the integration of technology in the respective statewide prescribed physics and biology curriculum documents.
4. A mapping and interpretation exercise to frame any inclusions of the integration of technology in terms of TPACK found in teachers' and students' practices, in teachers' and students' perceptions, and in the curricula.

In 2011, in the 2 months prior to Grade 12 students sitting their statewide HSC examinations, we issued questionnaires to every Grade 12 student in physics (n = 113) and biology (n = 246), and every Grade 12 teacher in physics (n = 8) and biology (n = 13) from the seven schools in the CEO Sydney, Southern Region, with 1:1 laptops. The questionnaires (see Appendix A) were administered via Google Doc Forms (with the links sent via email) for ease, efficiency, security (then 128-bit encryption), anonymity, and the minimisation of errors due to transcription. The respective response rates to the questionnaires were 47% for physics students, 51% for biology students, 88% for physics teachers, and 77% for biology teachers. These response rates far exceeded the average response rate for email-administered online surveys of 24% (Kaplowitz, Hadlock, & Levine, 2004), but nevertheless, constrained the representativeness of the sample.

5.7.1 Sample

The Grade 12 physics and biology teachers and students were from seven comprehensive high schools in CEO Sydney of varying socioeconomic, gender, and grade profiles (see Table 5.1). However, these schools all had a similar technological profile, with every student having been provided with a laptop due to the DER. Similarly, each school provided all teachers with their own laptops. Table 5.1 presents the profiles of the seven schools and the two respondent groups for students and teachers in physics and biology.

Table 5.1: Profiles of Schools, Students, and Teachers

Group	Profile
Schools	There were 7 schools studied: 2 boys', 1 girls' and 4 coeducational schools; 5 were 7-12 schools and 2 were 11-12 senior schools; the schools ranged in socio-economic status from 980 to 1088[1]; the total number of respondent physics students ranged from 4 to 12 per school; the total number of respondent biology students ranged from 2 to 42 per school; the schools' average score for prior attainment ranged from 77.9 to 84.8[2]. Every school had 1 physics class and teacher, apart from one school with 2 classes and 2 teachers; and 1-3 biology classes with 1-3 biology teachers.
Physics students	There were *n*=53 respondent physics students from across all 7 of the schools studied. The range of prior attainment for the physics students was 77 to 96. 30% of the physics students were girls.
Biology students	There were *n*=125 respondent biology students from across all 7 of the schools studied. The range of prior attainment for the biology students was 58 to 96. 58% of the biology students were girls.
Physics teachers	There were *n*=7 respondent physics teachers from across all 7 of the schools studied. 43% (3/7) of physics teachers were female. Each teacher taught one physics class.
Biology teachers	There were *n*=10 respondent biology teachers from across all 7 of the schools studied. 60% (6/10) biology teachers were female. Each teacher taught one biology class.

[1]The school socio-economic status (SES) was obtained from the Index of Community Socio- Educational Advantage (ICSEA) 2011 as presented on the MySchool website (http://www.myschool.edu.au/).
[2]In grade 10 2009 every student sat for the statewide School Certificate (SC) Science standardised examination, with a score out of 100. This is used as a measure of prior attainment, demonstrating a high degree of correlation with later attainment in the senior sciences (Crook, Sharma & Wilson, 2015).

More students studied biology (n = 125) compared to physics (n = 53). Contributing to this ratio, in general, many more girls studied biology (58%) than studied physics (30%; Baram-Tsabari & Yarden, 2008), which is often because it is seen as a pathway to careers in healthcare (Fullarton, Walker, Ainley, & Hillman, 2003).

Only 9 students studied both physics and biology. However, these students were excluded because their experiences with technology in one subject likely influenced their experiences in the other. Hence, they were not considered in the physics or biology samples in this study. They were not considered separately as a whole group within this study due to the small sample size.

Regarding prior attainment, the range of School Certificate science scores for biology students (58-96) was much greater than that for physics students (77-96), with biology exhibiting a far longer tail. The mean Grade 10 school certificate score for biology was 82.6 (*SD* = 6.9) and for physics was 88.1 (*SD* = 5.1). With physics and biology students represented from every school, the sociodemographic variability across the schools was reflected in the respective physics and biology student samples.

Given the greater numbers of biology students, there was necessarily a greater number of biology teachers. As with the student profiles, there was a greater percentage of female biology teachers (60%) than female physics teachers (43%).

5.7.2 Procedure and Instruments

5.7.2.1 Use of laptops

The respective teacher and student questionnaires asked the same three type-of-use questions. From a tick-a-box list that included the options word processing, spreadsheets, presentation software, simulations, science software, electronic textbook, wikis, blogs, Internet research, learning management system (LMS), video editing, podcasting, databases, email, and data logging, every teacher and student was asked the following:

- From the list please select *ALL* activities/applications that you have been asked to use as part of your physics/biology studies?
- From the list please select *up to 3* activities/applications you *MOST ENJOY* doing as part of your physics/biology studies?
- From the list please select the *up to 3* activities/applications you use *MOST OFTEN* as part of your physics/biology studies?

The results for each population group were then tallied and compared using *explosion* charts (see 5.8 Results).

5.7.2.2 Qualitative analysis of comments

Within the questionnaire, teachers and students were each asked to write a comment regarding their perceptions of the value of studying their respective science with a 1:1 laptop. These written responses were analysed using inductive qualitative content analysis (Elo & Kyngäs, 2008) using NVivo.

5.7.2.3 Analysis of curricula

The curriculum documents followed by the physics and biology students were the respective Board of Studies NSW HSC syllabuses (2009a, 2009c), both originally written in 2002. The structures of the two curricula were examined with regard to the role of technology in the syllabuses. Similarly, both curriculum documents were analysed by inspection for inclusions regarding the integration of technology. The terms that were searched for were *technology/ies* (not including biotechnology), *computer* (not including the actual physics of computers), *digital* (not including the actual physics of digital), *word processing, spreadsheets, presentation software, simulations, science software, electronic textbook, wikis,* *blogs, Internet research, learning management system, video editing, podcasting, databases, email and data logging*. By these means the two curricula were compared and contrasted.

5.8 Results

The results are sequenced to present the teacher responses, followed by the student responses and finally the curriculum document analysis.

5.8.1 Teachers

The data gathered from the three questions on type of use of the 1:1 laptops were processed to create explosion charts to draw comparisons. Each explosion chart contains one sector per activity, with the radius representing the magnitude (i.e., percentage of respondents), as compared to a pie chart where the magnitude is represented by the angle. For the ease of the reader every activity has its own color; for example, simulations are red. The key is included with every chart, as it also presents the hierarchy in each case. Within every triplet of charts, the first chart always has a scale up to 100%, whereas the second and third charts only scale up to 80% to aid the reader, since no values exceeded 80% within the second and third charts.

5.8.1.1 Laptop use

A comparison of Figures 5.2a and 5.3a highlights the differences between all of the activities and applications that physics teachers reported using on their laptops, compared to those reported by their biology colleagues. One hundred percent of the physics teachers reported using simulations and electronic textbooks (100%); spreadsheets, presentation software, and Internet research were each individually reported by 86% of the physics teachers. On the other hand, the biology teachers' top three most-reported applications were word processing (100%), Internet research (100%) and simulations (90%).

Only 57% of physics teachers reported using their laptops for word processing compared to 100% of biology teachers, whereas 86% of physics teachers reported using spreadsheets compared to only 40% of biology teachers, and 71% of physics teachers reported using science software compared to only 20% of biology teachers. Spreadsheets and science software, engaged in by a far greater percentage of physics teachers, would be considered capable of facilitating higher-order activities, whereas word processing—engaged in by a far greater percentage of biology teachers—would be considered to enable lower order activities. The terms *higher-* and *lower-order activities* pertain to using higher- and lower-order thinking skills, as defined in Bloom's Digital Taxonomy, (Churches, 2009; Crook & Sharma, 2013).

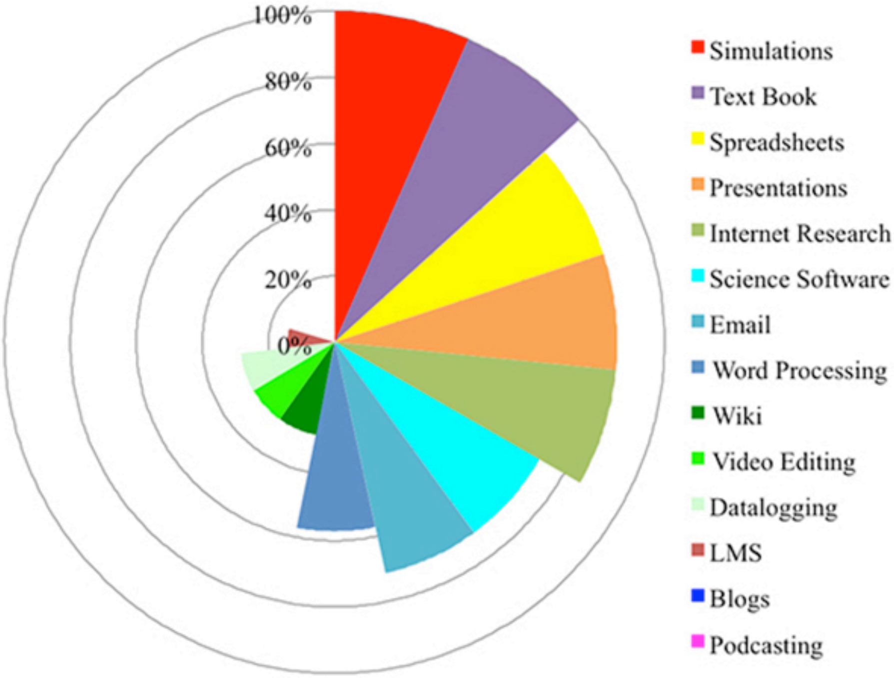

Figure 5.2a: All activities

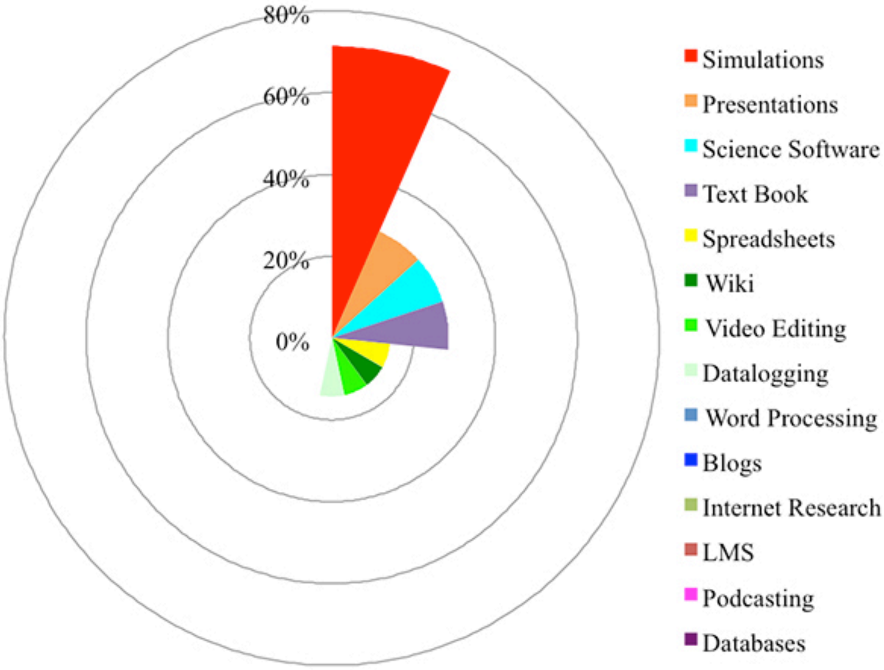

Figure 5.2b: Activities most enjoyed

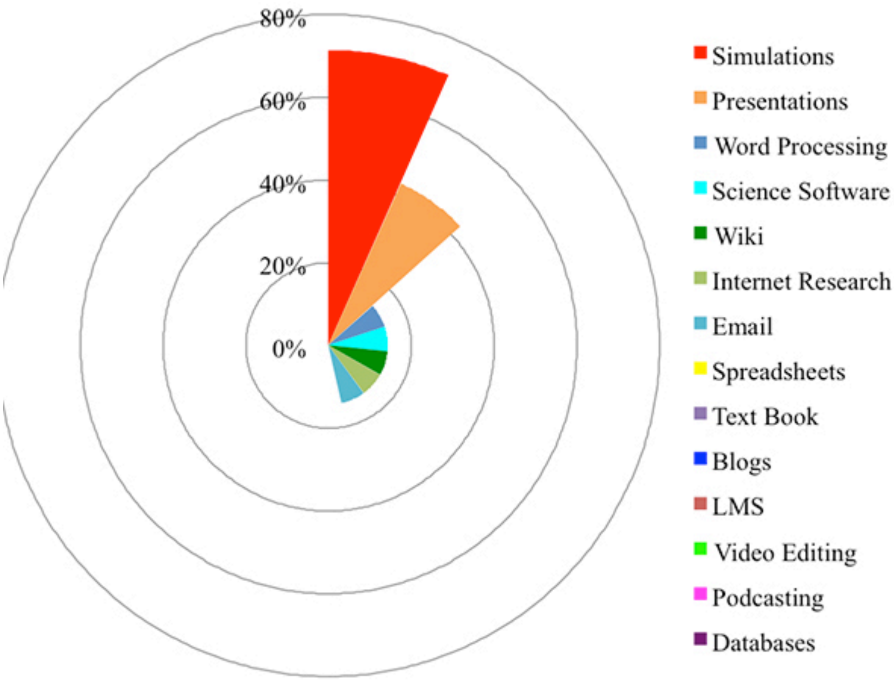

Figure 5.2c: Activities most often

Figure 5.2: Laptop activities engaged in by physics teachers

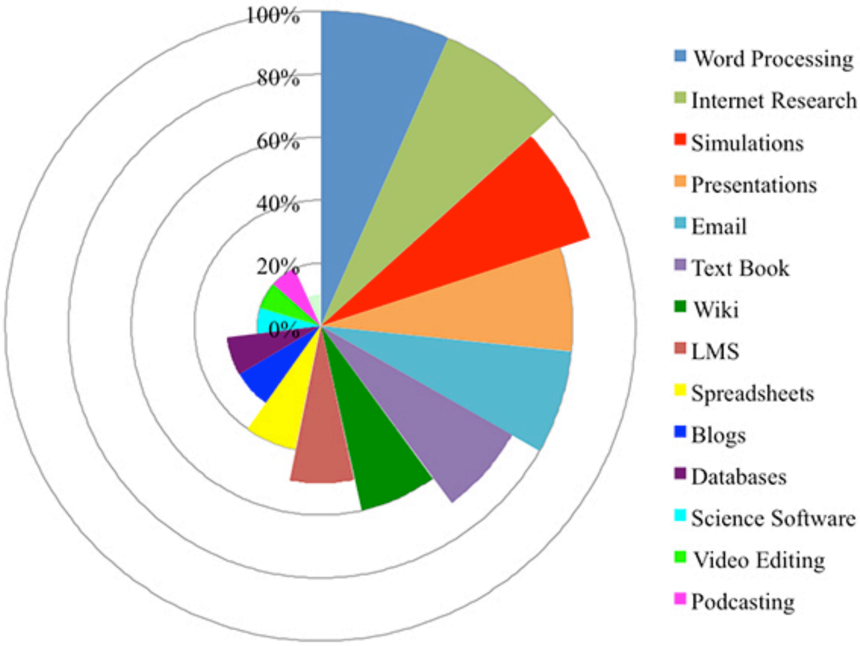

Figure 5.3a: All activities

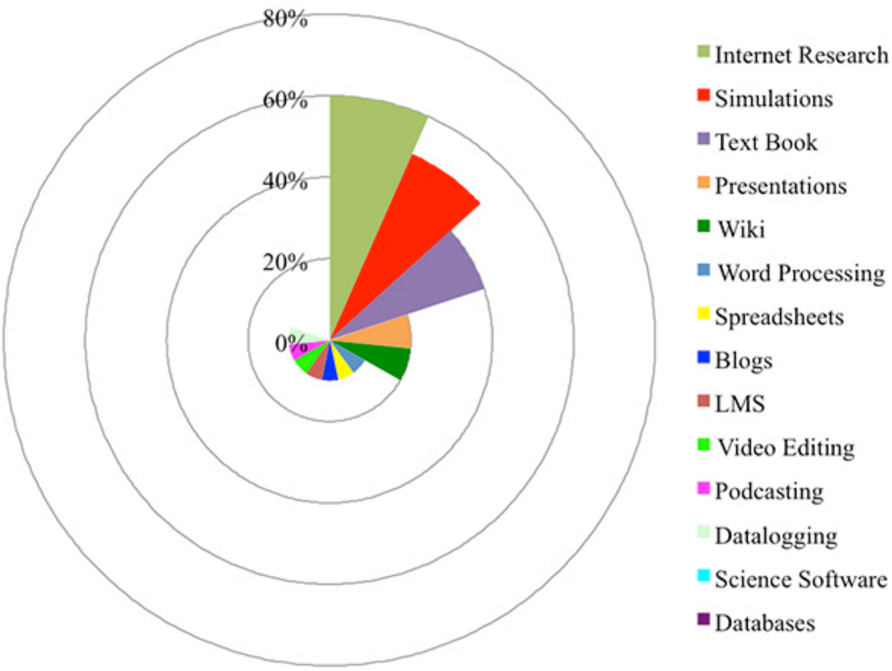

Figure 5.3b: Activities most enjoyed

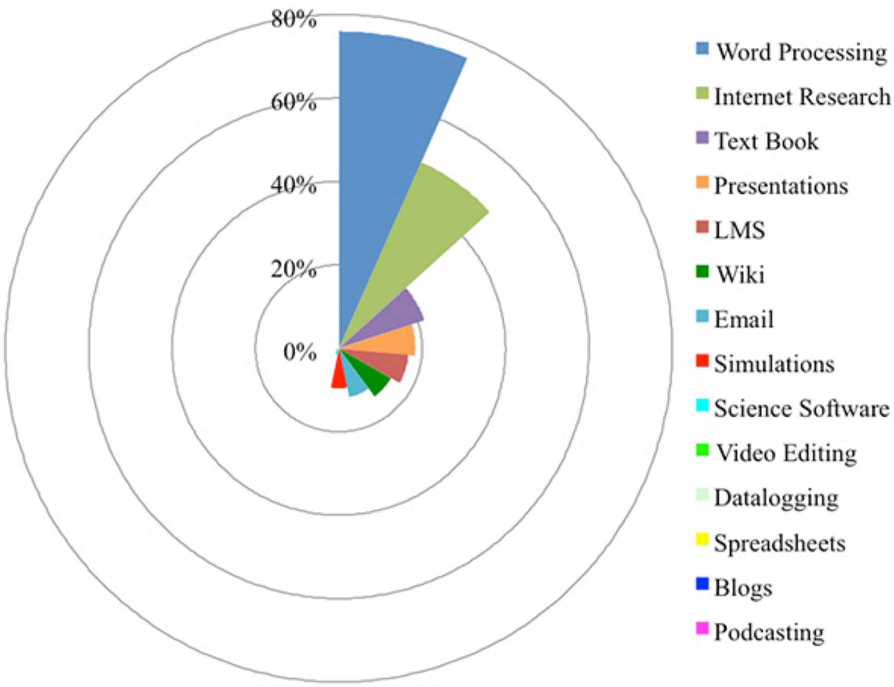

Figure 5.3c: Activities often

Figure 5.3: Laptop activities engaged in by biology teachers

5.8.1.2 Enjoyment

Figures 5.2b and 5.3b enable comparisons between the activities physics and biology teachers most enjoyed: The physics teachers most commonly reported enjoying simulations (71%); presentation software, science software, and electronic textbooks were each individually reported by 29% of physics teachers. The biology teachers reported most enjoying Internet research (60%), simulations (50%) and electronic textbooks (40%).

No physics teachers reported enjoying Internet research, while 60% of biology teachers did. However, 29% of physics teachers reported enjoying science software, compared to 0% of biology teachers; and 71% of physics teachers enjoyed simulations, compared to 50% of biology teachers.

Again, science software and simulations can enable higher-order activities thinking, whereas Internet research would be considered as enabling lower-order activities (Churches, 2009; Crook & Sharma, 2013).

5.8.1.3 Frequency of use

Figures 5.2c and 5.3c show which 1:1 laptop activities physics and biology teachers reported doing most often. Most often, physics teachers reported using simulations (71%), and presentation software (43%). In equal third place were word processing, science software, wikis, Internet research, and email (14%). Biology teachers reported most often using simulations (50%), Internet research (50%), and word processing (40%). The most sizeable differences between the two subject areas were Internet research (physics 14%, biology 50%), word processing (physics 14%, biology 40%), and presentation software (physics 43%, biology 20%).

Emergent trends observed included the following:

- Physics teachers reported use of simulations (discussed later) with the greatest frequency and also as the most enjoyable activity and the activity most often engaged in.
- Biology teachers reported Internet research with the first or second highest frequency for all three questions.
- When reporting on the activities most enjoyed and those engaged in most often, the physics teachers, as a whole, opted not to report about half of the activities each time. However, this is probably due to the smaller number of physics teachers ($n = 7$).

5.8.2 Students

Figures 5.4 and 5.5 present the reported data from the physics and biology students.

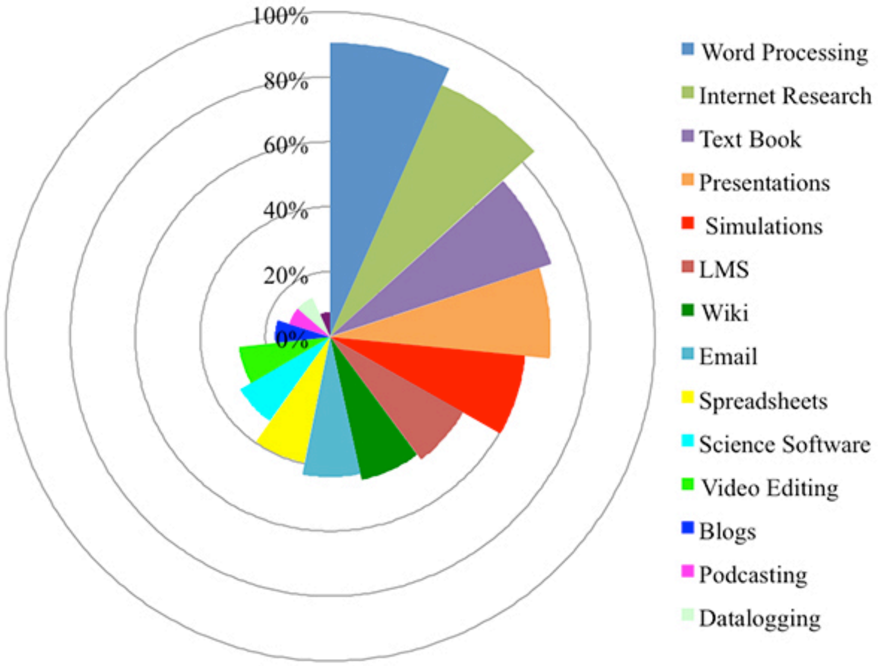

Figure 5.4a: All activities

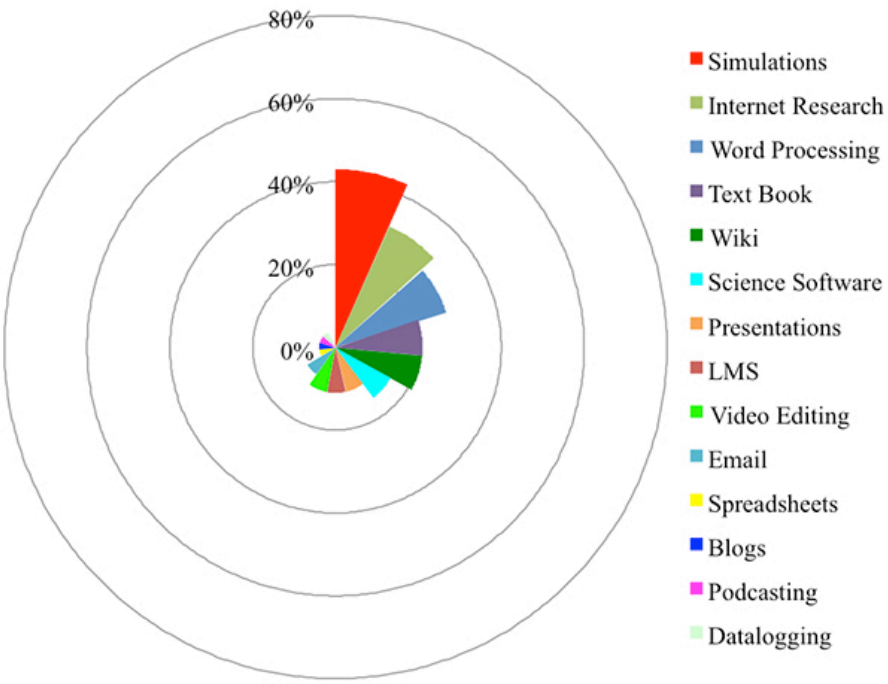

Figure 5.4b: Activities enjoyed

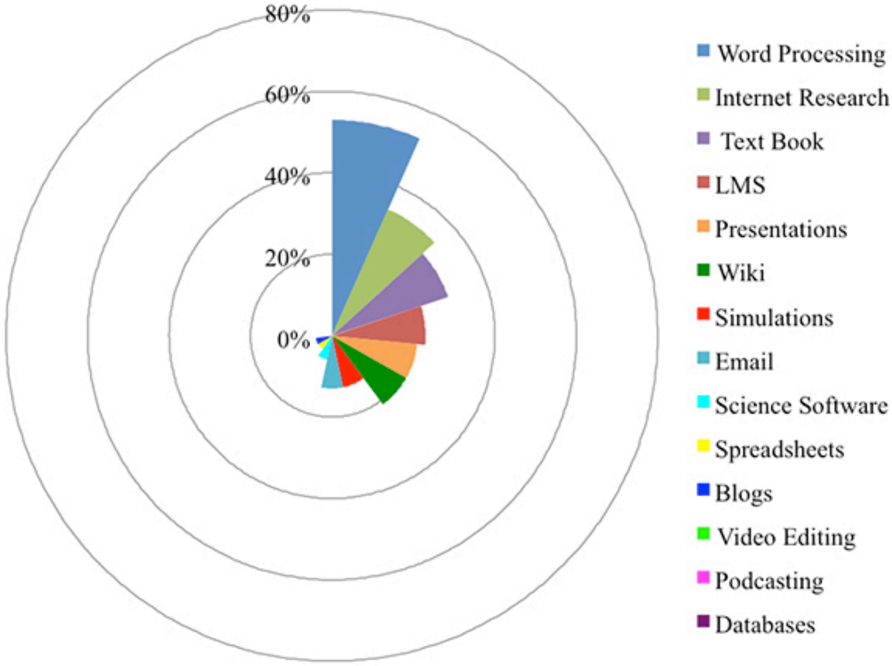

Figure 5.4c: Activities often

Figure 5.4: Laptop activities engaged in by physics students

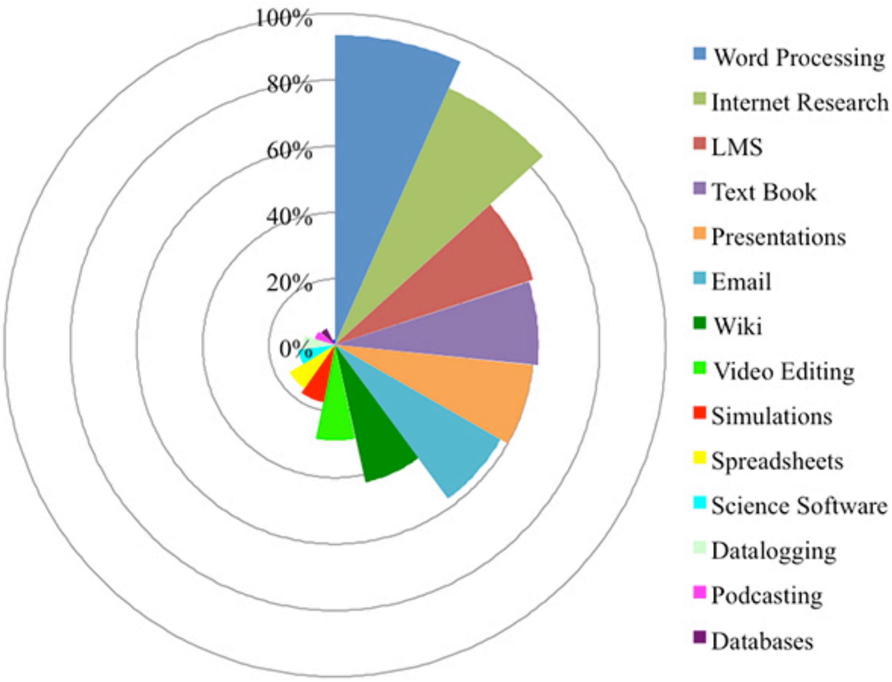

Figure 5.5a: All activities

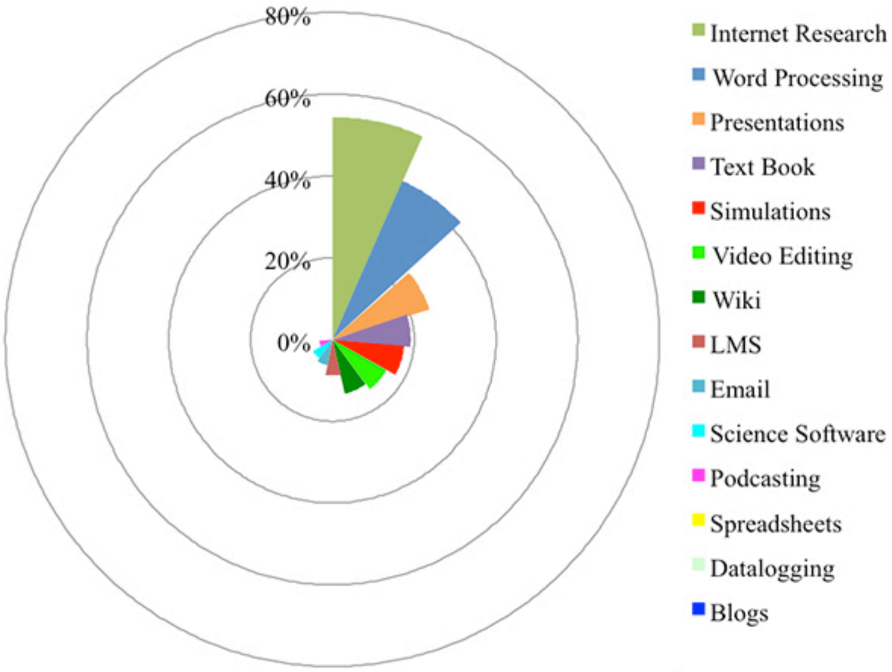

Figure 5.5b: Activities enjoyed

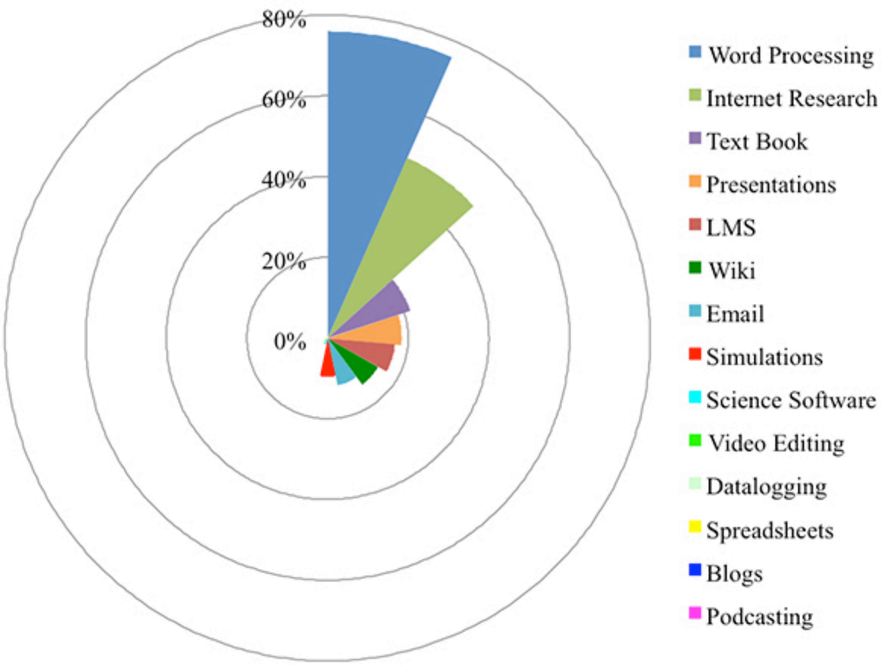

Figure 5.5c: Activities often

Figure 5.5: Laptop activities engaged in by biology students

5.8.2.1 Laptop use

Figures 5.4a and 5.5a compare all of the activities physics and biology students engaged in within their respective subjects with their laptops. Of all of the activities, the three most reported by physics students were word processing (91%), Internet research (85%) and electronic textbooks (72%). For biology students the three most-reported activities were word processing (94%), Internet research (85%), and the LMS (63%). The starkest differences between the two subjects were in relation to simulations (physics 60%, biology 18%), spreadsheets (physics 40%, biology 16%), and science software (physics 32%, biology 11%). (Compare the frequencies for simulations to the 10% average found by the Organisation for Economic Co-operation and Development [OECD], 2011). These results imply that a greater percentage of physics students engaged in higher-order technology integration in their learning than did the biology students.

Comparing between biology teachers and students (Figures 5.3a and 5.5a), it would appear that, although 90% of biology teachers reported using simulations in their teaching, a degree of misalignment is apparent (as also identified in Crook et al., 2013). Only 18% of biology students reported the same experience (Crook & Sharma, 2013).

5.8.2.2 Enjoyment

In terms of what the students most enjoyed, the top three activities in physics were simulations (43%), Internet research (32%), and word processing (28%). In biology it was Internet research (54%), word processing (42%), and presentation software (25%). The largest differences were in relation to simulations (physics 43%, biology 18%), Internet research (physics 32%, biology 54%), and word processing (physics 28%, biology 42%).

These data show that a greater percentage of physics students enjoyed the higher-order activity of simulations than did biology students, whereas many more biology students enjoyed the lower-order activities of Internet research and word processing than did physics students.

5.8.2.3 Frequency of use

An interesting overarching observation is what the students reported engaging in most often. Both physics and biology students reported most often engaging with word processing (physics 53%, biology 76%), Internet research (physics 34%, biology 49%), and electronic textbooks (physics 30%, biology 22%), in the same order. These are the same lower-order activities, in the exact same hierarchy as reported by Grade 10 science students from the same schools in 2010 (Crook & Sharma, 2013). On a day-to-day basis, word processing, Internet research, and electronic textbooks would appear to be the lower-order modus operandi for junior and senior science students.

5.8.3 Qualitative analysis of comments

Given the opportunity to write a comment within the questionnaire about using 1:1 laptops in their study of their science, the response rates among the actual respondents - physics teachers (2/7), biology teachers (3/10), physics students (11/53) and biology students (16/125) - were disappointing. Nevertheless, they were subject to inductive content analysis (Elo & Kyngäs, 2008).

Table 5.2: Terms in Student Comments

Hierarchy	Physics	+, 0, -	Biology	+, 0, -
1st	students	2, 6, 3	use	5, 1, 9
2nd	use	2, 4, 5	students	0, 2, 7
3rd	school	0, 2, 7	distraction	0, 0, 8
4th	teachers	2, 2, 4	learn	2, 0, 6
5th	way	0, 4, 3	education	1, 0, 5
6th	distraction	0, 1, 6	class	0, 1, 4
7th	motivation	1, 0, 4	affected	0, 0, 4

In Table 5.2 the terms most commonly referred to by the students are ranked and tallied in the positive, neutral, and negative manners in which they were used. Regarding the physics students who added comments, most terms were most often used negatively ("-" scored highest most often), with only two terms, *students* and *way*, most often used neutrally. With the biology students who contributed comments, all of the most common terms were most often used in a negative manner. Some typical comments included the following:

> *Laptops are quite possibly the worst thing to ever happen to schooling. They are a major distraction and they pose no benefits. All teachers want students to do podcasts and other technologically advanced presentation mediums. All teachers think that students love doing all this stuff but quite frankly it is pointless and boring. Either way students are going to hate doing assignments regardless of their form. Teachers also try to make students make use of [LMS] information but it is just a hassle and students would rather hand outs [sic] this way they can study off them and highlight appropriate things. [Physics student]*

> *Sometimes the laptop is an extrerme [sic] distraction and if everything is going negative for the class atmosphere it is always a big temptaion [sic] to simply play games or do anything other than the work that is recquired [sic]. [Biology student]*

It would appear from these limited comments that students believe the implementation of the 1:1 laptops to be detrimental to the study of senior physics and biology, although evidence indicates otherwise (Crook et al., 2015). Given the low response rate for comments, possibly only those students who had a complaint were the ones who commented. However, these comments should not be dismissed out of hand, since technology use can mold students' interest in science for better or for worse (OECD, 2010a). Sometimes students prefer not to use technology based on their personal interests and motivations (Beckman, Bennett, & Lockyer, 2014).

Two of the three biology teacher respondents commented on the challenges they faced when they were issued an Apple MacBook® after being used to a PC. Both physics teachers remarked on the laptops being enablers, allowing them to "use a wider set of tools" and that they "help if you need to show dangerous experiments or to provide other resources." Unlike the students, none of the physics or biology teachers mentioned laptops being distracting; for example, "People use Facebook a lot (but not me), it is very distracting for them." None of the teachers used strong adjectives, positive or negative, such as *very*, *major*, *a lot* or *extreme*; they were either neutral, softly positive, or softly negative, such as "the intrinsic motivation to achieve a personal best is independent of the use of technology" [Biology teacher].

5.8.4 Analysis of curricula

In analysing the respective physics and biology curriculum documents we discovered some stark findings. Both the physics and biology syllabuses had identical guidelines on the integration of technology in the *course structure, skills-conducting investigations, key competencies* and *domain Skills* (see Appendix C).

In fact, the domain Skills, that is, course outcomes including practical skills, were identical in physics and biology for both Preliminary (Grade 11) and HSC (Grade 12), with five inclusions for the integration of technology. Both syllabuses included the same emphasised generic statement in key competencies: "During investigations, students use appropriate information technologies and so develop the key competency of using technology" (Board of Studies NSW, 2009a, p. 18; 2009c, p. 17). Given these identical curriculum outlines the respective technological activities recommended or mandated to the physics and the biology teachers and students in the domain Knowledge and Understanding might have been nearly identical, albeit within their respective curriculum contexts. However, this was not the case at all.

Within the domain Knowledge and Understanding, the respective syllabuses specified what students *learn* and what they *do*. In the physics syllabus there were eight specific mentions of the use of technology: two mandating the use of simulations (along with data loggers and computer analysis in one instance); two suggesting the use of simulations; three suggesting a generic use of technology - for example, “alternate computer technology” (usually best achieved with simulations, such as replicating a cathode ray oscilloscope) - and one recommending data logging.

In biology, despite all of the references in the course outline, even mentioning data loggers, the syllabus made no specific mentions of the use of technology, even while specifying what students should learn and do. Given that both syllabuses were originally written at the same time in 2002 and the various technologies were already commonplace in the teaching of all science subjects, this finding raises questions around the consistency of the curricula and the syllabus writing.

5.9 Discussion

Teaching and learning have been found to benefit from the affordances offered by 1:1 laptops (and technology, in general) within some subjects more than others; for example, science over mathematics (Ainley, Eveleigh, Freeman, & O’Malley, 2010; Dunleavy & Heinecke, 2008) and physics over biology and chemistry (Crook et al., 2015). Within this paper we have established the differences in practices by physics and biology, as well as teachers and students, and unearthed contributory factors to these differences in the form of the respective curriculum requirements.

From the analysis of the uses of technology by the teachers and students in physics and biology, the biology teachers may not appear to have been engaging themselves or their students in the use of the 1:1 laptops in the classroom compared to physics teachers and students. However, it is quite apparent that the biology syllabus does not mandate or even recommend any specific uses of technology, whereas the physics syllabus does.

The physics syllabus specifies the use of simulations in student learning and, consequently, the physics teachers and students reported more use of simulations and similar technologies such as science software and spreadsheets than did their biology counterparts. Strictly speaking, the biology teachers engaging themselves and their students less with technology was not so much neglect on the part of the teachers but, arguably, a missed opportunity on the part of the biology curriculum writers. The biology teachers were merely doing what they were mandated to do regarding the use of technology, but probably with the conspicuous pressures of standardised external examinations, no more.

The specifying of simulations and data logging in the physics curriculum and the reports of more frequent use of simulations, spreadsheets, and science software by the physics teachers and students would entail a greater knowledge of how to use each of these technologies and when to use them. That is, the teachers would require a certain amount of TCK; that is, an understanding of how technology and content influence and constrain one another (Koehler & Mishra, 2009). Teachers would require science specific technology knowledge (Khan, 2010) to apply this with their students.

TCK is the overlap between technological knowledge and content knowledge (see Figure 5.1). "Teachers need to understand which specific technologies are best suited for addressing subject-matter learning in their domains and how the content dictates or perhaps even changes the technology—or vice versa" (Koehler & Mishra, 2009, p. 65). This TCK appears to be lacking in the self-reports of the biology teachers and students and, most definitely, in the biology curriculum document.

The findings in this study highlight several differences between teachers and students in regard to their reported use of 1:1 laptops in their respective sciences. This finding was particularly the case regarding the use of simulations in biology. It has been hypothesised that any such misalignment between teachers and students, implying a more teacher-centered classroom, could be counterproductive to student learning (Crook et al., 2013). "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).

As part of the $2.1 billion DER in Australia, all teachers, whatever curriculum specialism, are required to capitalise on the affordances 1:1 laptops offer for teaching and learning. Just because a curriculum syllabus does not mandate or recommend the use of technology does not mean teachers should opt out, particularly when students in their classes each have their own laptops. This imperative upon teachers has never been more acute as more and more schools move to a parent-funded bring-your-own-device model, as is the case across much of Australia since the end the federally funded DER (Digital Education Advisory Group, 2013). Detailed specification of technology within curriculum documents is unlikely to keep up with rapid technological developments, so relying on specification within curriculum documents to ensure appropriate integration of current technology within classrooms may be unreasonable.

Australian industry is currently bemoaning the lack of science and technology skills within the workforce, and there are calls for all levels of national policy and practice to address this need (Australian Industry Group, 2013). ICT is acknowledged within the national Australian

Curriculum as an across-curriculum general capability but, as seen here, subject/disciplinary variations and disparities exist between teachers' and students' views of how ICT is implemented in classrooms.

5.9.1 TPACK

Providing an interpretive framework, TPACK was used to make sense of the laptop use of the teachers and students and the technology inclusions found in the curriculum documents and to locate them within the various facets of TPACK. In other words, both the questionnaire responses of teachers and students and the curriculum documents were examined to see what elements of TPACK were evident. The physics curriculum document and consequent classroom practices incorporated far more TCK than did those in biology.

Koehler and Mishra said that "teachers need to master more than the subject matter they teach; they must also have a deep understanding of the manner in which the subject matter (or the kinds of representations that can be constructed) can be changed by the application of particular technologies" (Koehler & Mishra, 2009, p. 65). The physics curriculum document facilitated specific TCK and TPACK as a whole by articulating *what* and in some cases *how* technology can be used. However, the same cannot be said for the biology curriculum document. This delicate interplay between teaching practice and curriculum documentation cannot be understated.

5.9.2 Simulations

Simulations are a particular theme of the findings in this study. In the analysis of the curricula the use of simulations was an explicit difference between physics and biology. In the analysis of the teachers and students in physics and biology, differences also existed in the self-reported uses of simulations between the subjects and between the teachers and students. In a previous study most science teachers reported using simulations in their teaching, but far fewer students reported using simulations in their learning (Crook & Sharma, 2013). "Carefully developed and tested educational simulations can be engaging and effective. They encourage authentic and productive exploration of scientific phenomena, and provide credible animated models that usefully guide students' thinking" (Wieman et al., 2008, p. 683).

Opportunity exists to integrate simulations in science teaching (Khan, 2010), learning (Kay & Knaack, 2007), and assessments (Quellmalz et al., 2012). In a report from the OECD (2010b), one of the conclusions was that the use of simulations in science "highlights how technology can improve the teaching and learning process by enabling pedagogical approaches that are impossible or more difficult to facilitate without the use of technology" (p. 151). Examples would be using the Thomson experiment simulation on the Australian Multimedia for Physics Students website (http://www.hscphysics.edu.au/resource/template.swf) if one lacked the required equipment or skills to set up the equipment or using the simulation on the PhET website (http://phet.colorado.edu/en/simulation/mri) to manipulate the radio-frequency in an MRI scanner to cause the nuclei in brain tissue to resonate.

In the same vein, simulations empower teachers and students to engage in virtual experiments that would be too dangerous to do in real life (Guzey & Roehrig, 2012; Zucker & Hug, 2008); for example, manipulating control rods in a nuclear reactor, as simulated on the Scootle website (http://www.scootle.edu.au/ec/viewing/L48/index.html).

5.9.3 Professional development

For both preservice and practicing teachers, the professional development around the integration of technology in teaching science is of paramount importance, with amplified challenges due to the ever-evolving nature of technology (Guzey & Roehrig, 2012; Jimoyiannis, 2010).

The findings of this study reveal important lessons for preservice teacher training and the professional development of practicing teachers. Preservice and professional development for science teachers should include analysis of the TPACK framework, thereby making teachers more aware of the entire model and empowering them to be more balanced in their approach. Equally, preservice training and professional development should include an additional focus on TCK to assist teachers in their understanding of the references to the integration of technology in curriculum documents (e.g., junior science and senior biology), just as we have undertaken in this study.

Comparing curricula and understanding the differences can only empower future teachers. So, too, can an abstract understanding of the role of technology within teaching and learning. While ongoing development of specific technology skills will always remain a challenge, providing teachers with the TPACK framework with which they can reflect, analyse, and understand their own practice provides potential for long-term, self-driven, needs-based professional development.

In order for any professional development programs to have a significant impact on student science inquiry learning, they must be sustained over several years (3 to 5 to achieve the desired outcomes; Gerard, Varma, Corliss, & Linn, 2011; Towndrow & Wan, 2012). However, the development of teachers is not solely reliant on formal professional development. The same generic formal professional development around using 1:1 laptops with a class of students was made available to all teachers in this study as part of CEO Sydney Southern Region, plus some science-specific professional development around the use of data loggers, but no formal professional development around the integration of technology was available to the physics teachers but not to biology teachers.

Given the mandate from the curriculum documents, the physics teachers must have received greater preservice training or networked and taught themselves over time how to integrate technology into their teaching, relying on self-direction, collaboration, and metacognition. Subject/disciplinary skills and cultures may also have a role to play in the integration of technology within schools.

5.9.4 Limitations of the study

While drawing on the strengths of mixed methods, this study also had several limitations. Analysis of the qualitative comments was limited by the very low response rate and, accordingly, the content analysis also had limited scope. A deeper analysis could and should have been conducted had the response rate warranted it. These points are somewhat countered by the high student and teacher response rate in the technology checklist data and by the fact that we analysed the curriculum and syllabus documents to provide a fuller account of classroom practice.

5.9.5 Recommendations

We offer four recommendations:

- Curriculum writers should more consistently promote evidence-based effective TPACK in curriculum documents, particularly TCK, which is often lacking.
- Teachers, schools, and ultimately, school systems should move beyond the mandatory curriculum content and also capitalise on the opportunities afforded by a 1:1 laptop environment, such as engaging students in simulations for firsthand investigations.
- Preservice teacher training and teacher professional development should empower science teachers in the effective use of technology in the classroom to enrich scientific inquiry.
- Further research should examine TCK and TPACK as a whole in preservice teacher training and teacher professional development.

Capitalising on the potential of 1:1 laptops and technology, in general, not only to benefit students' learning in science but also to prepare students for the workforce and life (U.S.

Department of Education, 2010), needs to be reinforced in every way by curriculum documentation, preservice training, teacher professional development, and school and school district culture. However, given the rapidly changing nature of technology, up-to-date explicit documentation in curriculum documents may not be feasible. Statements of principle are needed in formal curricula and syllabuses, and these principles should be supported by other, more updateable, supporting documentation to ensure timely and consistent best practice.

TPACK holds potential for helping teachers develop understanding of how technology can be integrated into teaching and learning, regardless of the shifting technological capabilities and their required skills. We suggest two overarching mantra for all science teachers, whichever the subject discipline:

- It is in the best interest of science teachers to "focus on teaching approaches that yield high rates of student success and exploit learning technology" (Fraser et al., 2014, p. 2).
- Science teachers should not only "be able to use the latest tools and technologies with their students, but they also need to take advantage of the latest research on learning, pedagogies and practices" (OECD, 2014, p. 3).

5.10 Conclusion

Given the resources invested in digital technologies in schools, we set out to investigate if such technologies made a difference to student learning and how they were used. The answer to the former question was yes, although this result varied by subject (Crook et al., 2015). The answer to the latter is reported in this paper. Referring back to the original research questions (a) we have found that physics teachers and students engaged in more higher-order activities such as simulations, spreadsheets, and science software, compared to their biology counterparts; (b) although the students' comments perceived a negative impact and the teachers had less extreme views, the samples of respondents who commented were too small to draw any definitive conclusions; (c) fundamental differences exist between the physics and biology curriculum documents regarding mandates and recommendations around the use of technology, and these differences directly correlate with the differences found in the first research question; (d) the differences identified can be framed in terms of TPACK, with the physics curriculum and, consequently, the reported teaching and learning in physics containing more TCK.

Our perusal of curriculum documents suggests that technology may have been incorporated in an inconsistent, top-down manner. The findings of this study highlight the need to ensure that curricula embed and capitalise on the affordances offered by technology at all levels and in a systematic manner. The goal of researchers, teacher educators, and curriculum writers should be "to help teachers become aware of the full range of possible curriculum-based learning activity options and the different ways that digital and non-digital tools support each" (Harris et al., 2009, p. 411).

Locally in Australia, a unique opportunity to address this issue is provided within the new Australian Curriculum: Science. However, even though the *ICT General Capability* has been included in all of the curriculum documents so far released (science, mathematics, English and history), a disparity in the integration of technology already exists between these curricula (ACARA, 2011a; Board of Studies NSW, 2012). Given the recent consultations regarding the proposed directions for new senior science syllabuses (Board of Studies NSW, 2014), a consistent approach and collaboration must be fostered between the curriculum writers of each of the sciences. A considered and coherent, evidence-based approach to integrating technology into all curricula is necessary, since "excellent teaching can be enhanced with thoughtful consideration for the tools employed" (Yerrick & Johnson, 2009, p. 306). Schools and education systems need to be proactive in this regard. They cannot afford to treat technology as an optional toy on the side.

5.11 Author notes

This project has human ethics approval from CEO Sydney and The University of Sydney. We are extremely grateful for the support, participation and openness of the teachers and students of the participating schools; the cooperation and support of CEO Sydney and the constant support from the Sydney University Physics Education Research (SUPER) group. We acknowledge the commitment, time and expert advice provided by the journal editorial team in making this a better paper.

5.12 Additional material

Both as a standalone paper and within the context of this thesis, I chose in this chapter to use alternative graphical representations of frequency data to those used in Chapters 3 and 4 i.e. explosion charts over column graphs. The reason for this was twofold: (1) to provide a more eye-catching alternative to the mundane column graphs; and (2) to add to the use of innovative graphical representations within this thesis, along with the bubble graphs.

In my explosion charts within this chapter, sectors of differing radii are used to represent the corresponding frequencies of the 15 activities/applications. Accordingly, any differences are amplified for the reader with the area being directly proportional to the radius-squared i.e. frequency-squared, as compared to a column graph where the area is only directly proportional to the height or frequency (not squared). Arranging the frequencies, hence sectors, in order of magnitude, with colour coding as per the activity, striking and characteristic spiral effects are created for each explosion chart to help the reader interpret the relative frequencies and notice obvious differences between charts being compared.

To create the explosion charts I used Microsoft Excel to make radar charts with solid lines to each radial point. To generate any one sector, lines are created of the same radius fanning every degree over the angle for each sector. The following sector is made in the same way starting from where the previous sector finished and with its own radius. Essentially, every explosion chart is made of 360 lines; one for each of the 360 degrees of a circle. With 15 activities/applications, every sector fans 24 degrees i.e. is made up of a fan of 24 lines.

5.13 References

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Chapter 6
Teachers' transition into a 1:1 laptop environment: a longitudinal case study of four science teachers over 5 years

6.1 Abstract

This paper is the final in a multi-phase study exploring the impact of 1:1 laptops in Australian high schools since the Digital Education Revolution of 2008. The overall study tracked the deployment and use of the laptops in the sciences in 16 high schools, collecting various data over 5 years. We draw together the research data and report on additional in-depth qualitative follow-up interviews with four teachers specialising in different science disciplines who participated in every element of the overall study. Thus, we provide a rich description in the form of longitudinal case studies for these four teachers. Transformational shifts in teachers' confidence are evident; and there are substantial differences and changes over time in the ways laptops are used (e.g. spreadsheets, word processing, internet research and simulations). Many of the reported activities involve lower-order skills and thinking and thus present as lost opportunities for higher-order learning. However, the teachers' use is consistent with syllabus requirements which, except for Physics, provide little or no direction toward higher-order activities. A recurrent theme from teachers is that students are *digital natives*, more highly skilled than they are, who often make suggestions for activity resources and trouble-shooting. Thus, implementation of the laptops involved renegotiation of the power dynamics of the classroom and a shift in the teachers' role from traditional instructor to facilitator of independent learning. Further research is needed to examine these shifts which may well have far reaching ramifications for the future of education.

6.2 Introduction

This paper is the culmination of an extensive study into the ways 1:1 laptop computers are used by high school teachers and students in the sciences. The previous articles in this study have examined the similarities and differences between how science teachers and students perceived how they used their laptops (Crook, Sharma, Wilson & Muller, 2013); the types of uses in terms of lower- and higher-order activities (Crook & Sharma, 2013); quantitative analyses to evaluate the impact of 1:1 laptops on student attainment in the sciences (Crook, Sharma & Wilson, 2015a); and a curriculum analysis of science syllabuses and their technology requirements the help explain the quantitative findings (Crook, Sharma & Wilson, 2015b). Having previously used a mixed methods approach to analyse responses from science teachers and students, we now complete the narrative with a longitudinal case study approach examining four teachers who have participated in all elements of this study which saw the introduction of 1:1 laptops to grade 9 students and followed them through to grade 12. Peta was teaching senior high school physics, Cora chemistry, Ben biology and Sue was teaching senior school science for the period of the study using the newly acquired laptops. Within this paper we produce detailed case studies of these four science teachers; with analysis of in-depth interviews and questionnaire responses of the teachers and their students over a period of five years. With the saying "necessity is the mother of invention" in mind; we seek to explore the intended and unintended benefits and challenges of unexpected speedy and often unwelcome change – such as that instigated through the Australia's *Digital Education Revolution* (DER) which drove the introduction of the laptops. Our analysis focuses on the journey of the teachers through a period of rapid change with introduction and invigoration of ICT (information and communication technology) in schools as part of the DER and we report on: (1) teachers' feelings; (2) teachers' comments on changing practices; and (3) teachers' comments on the impact on students. We capture these teachers' creativity, resilience and reactions as they face challenges common throughout much of today's school education sector.

6.2.1 Teacher and student use of laptops

According to Abbott, Townsend, Johnston-Wilder and Reynolds (2009, p. 31), the potential of laptops is not obvious to every teacher (and consequently, not obvious to every student). In a study of Australian science teachers, Ainley and colleagues (2010) found they have relatively high levels of confidence in their capacity to use ICT compared to those of other countries. They also found that higher levels of ICT use are associated with higher self-efficacy, participation in professional development and a lack of perceived obstacles to ICT use within schools (Ainley, Eveleigh, Freeman & O'Malley, 2010). Using a multi-faceted approach to measure teachers' use of technology, Bebell, Russell and O'Dwyer (2004) demonstrated how complicated and varied technology use actually is in schools. Other studies have highlighted several factors, including the amount of professional development, time spent out-of-school hours and openness to change, which have the biggest impact on teachers' success in integrating technology in the classroom (Gerard, Varma, Corliss, & Linn, 2011; Higgins & Spitulnik, 2008; Klieger, Ben-Hur, & Bar-Yossef, 2010; Vannatta & Fordham, 2004). To enhance teacher use of laptops, school leadership must provide access to facilities, professional development, technical support, and organisational and administrative systems (Cowie, Jones, & Harlow, 2011).

Whilst laptops can add value to the teaching and learning process they can also create classroom management problems (Dunleavy, Dexter, & Heinecke, 2007) and can pose a big distraction to users and their fellow students (Fried, 2008). Research focusing on students' laptop use has found "school unrelated laptop utilization" can pull the attention of the student away from school related goals and result in lower academic satisfaction, semester grade point average, and performance relative to classmate; whereas, "school related laptop utilization", when the attention of the student is centred on school-related goals, is positively associated with academic satisfaction (Gaudreau, Miranda, & Gareau, 2014). Some research has highlighted the concept of "hard fun": with access to laptops, teachers have the capacity to offer their students activities that are both challenging and engaging (Berry & Wintle, 2009). Technologies which do not meet student-identified requirements may prove counter-productive or may simply be ignored (Edmunds, Thorpe, & Conole, 2012).

It has been demonstrated by numerous studies that teachers' own beliefs and attitudes about the relevance of technology to students' learning have the biggest impact on their success in integrating technology in the classroom (Ertmer, Ottenbreit-Leftwich, & York, 2006; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Inan & Lowther, 2010; Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010). It has been proposed that teachers' mindsets must change to include the idea that "teaching is not effective without the appropriate use of information and communication technologies (ICT) resources to facilitate student learning." (Ertmer & Ottenbreit-Leftwich, 2010, p. 255). By being more realistic with definitions of technology integration to more accurately represent practicing teachers' value beliefs, professional development can be better provided, increasing the chances of transfer to the classroom (Ottenbreit-Leftwich et al., 2010). More attention needs to be given to beliefs, attitudes, and confidence during pre-service teacher education, as these are perceived as being critical to later success in the classroom (Ertmer et al., 2006; Inan & Lowther, 2010).

Within Australia, the findings of the influential study by Ainley and colleagues (2010) confirmed that the use of ICT is greater when teachers have a higher level of or confidence in ICT, when teachers have participated in ICT-related professional development, and when there are fewer contextual obstacles (e.g. infrastructure, digital learning resources, access). Our study will examine these issues in detail in longitudinal case studies.

6.2.2 Longitudinal case studies

A small handful of studies have explored technology implementation using detailed longitudinal case studies such as that employed here. Over two years, Windschitl and Sahl (2002) used an ethnographic perspective to study how three middle school teachers learned to use technology in the context of a 1:1 laptop computer program. They found that 1:1 laptops were a catalyst that enabled a dissatisfied teacher, with teacher-centred practices, to transform her pedagogy to become more student-centred through collaborative student work and project-based learning.

In a later longitudinal case study over three semesters, Khan (2010) examined how an experienced science teacher taught chemistry with computer simulations and the impact on his teaching and students. Using classroom observations, teacher interviews and student surveys, Khan "revealed a pedagogy of teaching science with computer simulations" (Khan, 2010, p. 228). Khan found that by generating, evaluating, and modifying student ideas with the full integration of computer simulation technology, teachers were able to help students to "critically analyse a problem, make unobservable processes more explicit, and contribute to their science learning in ways that go beyond textbooks" (Khan, 2010, p. 228).

More recently, Zheng, Warschauer, Hwang and Collins (2014) performed a year-long, quasi-experimental study investigating the impact of the use of notebook computers and interactive science software in fifth-grade. Conducting classroom observations, teacher and student interviews and analysing examination scores, Zheng and colleagues found that "technology-facilitated science instruction is beneficial for improving at-risk students' science achievement, scaffolding students' scientific understanding, and strengthening students' motivation to pursue STEM-related careers" (Zheng et al., 2014, p. 591).

These studies illustrate the potential of in-depth qualitative data to contribute insights into the dynamics of technology implementation that may not have been anticipated, nor captured, by more structured quantitative data collection. The longitudinal aspect of the research, for example, is particularly useful in developing relationships and the rapport necessary to evoke full and frank accounts from the participating teachers and students. Thus as part of a larger project examining laptop use, we now draw together qualitative and quantitative data to make a further contribution to our understanding of technology implementation in schools.

6.3 Methods

In this five-year-long study, teachers and students participated in online surveys and gave permission for examination data to be used in investigating facets of the introduction of 1:1 laptops, results presented elsewhere (Crook, Sharma, Wilson & Muller, 2013; Crook & Sharma, 2013; Crook, Sharma & Wilson, 2015a, 2015b). The missing link was the trials and tribulations of the teachers which this paper presents. We posited a broad initial research question:

RQ1. What are science teacher's experiences of the implementation of the 1:1 laptops in schools?

In exploring this question in the case studies we used two more focused research questions to examine change and impact:

RQ2. How do teachers report on their change in laptop use and associated pedagogy, over the five-year period?
RQ3. What are teachers' perspectives on the impact of 1:1 laptops on overall student study habits and performance in the sciences?

For this study, we chose a mixed methods case study approach (Yin, 2012). First we sought teachers who had participated in all elements of the study as well as were teaching grade 9 to grade 12 science subjects during the period of this study. In Australia, most science teachers teach grades 7 to 10 science, which is compulsory for students, and specialise in one or more optional grade 11/12 subject. Teachers for this study were selected on the basis that they participated and provided complete data on all of the research phases of the overarching study and that they represented teachers in each of the four major science subjects taught in grade 12 (Physics, Chemistry, Biology and Senior Science (multidisciplinary)). We found four teachers who met our criteria and each was teaching a different science subject: Peta was teaching senior high school physics; Cora chemistry; Ben biology; and Sue was teaching Senior Science. These four teachers presented us with the four case studies which provide a rich and insightful description of the use of 1:1 laptops in high school science.

In this paper we use two data sources: first, questionnaires regarding 1:1 laptop use in science, completed by teachers and their students at different time intervals; and second, interviews with the teachers.

6.3.1 Questionnaires

In August and September 2010, 18 months after the students involved in this study had been issued with laptops (see Figure 6.1), the teachers were asked to complete online questionnaires. The online questionnaires were administered via *Google Doc Forms* for ease, efficiency, security (then 128-bit encryption, more recently 256-bit), and minimising any errors due to transcription. Similarly, in August and September 2012, prior to the students sitting their statewide external *Higher School Certificate* (HSC) examinations, the teachers were asked to again complete identical online questionnaire to allow for longitudinal study. An analysis of items on the questionnaire comparing student and teacher perceptions of practices using the 1:1 laptops can be found in the first paper of this study (Crook, Sharma, Wilson & Muller, 2013).

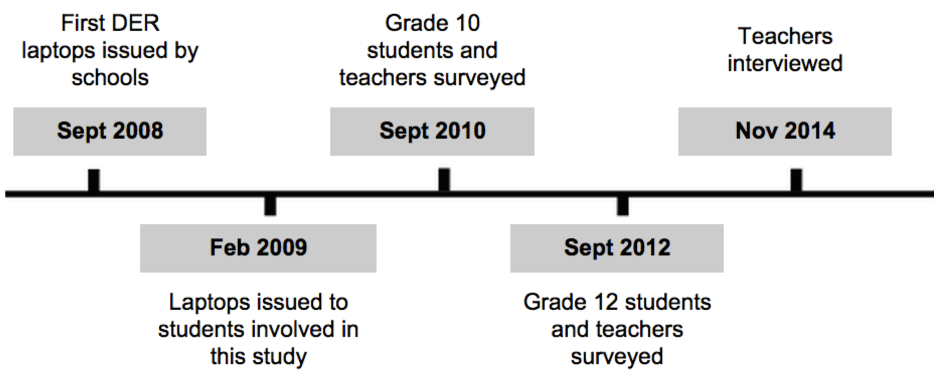

Figure 6.1: Timeline for this study

The survey items used in this paper were identical for the purpose of comparing teachers and students (see Appendix A) e.g.

Teacher (Q6): Which activities/applications do you utilise in your Science class?
Student (Q6): Which activities/applications do you utilise in your Science class?

The following list of activities/applications was provided for them to select using a tick-a-box list: word processing (e.g. Word, Pages); spreadsheets (e.g. Excel, Numbers); presentations (e.g. PowerPoint, Keynote); simulations; science software; textbook resources (e.g. CD, online). wikis/Nings/Google site; blogs; internet research; learning management system (MyClasses); video-editing (e.g. Windows Movie Maker, iMovie); podcasting (e.g. Audacity, Garageband); databases; email; data logging.

6.3.2 Interviews

Each of the four teachers was invited to a semi-structured interview to elaborate on their experiences of teaching science with 1:1 laptops and how that evolved for them over time. The interview questions were:

1. Thinking back to 2008, how did you feel <u>when you heard</u> that every grade 9 student was going to be issued with his or her own laptop?
2. How did you feel <u>when you were issued</u> with your own laptop? Can you remember how confident or not you felt about using a laptop yourself, and in your classroom, back then?
3. How confident do you feel <u>now</u> in using a laptop yourself, and in your classroom?
4. How has your teaching of grade 10 and grade 12 with laptops <u>changed over time</u>? How would you compare your teaching of grade 10 with grade 12 regarding the use of laptops?
5. Could you expand on your answers regarding <u>specific technologies</u> such as word processing, spreadsheets, presentations, simulations, science software, internet research, electronic textbooks, wikis, blogs, email, databases, data logging, video editing, podcasting and the LMS (learning management system)?
6. Why do you think there is a <u>difference to your approach</u> to integrating laptops in grade 10 and grade 12? How familiar are you with the syllabus requirements for the use of technology in grades 10 and 12 sciences?
7. Finally, how do you feel one-to-one laptops have <u>impacted on students'</u> study and overall performance in the sciences?

6.3.3 Analysis

For each teacher, from responses to *Teacher (Q6)* we obtained the ICT activities/applications the teacher had used in 2010 and in 2012 with a binary coding of Y representing yes, they did use it, and N if they did not use it. From responses to *Student (Q6)* we calculated the percentage of students from that teachers' class in that year who had indicated that they used the ICT activities/applications. Thus, we extracted whether or not the teacher had indicated that they used each ICT activity/application and the percentage of students from that class who reported using it in their class. These data are presented in Tables 6.2-6.6.

Interviews were subject to narrative analysis with the transcript data deconstructed and rearranged in temporal order, so that for each case verbatim data was organised with responses relating to a *pre-laptop period*; responses relating to *during laptop use*; and *post-implementation reflections*. In this way the data was organised to reflect each case's journey over the implementation of the laptops. Data was also sorted into a category *laptop issues* which included any comments on challenges. These categories were further sorted and coded according to a series of inductive codes, which emerged directly out of the transcripts. The emerging codes were: (1) *teachers' feelings*; (2) *comments on changing practice*; and (3) *comments on the impact of laptops on students*.

Table 6.1: References to Technology in Board of Studies NSW HSC Science Syllabuses

Section	Nature of reference to ICT
Course structure	Practical experiences should emphasise hands-on activities, including, … appropriate computer-based technologies, … internet and digital technologies, … computer simulations, … animation …
Skills –conducting investigations	… using a variety of technologies …
Key competencies	… using technology
Domain skills	... appropriate technology or strategy for data collection, … identifying technology, … employing appropriate technologies; including data loggers and sensors, … digital technologies and the Internet, computer assisted analysis
Domain knowledge and understanding	In Physics: Eight specific mentions of the use of technology: two mandating the use of simulations (along with data loggers and computer analysis in one instance); two suggesting the use of simulations; three suggesting a generic use of technology e.g. *alternate computer technology* (usually best achieved with simulations e.g. replicating a cathode ray oscilloscope); and one recommending data logging. In Chemistry: Four specific mentions of the use of technology: one mandating the use of computer-based technologies to perform a first-hand investigation; and three suggesting the use of simulations/digital technologies as possible secondary sources. In Biology: No mentions In Senior Science: No mentions

6.3.4 Comment on the syllabuses and professional development

Before we continue it is important to note the context in which the teachers were operating, in particular, the statewide syllabus documents teachers adhere to and professional development opportunities. Furthermore, an analysis of the curriculum document has potential to shed some light on the approaches and practices reported by the teachers in the case studies. Table 6.1

captures broadly the instances in the syllabuses (Board of Studies NSW, 2009) when ICT and its use is referred to.

While the senior syllabuses had identical guidelines on the integration of technology in the *course structure*, *skills-conducting investigations, key competencies* and *domain: skills* (see Table 6.1), only physics and chemistry had specific mentions in *domain: knowledge and understanding* (the mandated content and suggested activities) regarding the use of technology, particularly physics. The physics and chemistry requirements line up with higher-order thinking as outlined in the second paper of this study (Crook & Sharma, 2013).

The implementation of laptops was rapid and there were few subject related professional development opportunities. The schools participating in this study had generic opportunities presented to them and onsite help was available to schools. However, there was minimal professional development to help with integrating the laptops with consideration of any technological pedagogical content knowledge (TPACK) and certainly no explicit unpacking of TPACK (Crook, Sharma & Wilson, 2015b).

6.4 Results

The data relating to each teacher was compiled and is presented: firstly, with a summary table and discussion around the teachers' reported laptop use for lower-order thinking ICT activities/applications such as word processing and email (drawing on questionnaire data); and secondly, with a detailed description of each case study teacher. Each detailed description contains a brief glimpse of the teacher, their school and their networking. This is followed by a summary table and discussion around the teachers' reported laptop use of higher-order ICT activities/applications such as simulations and spreadsheets (drawing on questionnaire data), integrated with the teachers' reflections on the use of laptops over the full five years (drawing primarily on interview data).

6.4.1 Laptop use for lower-order thinking activities/applications

Table 6.2 displays six ICT activities/applications by teacher/class for activities which are generally linked with *lower-order thinking* (Crook & Sharma, 2013). The Y and N denote whether or not the teacher engaged in the activity with that class. The percentages are of the proportion of students within that teachers' class who reported engaging in those activities in their classes. These are *standard* ICT applications one would expect to be used, and indeed they are largely being used but to different extents. Amongst these four teachers, LMS is least popular while word processing is most popular.

Table 6.2: Six *lower-order thinking* activities/applications used by teacher (indicated by a Y for Yes used and a N for Not used) and percentage of students in class reporting the use of this activity/application.

Activity	Word processing	Electronic textbook	Internet research	Presentations	LMS	Email
Cora 2010	Y-100%	Y-42%	Y-83%	Y-17%	N-0%	Y-75%
Cora 2012	Y-95%	Y-74%	Y-74%	Y-21%	N-5%	Y-74%
Peta 2010	Y-100%	Y-79%	Y-96%	Y-83%	Y-42%	Y-42%
Peta 2012	Y-78%	Y-78%	Y-89%	Y-89%	N-0%	Y-78%
Sue 2010	Y-89%	N-44%	Y-78%	Y-67%	Y-56%	N-56%
Sue 2012	Y-100%	Y-58%	Y-84%	Y-58%	N-42%	Y-63%
Ben 2010	Y-85%	Y-85%	Y-100%	Y-23%	Y-62%	Y-15%
Ben 2012	Y-100%	Y-85%	Y-85%	Y-54%	N-46%	N-69%

Comparing across the four teachers and their classes, notable observations include that word processing, internet research and electronic textbooks are consistently reported highly amongst the four teachers' classes, both during grade 10 general science and later when they were well more settled into using laptops during grade 12 HSC sciences. Also, apart from Cora, we note an increase in the use of email. The use of LMS and presentations are more ad hoc with no clear patterns. These findings are consistent with a study of pre-service science teachers in Western Australia, where Dawson (2007) found that most frequent uses of ICT were word processing, Internet research, email, and presentations. The use of laptops for higher-order thinking is discussed in the detailed description for each teacher. Here we note what stands out for each teacher; summarising lower-order use for each teacher:

- Cora historically communicates via email and has not taken up LMS. She is not really into presentations. Her use of electronic textbook has increased.
- Peta historically has high use of presentations, in fact the highest. She was using LMS and has changed to communicating via emails.
- Sue is lowest with using an electronic textbook. Over time, Sue uses LMS less and email more but both changes are to small degrees.
- Ben has increased his use of presentations. He says he does not use LMS and emails but his students report that he does so.

In short, each teacher has their particular preferences and they do change their approaches and practices. We note there are instances of teachers saying they are not using activities/ applications and a proportion of their students saying they are. However, there are no cases of the reverse happening. The changes in these teachers' approaches and practices were different, possibly nuanced to their contexts, to be further explored in the case studies below.

6.4.2 Case descriptions

Analysis of all the teachers' responses to the interviews questions focuses on the categories that emerged: (1) teachers' feelings; (2) comments on changing practice; and (3) comments on the impact on students. These provided a framework for reporting the individual experiences of the case study teachers.

6.4.2.1 Chemistry: Cora

Cora is Singaporean-Australian female grade 10 science and grade 12 chemistry teacher in her fifties with 24 years' teaching experience. She teaches at a large 7-12 girls' school in a low-socioeconomic area of southwestern Sydney. In 2010, Cora taught a mixed-ability grade 10 science class. In 2012, Cora taught a mixed-ability grade 12 chemistry class. Cora has strong connections with her peers and actively works with other coordinators across disciplines in the local regional area. Cora considers herself a leader, taking ownership of her own professional learning and that of her colleagues.

Already a very experienced science teacher, Cora arrived at her school in 2010 as science coordinator (in the first year of our data collection). Having just moved from a high socioeconomic school to a low socioeconomic school she noticed a big difference between the schools in terms of technology. Cora said that her previous school had "really integrated technology" whereas her new school was "quite behind", where even though the teachers were each issued with a laptop "they never brought it to school". There was still a lot of angst that the school had moved from PC to Mac, and she "worried about the professional development of [herself] as a leader, and of the teachers". However, Cora emphasised that by 2014 this situation had very much changed.

Cora described herself as an early adopter having previously purchased her own laptop, prior to teachers receiving them at her last school, to familiarise herself and her colleagues ahead of time. As such, she felt "pretty confident" about using a laptop in 2010 although she had to relearn how to use a Mac. However, she was not so confident about teaching students with their own laptops, largely due to the unreliability at the time of the internet: "interactivity was very minimal because I always had to second guess when the internet was working". Internet connectivity was important for Cora. From Table 6.3 below we note that her students reporting use of wikis went from 0 in 2010 to 84% in 2012, the highest amongst the teachers.

Table 6.3: Nine *higher-order thinking* activities/applications used by Cora (Y/N) and percentage of students in class reporting this use.

Table 6.3a: The more science specific higher-order thinking activities/applications.

Activity	Spread sheets	Simulations	Science software	Databases	Data logging
Cora 2010	Y-17%	Y-8%	N-8%	N-0%	N-0%
Cora 2012	Y-32%	Y-5%	Y-11%	Y-0%	N-0%

Table 6.3b: Higher-order thinking activities/applications involving knowledge creation.

Activity	Wiki	Blogs	Video editing	Podcasting
Cora 2010	N-0%	N-8%	N-0%	N-8%
Cora 2012	Y-84%	N-11%	Y-5%	N-0%

In terms of teaching grade 10 science with 1:1 laptops, Cora described how in 2010 she mainly used her laptop for PowerPoint and preparing worksheets, however in 2014 she hosts all of the work online on Google Sites "where students can move ahead" i.e. allowing for self-paced differentiation. Her workload has increased substantially because the students "know that I access it, so communication both ways has increased so much that we are putting stuff up and constantly having to look at it". Cora reported a shift in communication, with "greater interactivity, collaboration … you know, kids used to wait until they talked to me, and now it's constant, we're talking things through, and they are talking with each other as well". Cora considers herself more "as a facilitator; it's not always teacher-centred ... the talking time to the class has reduced, the working time has increased". She put this change down to a combination of better wireless infrastructure over time plus a constant push by school leadership to integrate the laptops in teaching and learning.

Cora reported mixed feelings prior to the 1:1 implementation. Although she had high levels of confidence, she was worried about her own and others teachers' level of professional development support and was also concerned about technical issues like the shift to Mac. During implementation she reported a high level of excitement and commented that "our whole philosophy has changed". She felt that students were highly engaged with the technology and spurred her on. She maintains her enthusiasm but reports that her workload has increased e.g. through her own YouTube channel with supplementary materials and the increased level of communication with students.

Initially Cora noted that there were technology access barriers for students, but these resolved by the end of the study. She was less certain of the impact of the laptops on her grade 10 class than she was of her grade 11/12 chemistry classes. She reported that the technology made the grade 12 class "more accountable" (she was accessing students' personal work folders online to review their work) and enabled students to be more independent learners.

6.4.2.2 Physics: Peta

Peta is a Middle Eastern-Australian grade 10 science and grade 12 physics teacher in her forties. She works in a large girls' 7-12 school in a low-socioeconomic area of southwestern Sydney. In 2010, Peta taught the high-ability streams in grade 10 science and her students perform, on average, more than one standard deviation ahead of the others in the school. Peta has a well-established disciplinary network of colleagues in the science departments of other schools.

Peta had moved to the school just prior to the DER. Immediately she noticed a stronger focus on technology than her last school; and she expressed some trepidation "oh my god; I cannot teach with technology". She said she was happy to hear about the student 1:1 laptop initiative because it would give her a chance to orientate to the technology alongside the students, enabling her to "socialise with them through this particular technology, not only in the classroom but at home as well". However, initially Peta felt unconfident in employing the laptops pedagogically, she requested support for lessons using simulations. Her direct approach in asking for support helped her develop confidence and she rated herself as highly confident in the final phase of the research.

Table 6.4: Nine *higher-order thinking* activities/applications used by Peta (Y/N) and percentage of students in class reporting this use.

Table 6.4a: The more science specific higher-order thinking activities/applications.

Activity	Spread sheets	Simulations	Science software	Databases	Data logging
Peta 2010	Y-42%	Y-25%	Y-29%	N-8%	Y-8%
Peta 2012	Y-0%	Y-56%	Y-22%	Y-0%	N-0%

Table 6.4b: Higher-order thinking activities/applications involving knowledge creation.

Activity	Wiki	Blogs	Video editing	Podcasting
Peta 2010	Y-25%	N-4%	N-8%	Y-29%
Peta 2012	Y-78%	Y-11%	N-0%	Y-22%

For Peta, over two years her students reported a decreased use of word processing (100%→78%) and also the LMS (42%→0%) as per Table 6.2, a dramatic reduction in the use of spreadsheets (42%→0%), but large increases in the use of simulations (25%→56%), wikis (25%→78%) and email (42%→78%); "I asked them to …go to Wikispaces and start using the extra resources or additional secondary resources [the] app provided them". It is also interesting to note the increased use of email with older students. Interestingly, Peta is the only teacher, from the four who uses podcasting.

Peta teaches physics and there were eight specific mentions of the use of technology in the syllabus for grade 12 taught in 2012 as stated in Table 6.1. The syllabus has two instances mandating the use of simulations which Peta has adhered to and her students report use of simulations as well. However, Peta does not use data loggers even though there were instances requiring the use of data loggers or similar technologies. As with Cora, Peta reported that the laptops had enabled better communication with students outside of the classroom. In the interview Peta also described how her use of technology had diversified (using Mac, iPad; and Edmodo and Skype when she had to travel but still teach). She had a clear trajectory of growth in skills and confidence such that she "asked to be in charge of a group to help other teachers and students".

Peta did not think there was any direct impact of the technology upon her students' performance. She noted their high levels of skill with technology, but did not attribute this to school experiences. Rather she reports a shift in the power dynamics of the classroom (and beyond); where initially she wanted to maintain control she later came to understand that the technology enabled student independence and that she has to concede control to them and their superior skills in accessing and navigating the technology.

6.4.2.3 Senior Science: Sue

Sue is an Anglo-Celtic-Australian female teacher in her fifties. She had been teaching for 14 years at the time of the interviews and is a very proactive participant in the science teacher professional body. She was active in teacher networks statewide and nationally. Sue teaches in a large coeducational 7-12 school in a low-socioeconomic area of southwestern Sydney. In 2010, Sue taught a low-ability grade 10 science class and in 2012 she taught a mixed-ability grade 12 HSC Senior Science class.

Table 6.5: Nine *higher-order thinking* activities/applications used by Sue (Y/N) and percentage of students in class reporting this use.

Table 6.5a: The more science specific higher-order thinking activities/applications

Activity	Spread sheets	Simulations	Science software	Databases	Data logging
Sue 2010	Y-78%	N-22%	N-44%	Y-78%	N-11%
Sue 2012	N-42%	Y-16%	N-26%	N-0%	N-5%

Table 6.5b: Higher-order thinking activities/applications involving knowledge creation.

Activity	Wiki	Blogs	Video editing	Podcasting
Sue 2010	Y-78%	N-22%	N-22%	N-11%
Sue 2012	N-26%	N-16%	N-5%	N-0%

For Sue, over two years her students reported a decreased use of spreadsheets (78%→42%), science software (42%→26%), LMS (56%→42%) and video editing (22%→5%); a dramatic decrease in wikis (78%→26%) and databases (78%→0%); and an increase in the use of electronic textbooks (44%→58%). The highest reported laptop use for Sue is the 78% of students in 2010 that reported using databases. Even though databases were a mandatory part of the grade 10 science curriculum, very few teachers or students reported engaging with them as reported in previous research of the same district of schools (Crook & Sharma, 2013). However, perhaps due her role in the science teachers' professional body, she bucks this trend dramatically. Either way, databases did not feature at all in 2012. Sue reported an increased use of simulations by 2012 but the opposite was reported by her students.

Prior to the introduction of the laptops, Sue felt "a little bit apprehensive, but I did think that it could be valuable". She expressed mixed feelings in relation to monitoring and regulating laptop use in the classroom but enthusiasm and excitement at the resources available through the laptops. Sue considers herself computer savvy and had "no issue" with confidence when using technology. Reflecting on the change in her practice over the period, she commented that "teaching still needs conversations, you can't just read and hope to learn. There still needs to be a teacher to have a relationship. I think a lot of teachers just use them as substitution, a word processor; so they're not developing science skills, they just cram science content". She realised that for students the teacher "can really drive their motivation". Thus, Sue's comments reflected an adaption to the use of the laptop and technology tools, which acknowledged that central elements of the student-teacher relationship were unchanged, immutable.

Sue was positive in her estimation of the laptop effect upon her pupils. She believed that her low-ability grade 10 class had benefited from the learning around spreadsheet use and that, more broadly, the laptops provided "opportunities to model higher-order stuff and skills … I've taught Year 9s to annotate PowerPoint notes at the bottom; teaching them those skills."

6.4.2.4 Biology: Ben

Ben is an Anglo-Celtic-Australian, male, grade 10 science and grade 12 biology teacher in his mid-fifties with 33 years' teaching experience. Ben works in a large coeducational 7-12 school in a low-socioeconomic area of southwestern Sydney. Ben taught low-ability streamed grade 10 classes and mixed ability biology classes.

Over the two years Ben's students reported a decreased use in simulations (15%→0%), science software (23%→8%), wikis (31%→15%), internet research (100%→85%), and the LMS (62%→46%); but an increase in word processing (85%→100%), presentations (23%→54%), video editing (0%→15%), databases (0%→23%); and a dramatic increase in email (15%→69%) (see Table 6.2).

Table 6.6: Nine *higher-order thinking* activities/applications used by Ben (Y/N) and percentage of students in class reporting this use.

Table 6.6a: The more science specific higher-order thinking activities/applications

Activity	Spread sheets	Simulations	Science software	Databases	Data logging
Ben 2010	N-8%	N-15%	Y-23%	N-0%	N-0%
Ben 2012	N-15%	Y-0%	N-8%	N-23%	N-0%

Table 6.6b: Higher-order thinking activities/applications involving knowledge creation.

Activity	Wiki	Blogs	Video editing	Podcasting
Ben 2010	Y-31%	N-15%	N-0%	N-0%
Ben 2012	N-15%	N-8%	N-15%	N-0%

Ben reported never taking his laptop to class in 2010 but always doing so by 2012. This may go some way to explain some of the increased use of laptops in his class two years later.

At the outset, Ben reported being fairly confident regarding the laptop implementation, despite also saying "I was definitely not an expert in any way and I'm still not". Like some of the others, Ben's early expectations of what could be done with the laptops transformed substantially over the period: "I was expecting to use it as something on the side … now in real time I'm typing away and I Google; what I'm typing goes up on the screen and to the kids' laptops; I'm quite in awe of what it's doing". Similarly, he expressed awe at the students' capabilities with technology. He describes a particular class: "it was quite a low ability class and the first day they arrived with this thing [laptop] and they wanted to use it. It was clear that they were excited to use it and it was very much a matter of on the spot adapting to what was going on. That's how I felt about it. I had ideas before they walked in and they changed those ideas." He elaborated on using technology to motivate low-ability students and spoke of how he was also motivated to use the laptop because the students were excited about them. This enthusiasm from both students and their teacher was not based solely on novelty, as Ben reported ongoing enthusiasm for how the technology could help organise his students and his own work. For example, "it's quite amazing and they had it in their pocket and they could record video, they could put scales and …. they knew how to Bluetooth it. I'm still not an expert Bluetoothing."

6.5 Cross-case comparison and discussion

In this section, we present a comparison amongst the teachers for each of the research questions. We remind our readers, that while this is a study in which we probe teachers use of laptops, the study, being longitudinal, garners reflections as students go from grade 10 to grade 12 which culminates in a high stakes examination. During analysis we found that teachers' experiences (RQ1) are largely affected by this. From the analysis of the interview data, the shift in working with grade 10 to grade 12 students did not overshadow the reflections on use of ICT. The teachers focused on use of ICT even though the interview had two questions on experiences with grade 10 and 12 students - questions 4 and 6.

6.5.1 RQ1. What are science teacher's experiences of the implementation of the 1:1 laptops in schools?

From the survey data, we obtain a glimpse of the experiences of teachers and students via their self-reported use of ICT activities/applications in their classrooms. From Table 6.1 we see that, from amongst the standard ICT activities/applications associated with lower-order thinking, word processing and internet research are the only ones which all teachers indicate they use and more than 70% of their students say they use. While all teachers say that they use presentations, for Cora and Ben fewer percentages of students verify that they use them. In terms of communicating between teachers and students, interestingly, the use of LMS dwindles and none of the teachers say that they are using LMS in 2012. It should be noted that during this time the schools in question started to migrate from the incumbent LMS, MyClasses, to mostly Google Sites or wiki servers instead. Even amongst students, the use of LMS is reported as the lowest. Email appears to be more popular than LMS for communications. Ben is the only teacher who indicates that he does not use emails in 2012, but 69% of his students indicate that they do. We speculate that the increased use of emails with students implies increased out-of-classroom communication. We note that the 2010 data were about practices for and with grade 10 students and the 2012 with grade 12 students. Consequently, the increased maturity of the students in grade 12, and the massive importance to their futures of the HSC examinations, may account for the increase in email.

When considering ICT applications associated with higher-order thinking and science specific applications, we need to note that with the pressure of external examinations in 2012, teachers may not have been as adventurous. Peta is the most adventurous, using wikis, simulations, science software, podcasting and blogs, and her students report using these in their classrooms in both 2010 and 2012. Peta adheres to the use of simulations mandated in the syllabus, but not the use of data loggers. Cora uses spreadsheets and simulations in both years and has shown a dramatic increase in use of wikis. The sharp increase in the use of wikis (and the dramatic decrease in using a LMS) can be associated with her school acquiring wiki servers between 2010 and 2012; many schools invested in wiki servers to store and share materials remotely with students. Sue is reserved in that she indicates that she is not using ICT activities/applications but her students indicate that she is. In fact, from amongst the four teachers, she has the largest percentage of students reporting use of spreadsheets, science software, and data logging. Her students' use of these higher-order and science specific applications are impressive in 2010 and 2012. Ben is most reserved, but again we note the contradiction i.e. instances of Ben saying he did not use activities/applications but his students saying they did, for example with spreadsheets, simulations and databases. The percentage of Ben's students reporting using databases in the best amongst the teachers. There is the possibility that like Sue and Ben, as teachers get more accustomed to using ICT technology, it becomes more of their normal practice and they report not using it when they are. This may mask the level at which ICT has actually being embedded into the system; a direct consequence of forcing the implementation of ICT through the DER. Nevertheless, we note that adventurous teachers like Cora and Peta are exploring the cutting-edge novel applications, while reserved teachers like Sue and Ben are selective in using higher-order thinking and science specific applications.

Overall, the teachers were confident with laptop use, Sue was concerned about dynamics in the classroom. Ben expressed not being an expert, but was comfortable that he would be able to adjust. Cora was concerned about her colleagues and maintaining consistency in use, while Peta was looking forward to increased communications with students. All of the teachers noted student enthusiasm for the laptops and that this lifted their own motivation for their use.

What we see is that the use of laptops in different activities (e.g. spreadsheets, word processing, internet research and simulations) shows haphazard shifts over time and is substantially different between the case studies. This may be related to different curricular demands; the syllabus for physics is the only one stipulating use of simulations, while chemistry only suggesting their use and the other sciences making no suggestion of ICT use within knowledge and understanding contexts.

6.5.2 RQ2. How do teachers report their change in laptop use, and associated pedagogy, over the five years?

All teachers reported high levels of technical ability among their students. Notably, there were no reports of students struggling with the technology. Rather, the report of struggles and confidence related to teachers. Some of the teachers realised that the use of technology provided students with more independent learning opportunities. They reflected on the shift in power dynamics between the teacher and students that this necessitated. The teacher was no longer the sole provider of information, indeed students' access to information sources was now beyond teacher control; and some had to renegotiate their authority in terms of vetting information sources for the students. Others reported that students' technology expertise meant that they identified new sources of information and resources and provided these for the teacher and class. In essence, the control relates to a shift in teachers' and students' roles as illustrated in the following below.

Cora:

> *"They are more independent learners and they realise that it's important."*

Peta:

> *"To be honest at the beginning I resisted a little bit allowing students to be self-learners. At the moment I am more open to the idea that students actually can do it by themselves and I am guiding their learning."*

Sue:

> *"I've got these kids where I need them to be. They're understanding what learning is about."*

Ben:

> *"They [students] seem to be able to transfer the information; I was learning with them. I know that teaching is to learn with your students and be prepared to jump in areas where you don't know."*

Thus, most of them describe a transition from a teacher of material/content to a facilitator of independent learning (Story, 1985). Biesta notes this is a shift in educational philosophy which he describes as the "learnification" of education, with "redefinition of teaching as the facilitation of learning and of education as the provision of learning opportunities or learning experiences" (2009, p37). Only one teacher, Sue, commented on how the technology could be applied to promote higher-order thinking. For the others, their role as facilitators relates more to the development of skills. However, the literature suggests that some technologies, like simulations, are able to convey abstract concepts and help student to develop higher-order thinking (Huppert, Lomask, & Lazarowitz, 2002; Khan, 2010). This may also relate to the level of direction provided in each of the science subjects' curricula.

6.5.3 RQ3. What are teachers' perspectives on the impact of 1:1 laptops on overall student study habits and performances in the sciences?

Here we see divergent responses from teachers. Cora was not sure about impact on grade 10, but stated that laptops made grade 12 more accountable. Peta was not sure about impact of laptops beyond what was said above. Sue was positive and believed that her low-ability grade 10 class had benefited from the learning around spreadsheet use and that, more broadly, the laptops provided "opportunities to model higher-order stuff and skills. Ben spoke about impact beyond the classroom: "I encourage the kids to talk to parents, show them what you saw. Your parents probably want to know … show them what you did in science, show them the video."

Teacher's comments in relation to impact on students were surprisingly tempered, with few direct claims. What was evident was that they acknowledged the students' as digital natives with high levels of competencies in ICT. Some went as far as to admit these were more related to students' experiences beyond the classroom. Here again teachers described a reorientation of the education process, with a shift in power dynamics and re-invention of the teacher as a facilitator of thinking and learning.

6.6 Conclusion

In summary, these teachers have shared their trials and tribulations and have been on a steep learning journey with the rapid and ad hoc implementation of laptops in 2008 and 2009. They have adapted to the use of laptops and learnt from their students as well as with their students. Our findings show a transformation in teacher stances; varied use of laptops and teacher comments reflect a reorientation of the teacher-student relationship through the technology.

As students and teachers adapt to new technologies, they will continue to disrupt and transform many dimensions of educational processes and also in so doing challenge our conceptions of what education is and how it should best be done. This paper makes a contribution by providing detail on how these transformations are occurring at the classroom level. While embedded in a larger study, we examined only four cases and make no claims as to generalisability. Further research providing teachers' and students' first-hand accounts of technology transformations is needed if we are to optimise the benefits of technology in education.

It is interesting to note that, at a grass roots level, our case study teachers acknowledge the shifts in their work towards "facilitators of learning". However, there is no consensus as to how this might best happen and practice is varied. Technology is the product of higher-order creative thinking, but in classrooms it is frequently employed in lower-order thinking tasks. The use of laptops among our case study teachers is consistent with syllabus directives, yet research literature more highly values laptops' potential for evoking higher-order thinking through sophisticated science education software and simulations. There is potential to lift higher-order thinking through laptop use via teacher professional learning and revision of syllabus details. More importantly, there is a need for further research exploring how these shifts impact on classroom dynamics and student-teacher relationships, which undoubtedly have far reaching ramifications for the future of education.

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Chapter 7
Discussion: Lessons learned regarding using 1:1 laptops in the sciences

7.1 What are the implications of this research?

This research contributes to filling the void of quantitative research (Kposowa & Valdez, 2013) into the impact of technologies, particularly 1:1 laptops, on actual student attainment, particularly in an Australian context. Regarding 1:1 laptops specifically, this research demonstrates that, within the context of the schools studied, laptops can be beneficial to student learning and ultimately in attainment in standardised external examinations when used appropriately to provide new opportunities for higher-order learning to compliment other classroom instruction. The findings demonstrate that the laptops certainly were not detrimental or a distraction to learning. Regarding the Digital Education Revolution, this research contributes to filling the void of evaluating what ultimately became a $2.4 billion Australian Federal initiative (Australian National Audit Office, 2011), again, particularly with regard to quantitative research into actual student attainment.

In the first paper, Chapter 2, I investigated the level of alignment between teacher perceptions of student practices and students' self-reported practices with 1:1 laptops. In so doing, I devised the *Misalignment Index*. The intention was to see if this was a predictor of attainment in the multiple regression analyses to be performed in the third paper (Chapter 4). Upon performing the analyses, I found that the Misalignment Index had no statistically significant correlation in its current format. However, with refinement, the notion of misalignment could be investigated further using observational qualitative research methods, or generated quantitatively from more rigorous questionnaire data and/or other metrics.

The second paper, Chapter 3, found that the modal practice for students with 1:1 laptops is the lower-order paradigm of note-taking and working from textbooks through electronic means by word processing and electronic textbooks, plus simple online searching. This agrees with the extant literature and later findings in Chapter 5 and indicates an opportunity lost. Students enjoy engaging in higher-order activities. Most science teachers report using simulations but students do not report the same experience (another indicator of misalignment).

Chapter 4, the most important and far-reaching paper, found that, when 1:1 laptops are used to provide new relevant learning opportunities to students, the students achieved greater attainment in biology, chemistry and physics, particularly physics. Considering these findings, the observations of Chapter 3 are compounded further as an opportunity lost.

Chapter 5 provided some explanation for the greater positive correlation in physics over biology i.e. technological and pedagogical content knowledge plus the specified and recommended curriculum demands in physics and lack thereof in biology. With the syllabuses for all of the HSC sciences currently being rewritten (BOSTES, 2016), due consideration of this research should be taken by the curriculum writers to specify and make suggestions of utilising technologies where they have been demonstrated to benefit teaching and learning.

With its four case studies, the final paper, Chapter 6, demonstrated the diversity in practices and self-efficacies of teachers in how they incorporated the 1:1 laptops in their science classrooms over five years. Of particular interest were the reports of greater communication with students as they matured and as both teachers and students gained in expertise with the laptops; and the renegotiation of student and teacher roles in the classroom. The findings should provide further evidence for policy-makers, school districts and professional development providers as how to best target support for teachers to take full advantage of the affordances of 1:1 laptops as have been demonstrated in this thesis. In addition, this research will hopefully help influence education faculties in universities to better prepare preservice teachers for technologically-equipped classrooms (Jimoyiannis, 2010) and the benefits offered to teaching and learning when capitalising on the opportunities presented in utilising technologies such as 1:1 laptops. One of the strongest contributions of the fifth paper, and this thesis as whole, is its longitudinal nature over five years. Educational technology research, and for that matter physics education research, would benefit from more dedicated longitudinal studies.

This research has added to the impetus that educational research would greatly benefit from common practices in physics and science research by being more rigorous, quantitative, and also transparent by publishing the data for other researchers to scrutinise, thus corroborating (or contradicting) the published findings. As stated in *The Rise of Data in Education Systems*, "it was their work in science - agreeing measuring devices, conceptualizing systems, sharing data - that enabled [researchers] to work across borders, and influence educational governance" (Lawn, 2013, p. 21).

7.2 Transferability to recent and future educational technologies

The overall themes of this research i.e. self-reported use by teachers and students; alignment of teacher/student perceptions; higher-order applications; transparent quantitative analysis; targeted use of technologies providing new learning opportunities; curriculum analysis; and the evolution of teachers' beliefs and practices, should apply to all more recent and future educational technologies. The findings of this study could form part of the literature review (as has already happened (Haßler, Major, & Hennessy, 2016; Maxwell, 2015; Zheng, Warschauer, Lin, & Chang, 2016)) and basis for future research into recent and future technologies. Whether we are talking BYOD (Bring Your Own Device), iPads, augmented reality (e.g. Pokémon GO), virtual reality, robotics or even artificial intelligence and wearable technology (Johnson, Adams Becker, Estrada, & Freeman, 2016), research into the benefits or lack thereof of these various technologies could adopt some of the methodologies undertaken in this study.

Whilst Fullan stated that "the notion that having a laptop computer or hand-held device for every student will make her or him smarter is pedagogically vapid", he qualified this by saying *pedagogy* should "be in the driver's seat" (2010, p. 15). We have demonstrated that, when used appropriately, new technologies do not so much make students smarter than assist them in achieving higher attainment. However, the reality is, as had been demonstrated throughout this thesis, that traditional practices are often carried into the new technological paradigm, thus negating any new opportunities and perpetuating lower-order activities. Halverson and Smith captured this very well when they stated:

> *schools seemed to pick up on affordances that reinforced institutionalized priorities. Rather than opening up new opportunities to reframe how teachers teach and students learn, it seemed as though instructionalism bent technologies to extend existing pedagogical, curriculum delivery, and assessment practices (2009, p. 52).*

As well as some of the methodologies being transferable to research into other recent and future technologies, the key findings of this thesis are also applicable as bases for future research: especially that when technologies afford new teaching and learning opportunities and are used in such a manner, a measurable learning gain may well be expected.

7.3 Graphical representations incorporated

In the writing of the papers that make up this thesis, we decided upon some novel graphical representations of the data. In particular, we adopted *bubble graphs* in Chapter 2 and *explosion charts* in Chapter 5. The bubble graphs provide a means to display the distribution of students' responses to Likert scale questions and compare them with their teachers' responses to the same questions (see Figure 7.1).

The explosion charts, essentially radial histograms, provide an easy format, capitalising on the use of colour to compare charts with each other and the relative sizes of variables for different contexts. An example can be seen in Figure 7.2.

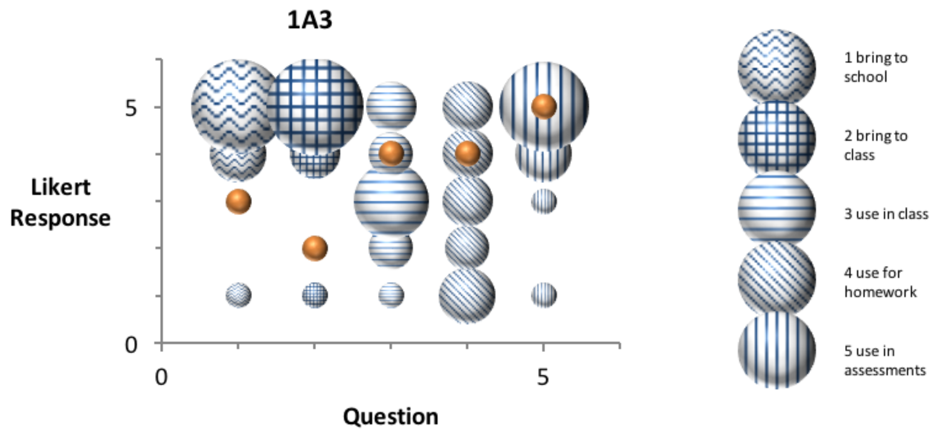

Figure 7.1: An example of a bubble graph

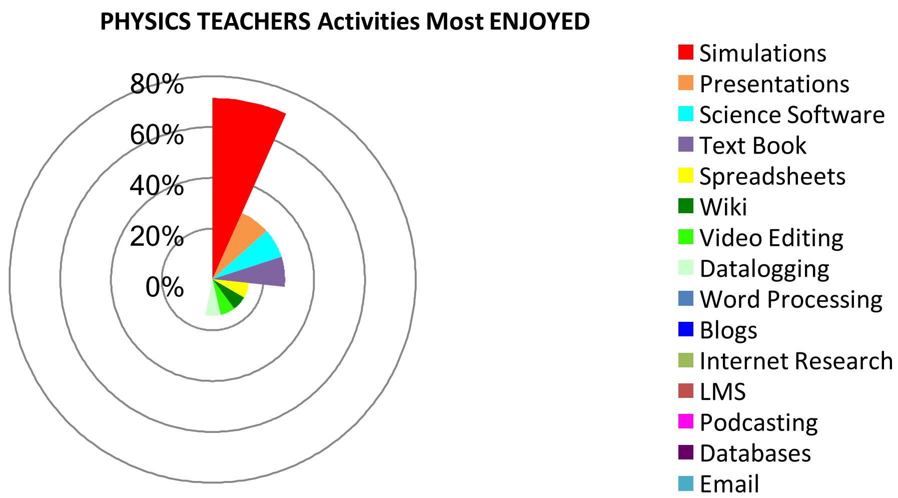

Figure 7.2: An example of an explosion chart

Again, these graphical representations could also be adopted in any future research.

7.4 Limitations of this research

There were several challenges with this research. With hindsight, we could have better designed the questionnaires and constructed them specifically to create a more robust metric for the *Misalignment Index*. However, this was not the main focus of this thesis, or even of the questionnaires. The Misalignment Index provided an interesting hypothesis and construct that ultimately did not work out, but the notion remains as something worth exploring further.

It should be noted that there are also natural limitations with observational and correlational research. Reliability and bias are always of concern in qualitative research methods. Any sense of bias and lack of reliability do not sit comfortably within the world of science (particularly physics) research, but are inevitable in physics education research. My research would be complemented by follow-up observations in classrooms, perhaps with video observation to verify patterns of use and thus improve reliability.

Whilst we were very happy with the statistical significance of our correlation coefficients in Chapter 5, the fit of our model was by no means perfect (and much weaker than is expected in physics research, but to be expected in physics education research). In fact, the fit of the model was particularly weak when looking at the chemistry cohort, hence its omission in the curriculum comparison in Chapter 6. This research would benefit with further refinement of the model with the identification of additional variables that could be measured e.g. a more robust Misalignment Index, to provide a better measure of fit overall.

7.5 A final comment on the Digital Education Revolution

Having ended in 2012, and with a change of Federal Governments, the Australian Digital Revolution (DER) endures an awkward legacy. Much of the literature and references used in the first two papers (Chapters 2 and 3) to outline the DER were hosted on the now defunct DEEWR (Department of Education, Employment and Workplace Relations) website (Department of Education and Training, 2013). Several of these were attributed to then Deputy Prime Minister (with responsibility for the Education portfolio) and future Prime Minister, Julia Gillard. As a consequence of the change of government in 2013, many of these references (DEEWR, 2008a, 2008b, 2008c; Gillard, 2008a, 2008b, 2009) have been simply erased from public record.

Of the few references still being made to the DER and its legacy, most are negative (Bita, 2016; Pandel, 2015) and attempt to link the DER to the recent generic findings by the OECD that "students who use computers very frequently at school do a lot worse in most learning outcomes" (OECD, 2015, p. 3). Whilst the OECD report presents an important overarching international comparative analysis of the digital skills that students have acquired, and the DER was at the very least inconsistent in its implementation and outcomes across sectors (Dandolopartners, 2013), those referencing the success or not of the DER would do well to cite quantitative research into the impact of the DER on student attainment obtained within an Australian schools context.

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Chapter 8
A personal odyssey

This PhD study has been a personal odyssey. Starting from relatively humble beginnings as a high school physics teacher, I was invited by the Sydney University Physics Education Research (SUPER) group to help create multimedia resources for HSC physics back in 2006. These resources, including the *Thomson's Experiment* simulation which I designed, were published two years later (Muller et al., 2008), just as I was starting a new career as *eLearning Adviser* for CEO Sydney. This was also the year that the Digital Education Revolution began and also the year I was offered postgraduate study at Sydney with the SUPER group. It was decided that I begin a part-time *Masters by Research* degree but with the full intention of upgrading to a part-time PhD after two years, thus allowing both parties a mutual get-out clause within the first two years. However, due to only being a temporary resident of Australia at the time, I had to wait until achieving my permanent residency status in 2010 to being my studies in July 2010. Fortunately, the intervening two years were not wasted. Firstly, my first son James was born in 2009. Secondly, even though I had not officially started, I was able to come up with my initial research questions, ideas for the flow of the thesis, decide upon the *thesis by publication* format, begin initial reading of the literature, and pave the way for immediate submission of Ethics to The University of Sydney and CEO Sydney. As a consequence, I began with considerable momentum.

With Ethics submitted and approved almost immediately by both The University of Sydney and CEO Sydney, I was able to survey 1245 students and 47 teachers within my first three months. This data was then analysed in two different and consecutive fashions to constitute the first two papers, Chapters 2 and 3. The paper for Chapter 2 was submitted to the *Australasian Journal of Educational Technology* (AJET) in 2012 and was accepted at the first attempt with minor modifications. We were over the moon with this immediate success in a journal well-respected internationally. The paper was published in 2013 (Crook, Sharma, Wilson, & Muller, 2013).

With a different emphasis and analysis, but drawing on data from the same surveys, the paper for Chapter 3 was also submitted in 2012. This paper was published in the *International Journal of Innovation in Science and Mathematics Education* (IJISME) hosted by the University of Sydney library, which had the dual advantage of us knowing we fitted the remit plus supporting this up-and-coming journal. Again, this paper was first published in 2013 (Crook & Sharma, 2013).

With two papers written and submitted in 2012, and one of them already accepted with minor amendments, we decided as originally intended to apply to upgrade my postgraduate degree to PhD. This upgrade was duly awarded, two years into the part-time study.

Also in 2012, my second son Patrick was born. Ever the opportunist, I was now able to read and study in the early hours whilst feeding and getting him back to sleep.

As previously mentioned, the most important paper, with its quantitative analysis of the unique dichotomous natural experiment, was always going to be the third paper, Chapter 4. Since we had agreed early on that a multiple regression analysis would be the analytical approach, in early 2011 I undertook two weeks of intensive summer school courses in multiple regression analysis using SPSS at ACSPRI (Australian Consortium for Social and Political Research Incorporated) at the Australian National University in Canberra. The knowledge and skills I picked up there were vital to help me analyse the 2011 examination data, which were released in early 2012, alongside the socio-demographic data. We realised early on that the results were very interesting and that this paper would be of great interest in both the world of academia and also Australian society at large. Consequently, we first submitted the initial draft to the esteemed journal *Science*. With only a 7% acceptance rate and very few articles pertaining to science education we knew it was a long shot. In the end, the paper was declined but with some very complimentary feedback and constructive suggestions. Building on the excellent advice from *Science* we improved the paper still further and submitted it to the high-ranking *International Journal of Science Education* (IJSE). This paper was accepted with minor amendments and published online in late 2014, appearing in print in early 2015 (Crook, Sharma, & Wilson, 2015b).

Combining the data used for the IJSE paper with the surveys issued to the same teachers and students, plus a curriculum analysis, we sought in the resulting fourth paper, Chapter 5, to provide explanations for the very interesting findings in the IJSE paper. This involved a mixed-methods approach with some basic quantitative analysis along with some qualitative analyses. To assist with the required qualitative analyses for the fourth and subsequent fifth papers, I fulfilled the rest of my instructed course requirement for the PhD (combined with the two courses already studied at ACSPRI) by completing the *Qualitative Research Methods* course at the Faculty of Education and Social Work at The University of Sydney. Since I had chosen TPACK as the theoretical framework for the fourth paper we submitted it to *Contemporary Issues in Technology and Teacher Education* (CITE Journal), the spiritual home of TPACK where it first appeared (Koehler & Mishra, 2009). It was accepted straight away with only very minor amendments in late 2014 and published mid-2015 (Crook, Sharma & Wilson, 2015a).

In late 2014, I conducted the interviews with the four science teachers that formed the case studies and basis for the fifth paper, Chapter 6. With the very efficient progress already made with having published 4 papers in under 5 years of a part-time PhD, we took our time in transcribing the interviews, analysing them and ultimately writing and submitting the fifth paper. At the time of writing, we are awaiting feedback from the journal for this paper (Crook, Sharma & Wilson, in review).

In the meantime, using the research, analytical and writing skills I have gained during my study, I decided to quit what was a very good career with CEO Sydney to start up my own company, *CrookED Science*. CrookED Science is a science and technology education consultancy working with primary and secondary schools and other organisations including universities (Crook, 2015b). Particularly with my work with secondary schools, I am now capitalising on my own research to best leverage 1:1 laptops and other technologies in the teaching and learning of HSC physics and the professional development of HSC physics teachers. In addition, I have also received several commissions to utilise my research and writing skills to help write papers for national and international educational journals, mostly around school and system improvement (Turkington & Crook, 2015).

8.1 Overall reception to my publications

My publications have been very well received, particularly the first (Chapter 2) and third (Chapter 4). At the time of writing, my first paper has been cited 17 times (including 5 self-citations) in everything from PhD theses (Jamil, 2015) and music education journals (Minott, 2015) to Australian educational research and policy documents (White, 2013).

The most important of my papers, Chapter 4, with its quantitative analyses, calculated correlation coefficients, significance and effect sizes, sparked a lot of interest in the national media with write ups in three national newspapers (Arlington, 2015a, 2015b; Ferrari, 2014), a radio interview (Crook, 2015a) and was featured in *The Conversation* (Crook, Sharma, & Wilson, 2015d), with a republication in a science teachers' association journal (Crook, Sharma, & Wilson, 2015c). Some of the initial findings from Chapter 5 were also included in these pieces.

At the time of writing, the third paper (Chapter 4) has been cited 6 times (five journals plus one thesis) including the highest ranked journal for education and educational research (Zheng, Warschauer, Lin, & Chang, 2016) and a leading journal in educational technology written by academics from Cambridge University (Haßler, Major, & Hennessy, 2016). As well as the positive general feedback received, the third paper has also been hailed for its transparency due to publishing its database alongside it (see Appendix B). This was very much appreciated by the journal IJSE and the reviewers. In fact, one of the many commenters on the synopsis published in The Conversation (Crook et al., 2015d) stated:

> *"Simon, I've only had a chance to skim your findings, but the fact you PUBLISHED YOUR DATA is just awesome! Your article is probably the most professional I have ever read in an Education journal, and I have never read an Education journal article which also publishes the data" (Brown, 2015).*

My reply stated that within the physics and science community it is far more commonplace to publish one's data, however, this is generally lacking in education. Hopefully this paper and thesis, with its crossover between physics and education, will continue the trend that education research can only benefit from more scientific rigour, quantitative analysis and transparency.

Whilst not public acclamation, during the peer review process of my fourth paper (Chapter 5) with the CITE Journal (Science), Reviewer #1 wrote:

> *"This is a beautifully written manuscript; it is the superlative piece of scholarship I have reviewed for the CITE Journal in my six years serving them as a reviewer".*

These reviews have been very flattering. It is thanks to such encouragement from academics unknown, as well as the support from my supervisors, research group, colleagues, family and friends, that I have been able to complete this thesis and abide by the motto of my beloved Everton Football Club:

Nil satis nisi optimum.

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Appendices

Appendix A – Teacher and student questionnaires

Appendix B – Anonymised database for Chapter 4 multiple regression analysis

Appendix C – References to Technology in Board of Studies NSW Physics and Biology Syllabuses

Appendix D – Relevant human ethics forms

Appendix A – Teacher and student questionnaires

Listed below are the questionnaires used during this study. Copies of each are included in the following pages:

i. Year 10 Teacher Questionnaire
ii. Year 10 Student Questionnaire
iii. Year 12 Teacher Questionnaire
iv. Year 12 Student Questionnaire

i. Year 10 Teacher Questionnaire

Edit this form

Y10 Teacher Response Survey

Please fill out this survey to assist with my postgraduate studies around the impact of student laptops in Science. It should take about 10 minutes. Your identity will be anonymised upon receipt. Your responses will not be shared with your Principal or the CEO. Any future academic publishing of data will retain the anonymity of students, teachers and schools.

S Crook, Student Researcher, University of Sydney

*Required

Surname *

School *

Name, Suburb e.g. DLS Cronulla

Gender *

- ○ male
- ○ female

What type of laptop have you been issued with? *

- ○ Mac
- ○ PC

How familiar were you with this type of laptop prior to receiving it?

	1	2	3	4	5	
Not at all familiar	○	○	○	○	○	Very familiar

How often do you bring your laptop to School? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you bring your laptop to your Year 10 Science class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop in this Science class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you require your students to use their laptop in this Science class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you require your students to use their laptop for Science homework? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you do you require your students to use their laptop in Science assessments? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

Which activities/applications do you utilise with this class as part of your Science teaching? *

Tick all applicable boxes

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ MyClasses

- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you utilise with this class as part of your Science teaching

Which activities/applications do you MOST ENJOY using with this class as part of your Science teaching? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ MyClasses
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you enjoy using with this class in Science

Which activities/applications do you utilise MOST OFTEN with this class as part of your Science teaching? *

Please tick up to 3 boxes maximum

- [ ] Word Processing (e.g. Word, Pages)
- [ ] Spreadsheets (e.g. Excel, Numbers)
- [ ] Presentations (e.g. Powerpoint, Keynote)
- [ ] Simulations
- [ ] Science software
- [ ] Text Book resources (e.g. CD, online)
- [ ] Wikis/Nings/Class Website
- [ ] Blogs
- [ ] Internet Research
- [ ] MyClasses
- [ ] Video Editing (e.g. Windows Movie Maker, iMovie)
- [ ] Podcasting (e.g. Audacity, Garageband)
- [ ] Databases
- [ ] Email
- [ ] Datalogging
- [ ] Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you utilise most often as part of your Science teaching

Overall for this class, how do you think having a laptop in Science has affected the students' motivation to work in Science? *

1 2 3 4 5

Decreased it a lot ○ ○ ○ ○ ○ Increased it a lot

Overall for this class, how do you think having a laptop in Science has affected the students' performance in Science? *

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

How would you rate your own computer skills prior to you being issued with a staff laptop? *

	1	2	3	4	5	
Total Novice	○	○	○	○	○	Expert

How much PD have you received around the use of your staff laptop? *

- ○ None at all
- ○ 1-2 hours
- ○ ½ day
- ○ 1 day
- ○ 2 days or more

How much PD have you received around students' use of laptops in the classroom? *

- ○ None at all
- ○ 1-2 hours
- ○ ½ day
- ○ 1 day
- ○ 2 days or more

How many years experience of teaching with 1-to-1 laptops do you have? *

- ○ 0-1
- ○ 1-2
- ○ 2-3
- ○ 3-4
- ○ 4+

How would you rate your own computer skills now? *

	1	2	3	4	5	
Total Novice	○	○	○	○	○	Expert

Any other comments or observations

(Optional)

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS SURVEY

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ii. Year 10 Student Questionnaire

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Year 10 Student Response Survey

Please fill out this survey to assist me with my postgraduate studies around the impact of student laptops in Science. It should take about 10 minutes. Your identity will be anonymised upon receipt.

S Crook, Student Researcher, University of Sydney

*Required

Surname, First Name *

e.g. Einstein, Albert

School *

Name, Suburb e.g. DLS Cronulla

Gender *

- ○ male
- ○ female

Science Teacher's Surname *

If you have more than one teacher for the same class please write both names

Do you have access to the internet at home *

- ○ Yes
- ○ No

Do you have access to a computer other than your school laptop at home? *

- ○ Yes
- ○ No

If so, what type of computer is it?

(tick both if you have both at home)

- ☐ Mac
- ☐ PC

When working at home which computer would you use the most?

- School Laptop
- Home Computer

How often do you bring your laptop to School? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	◯	◯	◯	◯	◯	Always

How often do you bring your laptop to this Science class? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	◯	◯	◯	◯	◯	Always

How often do you use your laptop in this Science class? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	◯	◯	◯	◯	◯	Always

How often do you use your laptop during Science homework? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	◯	◯	◯	◯	◯	Always

How often do you use your laptop during Science assessments? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	◯	◯	◯	◯	◯	Always

Which activities/applications have you been asked to use as part of your Science studies? *

Tick all applicable boxes

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ MyClasses
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you have used on your laptop in Science

Which activities/applications do you MOST ENJOY doing as part of your Science studies? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research

- ☐ MyClasses
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you enjoy doing in Science

Which activities/applications do you use MOST OFTEN on your laptop as part of your Science studies? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ MyClasses
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you do most often on your laptop in Science

How has having a laptop in Science affected your motivation to work in Science? *

(1 = decreased a lot, 2 = decreased some, 3 = no change, 4 = increased some, 5 = increased a lot)

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

How do you think having a laptop in Science has affected your performance in Science? *

(1 = decreased a lot, 2 = decreased some, 3 = no change, 4 = increased some, 5 = increased a lot)

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Any other comments or observations?

(Optional)

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS SURVEY

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iii. Year 12 Teacher Questionnaire

Edit this form

Teacher Response Survey - Year 12

Please fill out this survey to assist with my postgraduate studies around the impact of student laptops in Science. It should take about 10 minutes. Your identity will be anonymised upon receipt. Your responses will not be shared with your Principal or the CEO. Any future academic publishing of data will retain the anonymity of students, teachers and schools.

S Crook, Student Researcher, University of Sydney

*Required

Surname *

School *

Name, Suburb e.g. DLS Cronulla

Gender *

- Female
- Male

What type of laptop have you been issued with? *

- Mac
- PC

How familiar were you with this type of laptop prior to receiving it? *

	1	2	3	4	5	
Not at all familiar	○	○	○	○	○	Very familiar

How often do you bring your laptop to School? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

Are you teaching Year 12 BIOLOGY this year? *

- ◯ Yes
- ◯ No

How often do you bring your laptop to your Year 12 Biology class? *

	1	2	3	4	5	
Never	◯	◯	◯	◯	◯	Always

How often do you use your laptop in your Year 12 Biology class? *

	1	2	3	4	5	
Never	◯	◯	◯	◯	◯	Always

How often do you require your students to use their laptop in your Year 12 Biology class? *

	1	2	3	4	5	
Never	◯	◯	◯	◯	◯	Always

How often do you require your Year 12 Biology students to use their laptop for homework? *

	1	2	3	4	5	
Never	◯	◯	◯	◯	◯	Always

How often do you require your Year 12 Biology students to use their laptop in assessments? *

	1	2	3	4	5	
Never	◯	◯	◯	◯	◯	Always

Which activities/applications do you utilise with this Year 12 Biology class as part of your teaching? *

Tick all applicable boxes

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software

- [ ] Text Book resources (e.g. CD, online)
- [ ] MyClasses
- [ ] Wikis/Nings/Class Website
- [ ] Blogs
- [ ] Internet Research
- [ ] Video Editing (e.g. Windows Movie Maker, iMovie)
- [ ] Podcasting (e.g. Audacity, Garageband)
- [ ] Databases
- [ ] Email
- [ ] Datalogging
- [ ] Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you utilise with this Year 12 Biology class as part of your teaching

Which activities/applications do you MOST ENJOY using with this Year 12 Biology class as part of your teaching? *

Please tick up to 3 boxes maximum

- [ ] Word Processing (e.g. Word, Pages)
- [ ] Spreadsheets (e.g. Excel, Numbers)
- [ ] Presentations (e.g. Powerpoint, Keynote)
- [ ] Simulations
- [ ] Science software
- [ ] Text Book resources (e.g. CD, online)
- [ ] MyClasses
- [ ] Wikis/Nings/Class Website
- [ ] Blogs
- [ ] Internet Research
- [ ] Video Editing (e.g. Windows Movie Maker, iMovie)
- [ ] Podcasting (e.g. Audacity, Garageband)
- [ ] Databases
- [ ] Email
- [ ] Datalogging
- [ ] Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you enjoy using with this Year 12 Biology class as part of your teaching

Which activities/applications do you utilise MOST OFTEN with this Year 12 Biology class as part of your teaching? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you use most often with this Year 12 Biology class as part of your teaching

Overall for this Year 12 Biology class, how do you think having a laptop has affected the students' motivation to work in Biology? *

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Overall for this Year 12 Biology class, how do you think having a laptop has affected the students' performance in Biology? *

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Are you teaching Year 12 CHEMISTRY this year? *

○ Yes

○ No

How often do you bring your laptop to your Year 12 Chemistry class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop in your Year 12 Chemistry class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you require your students to use their laptop in your Year 12 Chemistry class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you require your Year 12 Chemistry students to use their laptop for homework? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you require your Year 12 Chemistry students to use their laptop in assessments? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

Which activities/applications do you utilise with this Year 12 Chemistry class as part of your teaching? *

Tick all applicable boxes

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you utilise with this Year 12 Chemistry class as part of your teaching

Which activities/applications do you MOST ENJOY using with this Year 12 Chemistry class as part of your teaching? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)

- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you enjoy using with this Year 12 Chemistry class as part of your teaching

Which activities/applications do you utilise MOST OFTEN with this Year 12 Chemistry class as part of your teaching? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email

- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you use most often with this Year 12 Chemistry class as part of your teaching

Overall for this Year 12 Chemistry class, how do you think having a laptop has affected the students' motivation to work in Chemistry? *

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Overall for this Year 12 Chemistry class, how do you think having a laptop has affected the students' performance in Chemistry? *

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Are you teaching Year 12 PHYSICS this year? *

- ○ Yes
- ○ No

How often do you bring your laptop to your Year 12 Physics class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop in your Year 12 Physics class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you require your students to use their laptop in your Year 12 Physics

class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you require your Year 12 Physics students to use their laptop for homework? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you require your Year 12 Physics students to use their laptop in assessments? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

Which activities/applications do you utilise with this Year 12 Physics class as part of your teaching? *

Tick all applicable boxes

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you utilise with this Year 12 Physics class as part of your teaching

Which activities/applications do you MOST ENJOY using with this Year 12 Physics class as part of your teaching? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you enjoy using with this Year 12 Physics class as part of your teaching

Which activities/applications do you utilise MOST OFTEN with this Year 12 Physics class as part of your teaching? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)

- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you use most often with this Year 12 Physics class as part of your teaching

Overall for this Year 12 Physics class, how do you think having a laptop has affected the students' motivation to work in Physics? *

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Overall for this Year 12 Physics class, how do you think having a laptop has affected the students' performance in Physics? *

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Are you teaching Year 12 SENIOR SCIENCE this year? *

- ○ Yes

- [ ] No

How often do you bring your laptop to your Year 12 Senior Science class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop in your Year 12 Senior Science class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you require your students to use their laptop in your Year 12 Senior Science class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you require your Year 12 Senior Science students to use their laptop for homework? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you require your Year 12 Senior Science students to use their laptop in assessments? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

Which activities/applications do you utilise with this Year 12 Senior Science class as part of your teaching? *

Tick all applicable boxes

- [ ] Word Processing (e.g. Word, Pages)
- [ ] Spreadsheets (e.g. Excel, Numbers)
- [ ] Presentations (e.g. Powerpoint, Keynote)
- [ ] Simulations
- [ ] Science software
- [ ] Text Book resources (e.g. CD, online)

- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you utilise with this Year 12 Senior Science class as part of your teaching

Which activities/applications do you MOST ENJOY using with this Year 12 Senior Science class as part of your teaching? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you enjoy using with this Year 12 Senior Science class as part of your teaching

Which activities/applications do you utilise MOST OFTEN with this Year 12 Senior Science class as part of your teaching? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you use most often with this Year 12 Senior Science class as part of your teaching

Overall for this Year 12 Senior Science class, how do you think having a laptop has affected the students' motivation to work in Senior Science? *

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Overall for this Year 12 Senior Science class, how do you think having a laptop has affected the students' performance in Senior Science? *

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Are you teaching Year 12 EARTH AND ENVIRONMENTAL SCIENCE this year? *

○ Yes

○ No

How often do you bring your laptop to your Year 12 Earth and Environmental Science class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop in your Year 12 Earth and Environmental Science class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you require your students to use their laptop in your Year 12 Earth and Environmental Science class? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you require your Year 12 Earth and Environmental Science students to use their laptop for homework? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you require your Year 12 Earth and Environmental Science students to

use their laptop in assessments? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

Which activities/applications do you utilise with this Year 12 Earth and Environmental Science class as part of your teaching? *

Tick all applicable boxes

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you utilise with this Year 12 Earth and Environmental Science class as part of your teaching

Which activities/applications do you MOST ENJOY using with this Year 12 Earth and Environmental Science class as part of your teaching? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)

- [ ] Simulations
- [ ] Science software
- [ ] Text Book resources (e.g. CD, online)
- [ ] MyClasses
- [ ] Wikis/Nings/Class Website
- [ ] Blogs
- [ ] Internet Research
- [ ] Video Editing (e.g. Windows Movie Maker, iMovie)
- [ ] Podcasting (e.g. Audacity, Garageband)
- [ ] Databases
- [ ] Email
- [ ] Datalogging
- [ ] Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you enjoy using with this Year 12 Earth and Environmental Science class as part of your teaching

Which activities/applications do you utilise MOST OFTEN with this Year 12 Earth and Environmental Science class as part of your teaching? *

Please tick up to 3 boxes maximum

- [ ] Word Processing (e.g. Word, Pages)
- [ ] Spreadsheets (e.g. Excel, Numbers)
- [ ] Presentations (e.g. Powerpoint, Keynote)
- [ ] Simulations
- [ ] Science software
- [ ] Text Book resources (e.g. CD, online)
- [ ] MyClasses
- [ ] Wikis/Nings/Class Website
- [ ] Blogs
- [ ] Internet Research
- [ ] Video Editing (e.g. Windows Movie Maker, iMovie)
- [ ] Podcasting (e.g. Audacity, Garageband)
- [ ] Databases
- [ ] Email

- [ ] Datalogging
- [ ] Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you use most often with this Year 12 Earth and Environmental Science class as part of your teaching

Overall for this Year 12 Earth and Environmental Science class, how do you think having a laptop has affected the students' motivation to work in Earth and Environmental Science? *

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Overall for this Year 12 Earth and Environmental Science class, how do you think having a laptop has affected the students' performance in Earth and Environmental Science? *

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

How would you rate your own computer skills prior to you being issued with a staff laptop? *

	1	2	3	4	5	
Total Novice	○	○	○	○	○	Expert

How much PD have you received around the use of your staff laptop? *

- ○ None at all
- ○ 1-2 hours
- ○ ½ day
- ○ 1 day
- ○ 2 days or more

How much PD have you received around students' use of laptops in the classroom? *

- None at all
- 1-2 hours
- ½ day
- 1 day
- 2 days or more

How many years experience of teaching with 1-to-1 laptops do you have? *

- 0-1
- 1-2
- 2-3
- 3-4
- 4+

How would you rate your own computer skills now? *

	1	2	3	4	5	
Total Novice	○	○	○	○	○	Expert

Any other comments or observations?
(Optional)

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS SURVEY

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iv. Year 12 Student Questionnaire

Edit this form

Student Response Survey Year 12

Please fill out this survey to assist with my postgraduate studies around the impact of student laptops in Science. It should take about 10 minutes. Your identity will be anonymised upon receipt.

S Crook, Student Researcher, University of Sydney

*Required

Surname, First name *

e.g. Einstein, Albert

School *

Name, Suburb e.g. DLS Cronulla

Gender *

- ○ Female
- ○ Male

Do you have access to the internet at home? *

- ○ Yes
- ○ No

Do you have access to a computer other than your school laptop at home? *

- ○ Yes
- ○ No

If so, what type of computer is it? *

(tick both if you have both at home)

- ☐ Mac
- ☐ PC

When working at home which computer would you use the most? *

- ○ School Laptop
- ○ Home Computer

How often do you bring your laptop to School? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

Are you studying BIOLOGY this year? *

○ Yes

○ No

Biology Teacher's Surname *

If you have more than one teacher for this class please write both names

How often do you bring your laptop to your Biology class? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop in your Biology class? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop during Biology homework? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop during Biology assessments? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

1 2 3 4 5

Never ○ ○ ○ ○ ○ Always

Which activities/applications have you been asked to use as part of your Biology studies? *

Tick all applicable boxes

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you have used as part of your Biology studies

Which activities/applications do you MOST ENJOY doing as part of your Biology studies? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software

- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you enjoy doing as part of your Biology studies

Which activities/applications do you use MOST OFTEN as part of your Biology studies? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you use most often as part of your Biology studies

Overall for this Biology class, how do you think having a laptop has affected your motivation to work in Biology? *

(1 = decreased a lot, 2 = decreased some, 3 = no change, 4 = increased some, 5 = increased a lot)

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Overall for this Biology class, how do you think having a laptop has affected your performance in Biology? *

(1 = decreased a lot, 2 = decreased some, 3 = no change, 4 = increased some, 5 = increased a lot)

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Are you studying CHEMISTRY this year? *

○ Yes

○ No

Chemistry Teacher's Surname *

If you have more than one teacher for this class please write both names

How often do you bring your laptop to your Chemistry class? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop in your Chemistry class? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop during Chemistry homework? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop during Chemistry assessments? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

Which activities/applications have you been asked to use as part of your Chemistry studies? *

Tick all applicable boxes

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you use as part of your Chemistry studies

Which activities/applications do you MOST ENJOY using as part of your Chemistry studies? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you enjoy using as part of your Chemistry studies

Which activities/applications do you use MOST OFTEN as part of your Chemistry studies? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you use most often as part of your Chemistry studies

Overall for this Chemistry class, how do you think having a laptop has affected your motivation to work in Chemistry? *

(1 = decreased a lot, 2 = decreased some, 3 = no change, 4 = increased some, 5 = increased a lot)

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Overall for this Chemistry class, how do you think having a laptop has affected your performance in Chemistry? *

(1 = decreased a lot, 2 = decreased some, 3 = no change, 4 = increased some, 5 = increased a lot)

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Are you studying PHYSICS this year? *

- ○ Yes
- ○ No

Physics Teacher's Surname *

If you have more than one teacher for this class please write both names

[ ]

How often do you bring your laptop to your Physics class? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop in your Physics class? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop during Physics homework? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop during Physics assessments? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

Which activities/applications have you been asked to use as part of your Physics studies? *

Tick all applicable boxes

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)

- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you use as part of your Physics studies

Which activities/applications do you MOST ENJOY using as part of your Physics studies? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases

- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you enjoy using as part of your Physics studies

Which activities/applications do you use MOST OFTEN as part of your Physics studies? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you use most often as part of your Physics studies

Overall for this Physics class, how do you think having a laptop has affected your motivation to work in Physics? *

(1 = decreased a lot, 2 = decreased some, 3 = no change, 4 = increased some, 5 = increased a lot)

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Overall for this Physics class, how do you think having a laptop has affected your performance in Physics? *

(1 = decreased a lot, 2 = decreased some, 3 = no change, 4 = increased some, 5 = increased a lot)

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Are you studying SENIOR SCIENCE this year? *

○ Yes

○ No

Senior Science Teacher's Surname *

If you have more than one teacher for this class please write both names

How often do you bring your laptop to your Senior Science class? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop in your Senior Science class? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop during Senior Science homework? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use you laptop during Senior Science assessments? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

Which activities/applications have you been asked to use as part of your Senior Science studies? *

Tick all applicable boxes

- [ ] Word Processing (e.g. Word, Pages)
- [ ] Spreadsheets (e.g. Excel, Numbers)
- [ ] Presentations (e.g. Powerpoint, Keynote)
- [ ] Simulations
- [ ] Science software
- [ ] Text Book resources (e.g. CD, online)
- [ ] MyClasses
- [ ] Wikis/Nings/Class Website
- [ ] Blogs
- [ ] Internet Research
- [ ] Video Editing (e.g. Windows Movie Maker, iMovie)
- [ ] Podcasting (e.g. Audacity, Garageband)
- [ ] Databases
- [ ] Email
- [ ] Datalogging
- [ ] Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you use as part of your Senior Science studies

Which activities/applications do you MOST ENJOY using as part of your Senior Science studies? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you enjoy using as part of your Senior Science studies

Which activities/applications do you use MOST OFTEN as part of your Senior Science studies? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)

- [ ] Spreadsheets (e.g. Excel, Numbers)
- [ ] Presentations (e.g. Powerpoint, Keynote)
- [ ] Simulations
- [ ] Science software
- [ ] Text Book resources (e.g. CD, online)
- [ ] MyClasses
- [ ] Wikis/Nings/Class Website
- [ ] Blogs
- [ ] Internet Research
- [ ] Video Editing (e.g. Windows Movie Maker, iMovie)
- [ ] Podcasting (e.g. Audacity, Garageband)
- [ ] Databases
- [ ] Email
- [ ] Datalogging
- [ ] Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you use most often as part of your Senior Science studies

Overall for this Senior Science class, how do you think having a laptop has affected your motivation to work in Senior Science? *

(1 = decreased a lot, 2 = decreased some, 3 = no change, 4 = increased some, 5 = increased a lot)

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Overall for this Senior Science class, how do you think having a laptop has affected your performance in Senior Science? *

(1 = decreased a lot, 2 = decreased some, 3 = no change, 4 = increased some, 5 = increased a lot)

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Are you studying EARTH AND ENVIRONMENTAL SCIENCE this year? *

- ○ Yes
- ○ No

Earth and Environmental Science Teacher's Surname *

If you have more than one teacher for this class please write both names

How often do you bring your laptop to your Earth and Environmental Science class? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop in your Earth and Environmental Science class? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop during Earth and Environmental Science homework? *

(1 = never, 2 = a lot less than half of the time, 3 = about half of the time, 4 = a lot more than half of the time, 5 = always)

	1	2	3	4	5	
Never	○	○	○	○	○	Always

How often do you use your laptop during Earth and Environmental Science assessments? *

	1	2	3	4	5	
Never	○	○	○	○	○	Always

Which activities/applications have you been asked to use as part of your Earth and Environmental Science studies? *

Tick all applicable boxes

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)

- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases
- ☐ Email
- ☐ Datalogging
- ☐ Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you use as part of your Earth and Environmental Science studies

Which activities/applications do you MOST ENJOY using as part of your Earth and Environmental Science studies? *

Please tick up to 3 boxes maximum

- ☐ Word Processing (e.g. Word, Pages)
- ☐ Spreadsheets (e.g. Excel, Numbers)
- ☐ Presentations (e.g. Powerpoint, Keynote)
- ☐ Simulations
- ☐ Science software
- ☐ Text Book resources (e.g. CD, online)
- ☐ MyClasses
- ☐ Wikis/Nings/Class Website
- ☐ Blogs
- ☐ Internet Research
- ☐ Video Editing (e.g. Windows Movie Maker, iMovie)
- ☐ Podcasting (e.g. Audacity, Garageband)
- ☐ Databases

- [ ] Email
- [ ] Datalogging
- [ ] Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you enjoy using as part of your Earth and Environmental Science studies

Which activities/applications do you use MOST OFTEN as part of your Earth and Environmental Science studies? *

Please tick up to 3 boxes maximum

- [ ] Word Processing (e.g. Word, Pages)
- [ ] Spreadsheets (e.g. Excel, Numbers)
- [ ] Presentations (e.g. Powerpoint, Keynote)
- [ ] Simulations
- [ ] Science software
- [ ] Text Book resources (e.g. CD, online)
- [ ] MyClasses
- [ ] Wikis/Nings/Class Website
- [ ] Blogs
- [ ] Internet Research
- [ ] Video Editing (e.g. Windows Movie Maker, iMovie)
- [ ] Podcasting (e.g. Audacity, Garageband)
- [ ] Databases
- [ ] Email
- [ ] Datalogging
- [ ] Other e.g. types of Web 2.0 (list in next question)

If you ticked 'Other' above please list the other activities/applications you use most often as part of your Earth and Environmental Science studies

Overall for this Earth and Environmental Science class, how do you think having a laptop has affected your motivation to work in Earth and Environmental Science? *

(1 = decreased a lot, 2 = decreased some, 3 = no change, 4 = increased some, 5 = increased a lot)

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

Overall for this Earth and Environmental Science class, how do you think having a laptop has affected your performance in Earth and Environmental Science? *

(1 = decreased a lot, 2 = decreased some, 3 = no change, 4 = increased some, 5 = increased a lot)

	1	2	3	4	5	
Decreased it a lot	○	○	○	○	○	Increased it a lot

How would you rate your own computer skills prior to you being issued with a laptop? *

	1	2	3	4	5	
Total Novice	○	○	○	○	○	Expert

How would you rate your own computer skills now? *

	1	2	3	4	5	
Total Novice	○	○	○	○	○	Expert

Any other comments or observations?

(Optional)

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS SURVEY

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Appendix B – Anonymised database for Chapter 4 multiple regression analysis

The anonymised database used for Chapter 4 is a xlsx spreadsheet available on the International Journal of Science Education publisher's website at http://dx.doi.org/10.1080/09500693.2014.982229.

Appendix C – References to technology in Board of Studies NSW physics and biology syllabuses

Section	Physics[1]	Biology[2]
Course Structure	Practical experiences should emphasise hands-on activities, including (p. 9): undertaking laboratory experiments, including the use of *appropriate computer-based technologies* research, using a wide range of sources, including print materials, the *Internet* and *digital technologies* using *computer simulations* for modelling or manipulating data using and reorganising secondary data extracting and reorganising information in the form of flow charts, tables, graphs, diagrams, prose and keys using *animation*, video and film resources to capture/obtain information not available in other forms	Practical experiences should emphasise hands-on activities, including (p. 9): undertaking laboratory experiments, including the use of *appropriate computer-based technologies* research, using a wide range of sources, including print materials, the *Internet* and *digital technologies* using *computer simulations* for modelling or manipulating data using and reorganising secondary data extracting and reorganising information in the form of flow charts, tables, graphs, diagrams, prose and keys using *animation*, video and film resources to capture/obtain information not available in other forms
Skills - conducting investigations	increasing students' skills in performing first-hand investigations, gathering first-hand data and accessing and collecting information relevant to physics from secondary sources *using a variety of technologies* (p. 13)	increasing students' skills in performing first-hand investigations, gathering first-hand data and accessing and collecting information relevant to biology from secondary sources *using a variety of technologies* (p. 14)
Key Competencies	During investigations, students use appropriate information technologies and so develop the key competency of ***using technology*** (p. 17)	During investigations, students use appropriate information technologies and so develop the key competency of ***using technology*** (p. 18)
Domain: Skills	Preliminary[3] (pp. 18-19)/HSC[4] (pp. 38-39) students: 11.1 identify data sources to: e) recommend the use of an *appropriate technology or strategy for data collection* or gathering information that will assist efficient future analysis 11.3 choose equipment or resources by:	Preliminary[3] (pp. 19-20)/HSC[4] (pp. 36-37) students: 11.1 identify data sources to: e) recommend the use of an *appropriate technology or strategy for data collection* or gathering information that will assist efficient future analysis 11.3 choose equipment or resources by:

	c) *identifying technology* that could be used during investigating and determining its suitability and effectiveness for its potential role in the procedure or investigations 12.2 gather first-hand information by: a) using appropriate data collection techniques, employing appropriate technologies, including data loggers and sensors 12.3 gather information from secondary sources by: a) accessing information from a range of resources, including popular scientific journals, *digital technologies and the Internet* 12.4 process information to: c) best illustrate trends and patterns by selecting and using appropriate methods, including *computer-assisted analysis*	c) *identifying technology* that could be used during investigating and determining its suitability and effectiveness for its potential role in the procedure or investigations 12.2 gather first-hand information by: a) using appropriate data collection techniques, employing appropriate technologies, including data loggers and sensors 12.3 gather information from secondary sources by: a) accessing information from a range of resources, including popular scientific journals, *digital technologies and the Internet* 12.4 process information to: c) best illustrate trends and patterns by selecting and using appropriate methods, including *computer-assisted analysis*
Preliminary Domain: knowledge and understanding	The wave model can be used to explain how current technologies transfer information Students: perform a first-hand investigation to observe and gather information about the transmission of waves in: slinky springs water surface ropes or use appropriate computer simulations (p. 22) Students: perform a first-hand investigation to gather information about the frequency and amplitude of waves using an oscilloscope *or electronic data-logging equipment* (p.22) Features of a wave model can be used to account for the properties of sound Students: perform a first-hand investigation and gather information to analyse sound waves from a variety of sources using the Cathode Ray Oscilloscope (CRO) *or an alternate computer technology* (p. 23) Students: perform a first-hand investigation, gather, process and present information using a CRO *or computer* to demonstrate the principle of superposition for two waves travelling in the same medium (p.23)	none

	Series and parallel circuits serve different purposes in households Students: plan, choose equipment or resources for and perform first-hand investigations to gather data and use available evidence to compare measurements of current and voltage in series and parallel circuits in *computer simulations* or hands-on equipment (p. 28)	
HSC Domain: knowledge and understanding	The Earth has a gravitational field that exerts a force on objects both on it and around it Students: perform an investigation and gather information to determine a value for acceleration due to gravity using pendulum motion *or computer-assisted technology* and identify reason for possible variations from the value 9.8 ms^{-2} (p. 41) Many factors have to be taken into account to achieve a successful rocket launch, maintain a stable orbit and return to Earth Students: perform a first-hand investigation, gather information and analyse data to calculate initial and final velocity, maximum height reached, range and time of flight of a projectile for a range of situations by *using simulations, data loggers and computer analysis* (p. 42) The study of binary and variable stars reveals vital information about stars Students: perform an investigation to model the light curves of eclipsing binaries *using computer simulation* (p. 64)	none

[1]Physics syllabus available at http://www.boardofstudies.nsw.edu.au/syllabus_hsc/pdf_doc/physics-st6-syl.pdf
[2]Biology syllabus available at http://www.boardofstudies.nsw.edu.au/syllabus_hsc/pdf_doc/biology-st6-syl.pdf
[3]Preliminary course studied in grade 11
[4]HSC course studied in grade 12

Appendix D – Relevant human ethics forms

All activities involving human participation of this research were conducted under the supervision and approval of the University of Sydney Human Ethics Committee.

This appendix contains the three relevant participant information statements that were offered to participants before they consented to be involved in the research.

These are:

i. The Participation Information Statement for year 10 and 12 teachers completing questionnaires (relevant for Chapters 2-6).
ii. The Participation Information Statement for year 10 and 12 students completing questionnaires (relevant for Chapters 2-6).
iii. The Participation Information Statement for teachers being interviewed (relevant for Chapter 6).

i. The Participation Information Statement for year 10 and 12 teachers completing questionnaires (relevant for Chapters 2-6).

THE UNIVERSITY OF SYDNEY

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Simon Crook
Student Researcher

Email:
simon.crook@ceosyd.catholic.edu.au

A research study to assess the impact of 1-to-1 laptops on student performance in Science

PARTICIPANT INFORMATION STATEMENT
STAFF

(1) What is the study about?

There is much debate about whether computers in the classroom enhance learning. This study investigates if student performance in Science can be attributed to the 1-to-1 laptop program instigated through the Australian Federal Government's Digital Education Revolution.

(2) Who is carrying out the study?

The study is being conducted by Mr Simon Crook and will form the basis for the degree of MSc (Research) at The University of Sydney under the supervision of Associate Professor Manjula Sharma.

(3) What does the study involve?

The study involves completing and submitting an online survey on the use of computers in Science.

(4) How much time will the study take?

The survey will take 10 minutes to complete.

(5) Can I withdraw from the study?

Being in this study is completely voluntary and you are not under any obligation to consent to complete the survey. Submitting a completed survey is an indication of your consent to participate in the study. You can withdraw any time prior to submitting your completed survey. **Once you have submitted your survey it will be anonymised** and your responses cannot be withdrawn.

(6) Will anyone else know the results?

All aspects of the study, including results, will be strictly confidential and only the researchers will have access to information on participants. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report.

(7) Will the study benefit me?

The study will provide you with the opportunity to reflect on how you get your students to use their laptops to study science. The self-reflection could be constructive in self development and enhancing your classroom practice.

(8) Can I tell other people about the study?

Yes, by all means. There is no reason to keep this study a secret.

(9) What if I require further information?

When you have read this information, *Mr Simon Crook* will discuss it with you further and answer any questions you may have. If you would like to know more at any stage, please feel free to contact Mr Simon Crook, simon.crook@ceosyd.catholic.edu.au, MSc (Research) student or Assoc/Prof Manjula Sharma, 9351 2051, Room 226E, Physics Building, m.sharma@physics.usyd.edu.au, Head of the SUPER group, Dr Louise Sutherland, Lecturer in Education, 9351 6258, Education Building, louise.sutherland@sydney.edu.au.

(10) What if I have a complaint or concerns?

Any person with concerns or complaints about the conduct of a research study can contact the Deputy Manager, Human Ethics Administration, University of Sydney on +61 2 8627 8176 (Telephone); +61 2 8627 8177 (Facsimile) or ro.humanethics@sydney.edu.au (Email).

This information sheet is for you to keep *ii The Participation Information Statement for year 10 and 12 students completing questionnaires (relevant for Chapters 2-6).*

THE UNIVERSITY OF SYDNEY

Sydney University Physics Education Research (SUPER) group
School of Physics
Faculty of Science

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Student Researcher

Email: simon.crook@ceosyd.catholic.edu.au

A research study to assess the impact of 1-to-1 laptops on student performance in Science

PARTICIPANT INFORMATION STATEMENT
STUDENT

(1) What is the study about?

There is much debate about whether computers in the classroom enhance learning. This study investigates if student performance in Science can be attributed to the 1-to-1 laptop program instigated through the Australian Federal Government's Digital Education Revolution.

(2) Who is carrying out the study?

The study is being conducted by Mr Simon Crook and will form the basis for the degree of MSc (Research) at The University of Sydney under the supervision of Associate Professor Manjula Sharma.

(3) What does the study involve?

The study involves completing and submitting an online survey on the use of computers in Science.

(4) How much time will the study take?

The survey will take 10 minutes to complete.

(5) Can I withdraw from the study?

Being in this study is completely voluntary and you are not under any obligation to consent to complete the survey. Submitting a completed survey is an indication of your consent to participate in the study. You can withdraw any time prior to submitting your completed survey. **Once you have submitted your survey it will be anonymised** and your responses cannot be withdrawn.

(6) Will anyone else know the results?

All aspects of the study, including results, will be strictly confidential and only the researchers will have access to information on participants. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report.

(7) Will the study benefit me?

The study will provide you with the opportunity to reflect on how you use your laptop to study science. The self-reflection could be constructive in self development and enhancing your study practices.

(8) Can I tell other people about the study?

Yes, by all means. There is no reason to keep this study a secret.

(9) What if I require further information?

When you have read this information, *Mr Simon Crook* will discuss it with you further and answer any questions you may have. If you would like to know more at any stage, please feel free to contact Mr Simon Crook, simon.crook@ceosyd.catholic.edu.au, MSc (Research) student or Assoc/Prof Manjula Sharma, 9351 2051, Room 226E, Physics Building, m.sharma@physics.usyd.edu.au, Head of the SUPER group, Dr Louise Sutherland, Lecturer in Education, 9351 6258, Education Building, louise.sutherland@sydney.edu.au.

(10) What if I have a complaint or concerns?

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This information sheet is for you to keep

iii The Participation Information Statement for teachers completing being interviewed (relevant for Chapter 6).

A research study to assess the impact of 1-to-1 laptops on students performance in science
Page 2 of 2
Version 1 – 3 June 2010

PARTICIPANT INFORMATION STATEMENT

(1) What is this study about?

You are invited to take part in a research study examining the impact of the one-to-one laptop program on student performance in Science. As you will be aware, in recent years Simon Crook has been studying the impact of 1-to-1 laptops on students' performance in the sciences. To this end we now wish to conduct some interviews to generate some longitudinal case studies as the final part of Simon's

- Associate Professor Manjula Sharma, Head of Sydney University Physics Education Research (SUPER) group, The University of Sydney.
- Dr Rachel Wilson, Co-supervisor, Faculty of Education & Social Work, University of Sydney.

Simon Crook is conducting this study as the basis for the degree of PhD at The University of Sydney. This will take place under the supervision of Associate Professor Manjula Sharma, Head of Sydney University Physics Education Research (SUPER) group.

(3) What will the study involve for me?

For this aspect of the study we ask to interview you for 50-60 minutes regarding your observations, perceptions and previous survey responses around the use of one-to-one laptops in teaching and learning in science. The questions would relate to how you and your students have used the laptops in science and how this has evolved over time. It would be the intention to interview early Term 4 when your Year 12 class(es) would be on examination leave and you would have time in lieu. Simon would liaise with yourself and your school to negotiate the best time. He would take you out for lunch at a local restaurant to allow for an informal interview and as a way of saying thank you for your ongoing support. The conversation would be recorded via a microphone on an iPad and then transcribed to allow for the qualitative analysis for the case study. As with previous aspects of this study your identity would be anonymised and any descriptive meta-data presented would not allow for you to be identifiable. Should you wish to review your interview transcript, how your interview is presented and how it is analysed in the final paper, all documentation would be made available to you in advance. Of course, upon publication you would be notified and the publication would be shared with you for your own interest and records.

(4) How much of my time will the study take?

This study would require just over an hour of your time for the interview and travel to and from the restaurant. In addition, should you wish to review the transcript and/or paper it would require a couple of hours of your time within the following three months.

(5) Who can take part in the study?

This study is asking for the voluntary participation of science teachers from the Catholic Education Office Sydney who have participated in the previous surveys and whose previous students have also participated in good numbers. We will be approaching two teachers from each of Year 12 biology, chemistry, physics and senior science who fulfil the above criteria. Collecting interview data from teachers across these four HSC science subjects would allow the researchers to further compare and better explain the uses of one-to-one laptops across the subject disciplines, a focus of our latest two papers currently in review in leading academic journals, and allow for a longitudinal case study.

(6) Do I have to be in the study? Can I withdraw from the study once I've started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate will not affect your current or future relationship with the researchers or anyone else at the University of Sydney or the Catholic Education Office Sydney.

If you decide to take part in the study and then change your mind later, you are free to withdraw at any time. You can do this by simply emailing Simon Crook (simon.crook@syd.catholic.edu.au) or Manjula Sharma (manjula.sharma@sydney.edu.au).

You are free to stop the interview at any time. Unless you say that you want us to keep them, any recordings will be erased and the information you have provided will not be included in the study results. You may also refuse to answer any questions that you do not wish to answer during the interview.

(7) Are there any risks or costs associated with being in the study?

Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study.

(8) Are there any benefits associated with being in the study?

This study will be of benefit to future researchers, education authorities, schools and teachers when investigating the impact and use of technology and one-to-one devices in teaching and learning.

(9) What will happen to information about me that is collected during the study?

Interview sound files and notes will be collected during the interviews for this study. The sound files will be transcribed. The transcriptions and notes will be stored securely in the office of Associate Professor Manjula Sharma as supervisor, and used as part of the data and analysis for our final publication. The final submitted paper will ultimately be stored on an academic journal's server via a secure online submission, accessible through the journal's website and possibly in a printed version of the journal. The resulting paper will be published within an academic journal; will contribute as a chapter of a PhD thesis by publication; a summary version will be presented at an academic conference; and the findings will also circulated within the Sydney University Physics Education Research (SUPER) group and the Catholic Education Office Sydney. Upon the acceptance of the PhD thesis and the successful award of the higher degree all data involved in this study will be stored securely in the office of Associate Professor Manjula Sharma, as determined by the Human Research Ethics Committee.

All personal information will be kept confidential and all identities will be anonymised from the outset.

By providing your consent, you are agreeing to us collecting personal information about you e.g. age, years teaching, for the purposes of this research study. Your information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise.

Your information will be stored securely and your identity/information will be kept strictly confidential, except as required by law. Study findings may be published, but you will not be individually identifiable in these publications.

(10) Can I tell other people about the study?

Yes, you are welcome to tell other people about the study.

(11) What if I would like further information about the study?

When you have read this information, Simon Crook will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact Simon Crook, Student Researcher, Sydney University Physics Education Research (SUPER) group, email: simon.crook@syd.catholic.edu.au, phone: 0458 299573; or, Associate Professor Manjula Sharma, Head of Sydney University Physics Education Research (SUPER) group, email: manjula.sharma@sydney.edu.au, phone: 9351 2051.

(12) Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. You can tell us that you wish to receive feedback by informing Simon Crook during the interview or emailing him at simon.crook@syd.catholic.edu.au. This feedback will be in the form of a one page lay summary. You will receive this feedback after the study is finished.

(13) What if I have a complaint or any concerns about the study?

Research involving humans in Australia is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this study have been approved by the HREC of the University of Sydney *[INSERT* protocol number once approval is obtained*]*. As part of this process, we have agreed to carry out the study according to the *National Statement on Ethical Conduct in Human Research (2007)*. This statement has been developed to protect people who agree to take part in research studies.

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the university using the details outlined below. Please quote the study title and protocol number.

The Manager, Ethics Administration, University of Sydney:

- **Telephone:** +61 2 8627 8176
- **Email:** ro.humanethics@sydney.edu.au
- **Fax:** +61 2 8627 8177 (Facsimile)

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