Enhancing teachers' use of web-based resources: A case study of secondary technology teachers

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ABSTRACT

The need for teachers to develop their content knowledge and understanding of the nature of technology remains an issue for technology education in New Zealand, and although web-based resources (WBRs) offer an effective means of supporting teachers in this endeavour, and have acknowledged potential to transform education, teachers are not necessarily well prepared to integrate WBRs effectively into their pedagogy.

This research set out to investigate how teachers could be supported to enhance their classroom use of WBRs in secondary school technology education. This involved investigating the nature and extent of the participants' existing classroom practice using WBRs, designing and implementing a sustained intervention programme to support them to expand and enhance the ways in which they integrated WBRs into their technology programmes, and evaluating how and why this influenced their classroom practice. The participants – seven experienced secondary school technology teachers – were from three different schools, had a range of backgrounds, and taught a range of technological areas including food, textiles and structural technology.

The study employed an interpretive research design and qualitative research methods, and was underpinned by a sociocultural theoretical perspective. The design of the intervention was informed by literature on characteristics of effective teacher professional development in general, ICT professional development in particular, sociocultural theories of learning, and Bell and Gilbert's (1994) model of teacher professional development which emphasises the importance of addressing three dimensions of teacher development (personal, professional and social). The intervention incorporated the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006) as a tool for communicating the complex knowledge base required for effective integration of WBRs. The framework was also used to analyse participants' developing knowledge as they integrated new ideas and approaches in the classroom.

This research concludes that when particular components are included in a professional development programme, teachers can be supported to enhance their classroom use of WBRs and to become empowered to continue their own ongoing development, even when they have limited skills and knowledge and face significant constraints. While the critical elements of the intervention were not new, the particular combination of components was unique.

The study also draws attention to the complex range of variables that can influence individual teachers as they progress in their integration of WBRs and development of TPACK. It explores, using velocity as an analogy, how various factors, and their interactions, impacted on the degree, and rate, of change of the teachers' integration of WBRs.

Findings indicate that in the current educational and ICT environment, and in technology education in particular, with recent curriculum and assessment changes, teachers are likely to acknowledge a need to increase and/or enhance their classroom use of ICT and are therefore willing to engage in professional development that appears relevant and manageable in their particular teaching context.

Although examples of transformative use exist, the overall impact of ICT in education remains limited despite government funding for ICT initiatives and increasing use of ICT in education. Therefore the conclusions of this study are particularly relevant in the current educational environment. Although the research is limited in scope to integrating WBRs in technology education, it is likely that the key principles of the intervention can be more broadly applied to ICT professional development in other subject areas.

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PUBLICATIONS ARISING FROM THIS THESIS

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Mangan, J., Forret, A. M., & Buntting, C. (2011). Integrating web-based resources in Technology Education. In *Proceedings of the 7th Biennual Conference on Technology Education Research.* Surfers' Paradise, Australia.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

The Internet is arguably the most ubiquitous and influential communication technology ever created. Never before in human history has so much information been so readily available to so many people. Web-based resources (WBRs) have the potential to transform education in the same way that they have transformed so many aspects of our everyday lives.

This research investigates how teachers can be supported to enhance their integration of WBRs in technology education. This chapter provides the introduction and rationale for the study. The researcher's background and motivation leading to the study is described first, followed by an overview of the context of the research that includes two sections: technology education, and ICT in education. The chapter goes on to outline the rationale, aim and research questions, before concluding with an overview of the thesis.

1.1 Researcher's background

My journey to undertaking this research began with the completion of a Master of Education degree in 2003. My Master's research investigated factors affecting the implementation of the (then) new technology curriculum. My data collection was in 2001 – one year after the new curriculum was mandated for compulsory implementation. Technology education was still very much in its infancy in New Zealand and the levels of acceptance and understanding of staff tasked with teaching the new subject, as well as wider staff and management, varied widely. My study was therefore very timely and enabled me to develop a better understanding of technology education as a subject and prepared me for taking a leadership role in the implementation of the new curriculum and in supporting other teachers to develop their understanding of technology education.

I was subsequently appointed to the position of Head of Department (HOD) Technology in my school, and in the ensuing years was involved in many other leadership roles in technology education, including facilitator of National Certificate of Educational Achievement (NCEA) Technology jumbo days, and moderator and marker of NCEA Technology. In these roles I became very aware of the lack of knowledge and understanding of the new curriculum that many teachers continued to show and observed the impact of this on student learning. In particular, many teachers continued to hold a narrow view of technology as a skills-based subject, and consequently there was limited change in their classroom practice. It was clear to me that teachers needed to develop their understanding of the nature of technology in order to interpret the curriculum and assessment, teach it effectively, and support student achievement.

Changes to the technology curriculum introduced in the revised New Zealand Curriculum (Ministry of Education, 2007) were designed to address the lack of change that had been evident in classrooms. Technological knowledge and the nature of technology were made more explicit by adding two new strands, and a standards' alignment process followed to ensure consistency between the curriculum and NCEA assessment standards (see Section 2.1.6). This was informed by research and supported by significant professional development for teachers. The standards' alignment prompted more teachers to engage with the new curriculum and begin to consider the need for change. However, it was still a significant step for teachers to develop the knowledge and understanding required to implement the new curriculum successfully.

In 2008 I was awarded a New Zealand Science, Mathematics and Technology Teacher Fellowship. The Fellowship gave me the opportunity to spend a year experiencing authentic technological practice in industry and research. Half my time during the Fellowship year was with The Biotechnology Learning Hub – a web-based portal combining industry-based case studies with curriculum-linked teaching resources, focusing on contemporary New Zealand research and development in biotechnology.

My Teacher Fellowship year and subsequent work as a content developer for the Biotechnology and Science Learning Hubs gave me insights into a wide range of innovative technological developments, and I was able to translate these into multi-media teaching resources for publishing on the web. The experience contributed enormously to my own technology knowledge, and with my background in technology education, I was inspired by the potential of these resources to support technology teachers and their students to better understand the nature of technology, and to explore a range of technological concepts in relevant and engaging contexts. However, the usefulness of these resources is dependent on teachers being aware of their existence, perceiving their educational value, having adequate classroom access to computers and the Internet, and having the knowledge and skills to integrate WBRs effectively in their teaching.

As an employee of the University of Waikato I was fortunate to have the opportunity and the encouragement to undertake Doctoral study. Hence, I began my doctoral research journey seeking to better understand the nature and extent of technology teachers' use of WBRs, and to investigate how technology teachers can be better supported to overcome barriers and develop the knowledge and skills necessary to enhance their classroom integration of WBRs.

1.2 Background to the research

This section introduces the background context for this research, and identifies the problem that the research sought to address. Thus, it provides the rationale for the study.

1.2.1 Technology education

As indicated in the previous section, technology education is still a relatively new curriculum internationally compared to traditional school subjects such as English, science and mathematics, having emerged as a distinct area of study in many countries in the last two to three decades. Although aspects of technology education have a longer history, having their roots in technical and craft subjects, these earlier curricula had a narrow focus on developing technical skills, as opposed to broader concepts of technology and technological literacy that underpin contemporary technology education curricula (Jones, 2009a).

In New Zealand, technology education was introduced as an ‘essential learning area’ in the curriculum in 1995, and mandated for compulsory implementation (from Year 1 to Year 10) in 1999. Implementation of the new curriculum was a significant challenge for schools and in particular for the teachers who were expected to teach it. In particular, there were no specifically trained technology teachers and teachers held a range of views about technology and the purpose and content of technology education. Generally views were narrow and influenced by teachers’ subject subcultures (Moreland, Jones, & Northover, 2001).

In many New Zealand secondary schools, technology education became the responsibility of previous technical subject teachers. In the absence of professional development, and influenced by their traditional subcultures, the emphasis tended to remain on technological practice and skills rather than a broader focus on developing technological literacy (Compton & France, 2007; Jones & Compton, 2009). Research reviewing the implementation of the new curriculum indicated that teachers’ understanding of the nature of technology was still limited (Compton & Jones, 2004). National examination results and research findings showed that despite high levels of student engagement, students’ technological literacy lacked breadth and depth (Jones & Compton, 2009). These findings were addressed in revisions to the technology curriculum as part of a national curriculum review, culminating, in 2007, in a restructured technology curriculum in the New Zealand Curriculum (Ministry of Education, 2007). The new curriculum places a stronger emphasis on the nature of technology by defining this aspect in a new strand, and aims to develop a broader and more critical technological literacy (Jones & Compton, 2009).

For teachers, who in many cases were still developing an understanding of this relatively new curriculum area, it represented a significant challenge. Although there was considerable professional development provided to support the new curriculum, and pockets of innovative classroom practice developed, system-wide change was more limited. A key issue at secondary level was teachers’ limited understandings of the curriculum. As Buntting, Williams and Jones (2015) point out, teachers' perceptions of the nature of technology are often entrenched, and changes in curriculum do not automatically result in changes in their understandings. Sustained professional development is needed to support the development of more robust philosophical understandings of the discipline.

Affordances of the Internet offer considerable potential to support teachers to develop their own conceptual and philosophical understanding of technology and technology education in order to effectively interpret, implement and assess against the 2007 technology curriculum, while at the same time better supporting the broad and interdisciplinary resource needs of their students. However, developing the knowledge and skills required to integrate the Internet effectively in the classroom to enhance teaching and learning is far from a straightforward process.

1.2.2 ICT in education

Information and communication technology (ICT), particularly since the introduction and rapidly increasing scope of the Internet, has fundamentally changed the way we communicate, work and do business and has increased the rate of change itself. While one might expect a similar transformation in education, generally the vision of transformative change in education has not yet been achieved (Bolstad et al., 2012; Lai & Pratt, 2007; Somekh, 2008). Despite significant investment in digital resources in schools, research suggests that low-level uses of ICT are dominant with limited pedagogical change both internationally and in New Zealand (see Sections 2.3.3 and 2.3.4).

For many years, integration of ICT was considered to be simply a matter of providing the hardware and software in schools with the expectation that effective use of ICT would automatically follow (Cuban, Kirkpatrick, & Peck, 2001). Professional development was mostly generic and focused on developing skills for using hardware and software with little emphasis on pedagogy, or relevance and applications to specific subject areas (Thompson & Mishra, 2007; Wallace, 2004). These approaches resulted in mostly technocentric and low-level uses of ICT in classrooms, such as replacing the use of overhead transparencies with presentation software. Evidence shows that where teachers use ICT simply to replace older technologies (low-level uses) without further changes in their pedagogy, there is minimal impact on learning (Wright, 2010).

The importance of pedagogy and constructivist theories of learning in effective ICT use and in better meeting the needs of twenty first century learners is now well recognised (Albion & Ertmer, 2002; Lai, 2008; Lai & Pratt, 2007; Voogt, 2008, 2010; Wright, 2010), and is also reinforced in current New Zealand education policy. The New Zealand curriculum document states: “Schools should explore not only how ICT can supplement traditional ways of teaching but also how it can open up new and different ways of learning” (Ministry of Education, 2007, p. 36).

In New Zealand, a national ICT Strategy announced by the Government in 1998 acknowledged a significant gap between expectations for ICT and realities in education (Billowes & Alexander, 2010). Projects that formed part of this strategy included the *ICT PD School Clusters* programme introduced in 2000, and the *TELA Laptops for Teachers* scheme introduced in 2003. Lai’s (2010) evaluation of the impact of these strategies on learning and teaching, based mainly on research and evaluation reports published in the journal *Computers in New Zealand Schools (CINZS)*, reported significant improvements in teacher knowledge and skills in ICT use, and changes in attitudes. However, he identified a lack of evaluation of some strategies, and in general a lack of research-based evidence about the impact of the strategies on teaching and learning.

A regular survey of ICT in New Zealand schools conducted most recently by the 2020 Communications Trust, in cooperation with the Ministry of Education, indicated that in 2011 (the year of data collection for this research) and 2014 (the latest report) computer access levels had remained unchanged since 2007, at four students per computer in secondary schools (excluding computers for administrative use). Also, most computer access in secondary schools was in libraries, computer labs and pods, suggesting that access in many classrooms may still be limited.

Furthermore, 2011 survey findings indicated that the Internet generally had low levels of student use – the reason for this remained unexplored. In 2014, despite many schools having gained better Internet access through ultra-fast broadband (UFB), most principals reported that web-based resources were “not being used extensively by students on a weekly basis” (2020 Communications Trust, 2011, p. 69), with the exception of Wikipedia. Although a high level of student engagement with some types of e-learning was reported in 2014, only one-third of principals reported that digital technologies were having “quite a significant impact” on raising student achievement in their school (p. 64). In addition, in 2014 only 14 percent of principals felt that all their teachers had the necessary skills to manage student use of personal digital technologies effectively.

Clearly, a decade and a half after the launch of the New Zealand ICT Strategy, there is still considerable progress needed before effective ICT integration can be claimed as the norm in New Zealand schools.

1.3 Research rationale, aim and questions

The focus of this research is on teachers’ classroom use of WBRs, in particular in the subject area of technology education. In technology education, WBRs offer potential to better enable teachers to meet many of the complex resource needs of students while also developing their own understandings of the subject, as outlined in the previous sections. However, as already indicated, the potential of the Internet has yet to be widely realised in mainstream education.

In spite of the considerable resourcing and professional development already provided to support ICT and Internet integration, both in New Zealand and in other countries, teachers are still not well prepared to teach with the Internet. While the *ICT PD School Clusters* programme and the *TELA* laptop scheme in New Zealand have had significant impacts on teachers’ skills and confidence to use ICT, the focus has been very broad, ranging from managing multi-media such as digital photography to desktop publishing and participating in online networks (Billowes & Alexander, 2010). For most teachers technical upskilling remains their main goal (Billowes & Alexander, 2010). While teachers now regularly use computers for lesson preparation, apart from the ‘enthusiasts’, ICT-based activities in classrooms are much less regular and a focus on integrating WBRs has not been evident.

The national surveys show that classroom use of WBRs remains limited and it appears that teachers still need considerable support to develop the knowledge, beliefs and pedagogy that will enable them to move beyond technocentric approaches. In response to this need, this research set out to investigate how New Zealand technology teachers can be more effectively supported to develop their knowledge and classroom practice in order to realise the potential of WBRs to enhance student learning.

The overarching research question guiding this investigation is:

How can secondary technology teachers be effectively supported to enhance their classroom integration of WBRs?

In order to answer this question, this research set out to identify strategies likely to contribute to effective professional development for enhancing technology teachers' integration of WBRs, to design and implement an intervention strategy to support technology teachers to integrate WBRs in a range of secondary schools, and, to evaluate the overall impact of the intervention on teachers' classroom practice.

The sub-questions underpinning the overarching research question are:

1. a. What is the nature and extent of secondary technology teachers' existing use of WBRs in the classroom?

   b. What are teachers' existing perceptions of using WBRs in technology education and what barriers are impacting on integration?

2. What are key components of an intervention to support technology teachers to enhance their integration of WBRs?
3. What is the impact of the intervention on teachers' integration of WBRs?
4. What is the nature of change in teachers' classroom use of WBRs and what are the key influential factors?

It is hoped that this investigation will contribute to better understanding how WBRs can be effectively integrated into classroom teaching to enhance teachers' knowledge and practice, and student learning in technology education. Schools may benefit by using the findings of the research to inform decisions about the design of ICT professional development programmes both within and between schools. Strategies that prove successful in the context of this research may also provide guidance for schools in establishing support systems within their schools to help teachers sustain an ongoing focus on enhancing ICT integration and facilitating a shift from technocentric to learner-centred approaches to classroom integration.

1.4 Thesis overview

This thesis is organised in seven chapters. The first chapter has provided an introduction to the research by outlining the researcher's background, the background context of the study, and the rationale, aim and research questions. Chapter two presents a review of literature relevant to this research. The literature review chapter is divided into five sections, which include technology education, theoretical perspectives of learning, ICT in education, teacher professional development and a chapter summary.

Chapter three explains and justifies the research methodology and design of this research. It explains the interpretive qualitative methodology that underpins the study, and discusses relevant quality issues in this methodological approach and how they are addressed in this research. This is followed by discussion of the research design, in particular the case study approach and methods of data collection. Section 3.4 explains methods used for data analysis, and Section 3.5 describes the ethical considerations relevant in this study and how these were addressed. The final section provides a summary of the chapter.

Chapter four describes the design of the intervention. The chapter introduction is followed by an overview of the principles guiding the intervention design. The subsequent three sections describe the aims and components of each of the three phases of the intervention, before the final section provides a chapter summary.

Chapter five presents an analysis of initial data relating to the three participating schools and the individual teacher participants. The chapter is divided into five sections. The first section introduces the chapter before the second to fourth sections present the data relating to each of the three schools. Data relating to the individual participants are included with the relevant school data. The chapter concludes with a summary section.

Chapter six presents the findings from phase two and three of the research as the participants responded to, and moved towards, the goal of the intervention. The first section provides an introduction and is followed by three sections, which each focus on a different participating school. Each of the three school sections present analysis of the participants' post workshop activity, their planned units of work, how they enacted their plans in the classroom, their changing views about the value of WBRs, changes in pedagogy, and their development of TPACK. The chapter concludes with a summary.

Chapter seven discusses the research findings in relation to relevant literature. After an introductory section, the second section discusses the participants' initial context and use of WBRs. This is followed by discussion of the principles underpinning the design of the intervention and then insights into the nature of change for individual teachers are discussed. The chapter concludes with a section summary.

Chapter eight begins with an introduction before presenting the conclusions that are drawn from the discussion in the previous chapter. The chapter goes on to discuss the implications of the research findings for ICT professional development, and the implications for teachers. The next section presents the limitations of the study, followed by suggestions for further research. Moving beyond web-based resources is the focus of the next section, and the chapter concludes with closing remarks.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents a review of key literature relevant to this research project. There are four areas that are the foci of this review. The first is technology education in the New Zealand curriculum, which is the subject context of the participants in this study. This section provides a background to the nature of the current revised curriculum and insight into some of the challenges facing teachers in this discipline area.

The focus of the second section is on theoretical perspectives of learning. This section provides an overview of the three main learning theories that have been evident in education since the beginning of the last century – behaviourism, cognitivism and constructivism. Constructivism and sociocultural theory are explored as relevant learning theories in contemporary education, and different approaches to integrating ICT in education are linked to these learning theories.

The third focus of this literature review is the integration of ICT in education, which relates to the main goal of this research. The disparity between the vision for ICT in education and the current reality that is dominant in classrooms both internationally and in New Zealand is explored. The significant challenge that integration poses for classroom teachers, both in terms of the broader knowledge base required and their role in effecting high-level uses of ICT, is considered providing some insight into the current status of ICT in education. Technological pedagogical content knowledge (TPACK) is introduced as an emerging framework for defining the complex knowledge requirements for effective ICT integration.

The fourth main focus of this chapter is teacher professional development. This section discusses teacher professional development in relation to changing theories of learning. It identifies characteristics associated with effective professional development, including ICT-related professional development, and aligns these with sociocultural theories of learning. Professional development approaches using the TPACK framework as a tool to support the development and/or analysis of teacher knowledge for effective ICT integration are also discussed. Section 2.5 provides a chapter summary.

The following figure provides a conceptual map of the literature review showing how it links and informs this research project.

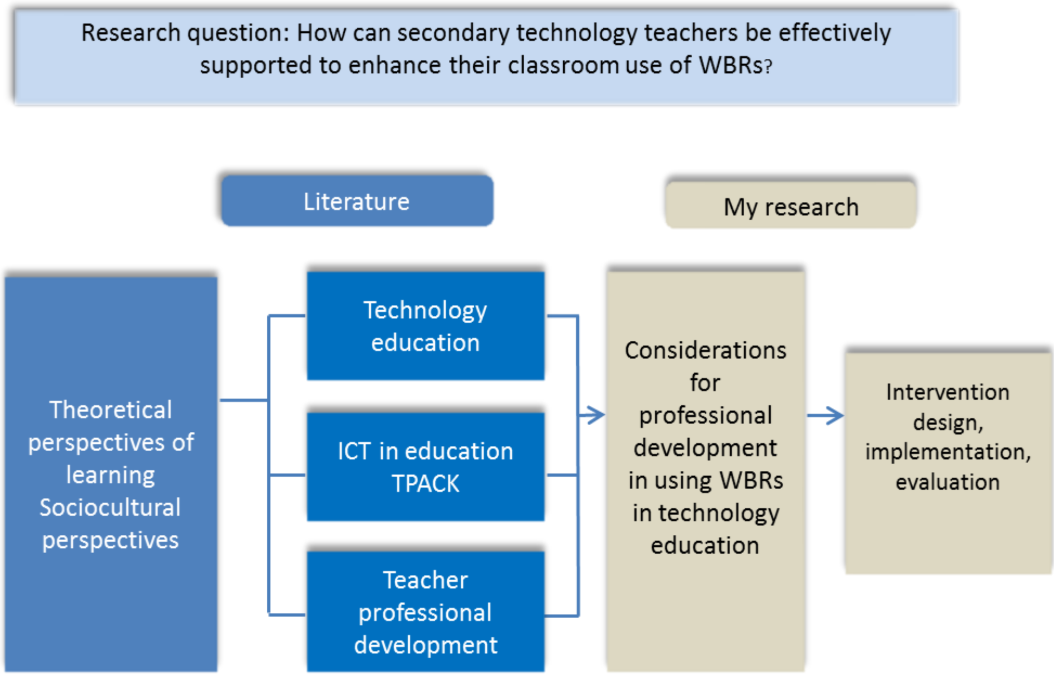

Figure 2.1. Literature conceptual map

2.1 Technology education in the New Zealand Curriculum

This section provides background to the implementation and development of technology education in New Zealand schools. As such it offers insights into the wider context within which the participants in this research were working and highlights some of the constraints and challenges impacting on teachers working in this subject domain. It goes on to identify the potential value web-based resources (WBRs) offer to support technology teachers in addressing some of the issues they are facing in implementing a relatively new subject area.

2.1.1 Terminology

This research involves teachers using computers and the Internet, often broadly referred to as *technology*, in the classroom. Given that these teachers are also teaching in the curriculum area of technology education, it is important for the purposes of this thesis to clarify the distinction between *technology used in education* and *technology education*. To complicate matters further, technology education tends to be taught in separate technological areas, generally by specialist teachers, and one of these is *information and communication technology* (ICT), more recently renamed *digital technology*. Other technological areas include *food technology, materials technology* and *structural technology* (although schools can choose their own names).

Technology in education refers to the use of technologies such as computer hardware and software, data projectors, digital cameras, etc., in the classroom for mediating the teaching and learning process. In contrast, *technology education*, as defined in the New Zealand Curriculum (Ministry of Education, 2007), refers to teaching and learning *about* and *in* technology. ICT, on the other hand, in the context of the technology curriculum refers to the development of solutions to needs and opportunities, where the outcomes are products generated through the use and manipulation of computer-based technologies. This thesis uses technology education to refer to the learning area and ICT for technologies used in education.

2.1.2 Technology education: a new curriculum

As indicated in Section 1.2.1, technology education is still a relatively new field of study in school curricula internationally, particularly when compared to more established subjects like science and history. Technology in the New Zealand Curriculum (Ministry of Education, 1995) has been part of compulsory education in New Zealand schools for less than two decades, introduced in 1995 and mandated for compulsory implementation in 1999.

Emerging from government and industry recognition of the relationship between technological development and economic growth, it arose from the need for all young people to develop a level of technological literacy to enable them to participate and contribute responsibly within a rapidly changing technological society. As De Vries and Tamir (1997) point out, quality of life in any society is directly related to how well people understand and use technology, as well as how they go about developing new technologies. However, as a society deeply dependent on technology we are largely ignorant about its nature and the factors underpinning its development (Compton & Jones, 2004).

Although aspects of technology education have existed in previous school curricula, mainly technical education, they have generally been narrow skills-based programmes (Jones, 1997; Jones & Compton, 2009). Participation tended to be gender-specific, often vocationally oriented, and linked to socioeconomic position and ability (Compton, 1997), and pedagogies were generally based on behaviourist theories of learning. While technical education may have been appropriate for an industrial society, it does not prepare all young people adequately for a rapidly changing technological society.

Technology education, based on a broad definition and underpinned by sociocultural learning theories, emerged as a separate subject in New Zealand as a result of curriculum reforms in 1990 (Jones & Compton, 2009). In New Zealand, generally, the responsibility for implementing this new curriculum in intermediate and secondary schools was taken up by home economics and workshop technology departments.

2.1.3 Challenges associated with implementing the 1995 curriculum

Implementation of technology education presented a significant challenge to schools, and in particular to the individual teachers charged with the responsibility of teaching the new curriculum. There was initial resistance to implementation in many secondary schools, and many remained noncompliant with the requirement for technology education to be compulsory for all students up to Year 10 (14-15 year olds) (Ferguson, n.d.). One of the major factors underpinning this resistance was the lack of understanding and range of views that existed about technology and technology education, and its purpose and value in compulsory education.

In the absence of specifically trained teachers, an established discipline and subculture of technology education, and ongoing professional development, early implementation varied, reflecting the range of teacher perspectives. Given that the teachers implementing technology education were mainly from traditional technical disciplines, the focus of their teaching tended to be on practical skills, and designing and making products (Jones, 1997), with concepts of technological knowledge and the nature of technology largely absent. Very few teachers had a broad view of technology. Teachers were in the beginning stages of becoming technology teachers, and with little collective, coherent technology education practice to guide them the tendency was to develop strategies for learning outcomes more closely associated with their traditional subject subculture (Moreland et al., 2001). The focus of teaching was on completing a task rather than on specific technological concepts, therefore the need for teachers to build a knowledge base in technology was clearly evident.

For secondary teachers from a technical education background a significant shift was needed from an emphasis on teaching predetermined skills and knowledge, with curriculum delivery embedded in behaviourist theories of learning, to technology education, based on constructivist and sociocultural learning theories. As Harwood and Compton (2007) argued, this is why it is so hard for teachers who have been trained to teach within a technical education framework to make the changes required to teach technology. Extensive professional development was needed to change the focus of teaching to include both predetermined and negotiated learning intentions in response to student needs and the particular project being undertaken. However, without a clear knowledge base in technology, such a significant change in pedagogy was difficult for many teachers.

Narrow concepts of technology among students also challenged teachers and affected student learning of technological concepts. Where students had a narrow focus on producing an end product, this expectation dominated their classroom practice, this challenged the teachers' ability to move on from their traditional focus (Mangan, 2000). In addition, student misconceptions can be particularly challenging where teachers' concepts are fragile (Jones, 2009b) and this was the case for many teachers who were charged with the responsibility of delivering the first iteration of the technology curriculum.

2.1.4 The National Certificate of Educational Achievement

The National Certificate of Educational Achievement (NCEA) was initiated in 2002 and phased in over three years. This qualification system replaced the previous School Certificate and University Bursary qualification, and also introduced technology education as a senior secondary school subject leading to a national qualification. Significantly, although traditional technical subjects had previously been available for the School Certificate examination at Year 11, there had never been a nationally recognised qualification for such courses at Year 13.

The introduction of NCEA required technology teachers to adapt their traditional senior level courses to meet the objectives of the 1995 curriculum. The alternative was to use the existing Unit Standards assessment system designed for the traditional, vocationally oriented skills-based courses, including Industry Training Organisation (ITO) Unit Standards. Some teachers who were still struggling to make the shift from their traditional subject background to technology education, continued with their traditional senior subjects rather than implementing NCEA technology education standards. Some trialled the standards in the early years but were disappointed with student results and subsequently reverted back to their traditional disciplines. Consequently there was wide variation in implementation and development of technology education programmes nationally, and in the development of skills, knowledge and confidence of the teachers delivering the programmes.

Teacher professional development was introduced to support NCEA in all subjects. This provided a valuable professional development opportunity in technology education for teachers who were implementing the Achievement Standards to not only develop their understanding of the new assessment system, but also to further develop their understanding of the subject content, purpose and pedagogy (Ferguson, n.d.). For a significant number of teachers, this was the first professional development they had received in technology education. While some teachers took up the challenge of developing their understanding, many continued to resist the new curriculum and chose not to implement technology Achievement Standards. As a result, these teachers missed out on an opportunity to enhance their understanding of technology education.

While teachers could choose to offer alternative vocational qualifications at senior level, schools were required to deliver the technology curriculum up to Year 10. However, senior programmes, and in particular the related national external assessment, had a significant influence on what teachers taught at junior level (Jones & Compton, 2009). Where teachers had participated minimally in professional development, or not at all, and resisted teaching NCEA technology, generally there was little change in their junior programmes. The implication in these cases was that there was likely limited ongoing development of teacher understanding of technology.

2.1.5 Reviewing the 1995 Technology Curriculum

A period of review of all learning areas in the New Zealand Curriculum Framework began in the early 2000s, to inform the development of a revised New Zealand Curriculum document. This included a review of the early implementation of technology education.

Student NCEA results in technology and findings from national research projects indicated that students' active participation in technological practice was increasing their engagement in technology education (Jones & Compton, 2009). However, results also indicated that teachers' understanding of the nature of technology was still limited (Compton & Jones, 2004) and student learning was largely focused on their own technological practice, and the nature of technological literacy developed lacked breadth, depth, and a critical dimension (Compton & France, 2007; Jones & Compton, 2009). These research findings suggested that technological practice on its own was not enough to develop students' technological literacy (Ministry of Education, 2012). This subsequently informed the restructuring of technology education in The New Zealand Curriculum (Ministry of Education, 2007).

2.1.6 The revised Technology Curriculum 2007

The focus in restructuring the technology curriculum was "to provide a stronger focus on the philosophical basis of technology and technological knowledge" (Jones & Compton, 2009, p. 7). The result was three new curriculum strands

(Table 2.1). The inclusion of the two strands: *Nature of Technology* (NoT) and *Technological Knowledge* (TK), reflect their importance in developing technological literacy and subsequently addressing the limitations of the earlier curriculum. The third strand, *Technological Practice* (TP), combined the original three strands from the 1995 Technology Curriculum (Ministry of Education, 1995) – *Technological capability*, *Technological knowledge*, and *Technology and society*. The three new strands are interrelated and the aim is to develop deeper, broader and more critical technological literacy (Compton & France, 2007).

Table 2.1. Technology curriculum strands and their components

Technological Practice	Technological Knowledge	Nature of Technology
Brief Development	Technological Modelling	Characteristics of technology
Planning for Practice	Technological Products	Characteristics of Technological Outcomes
Outcome Development and Evaluation	Technological Systems	

The challenge with the revised curriculum is to develop teachers' understanding of the two 'new' strands - NoT and TK – and how to integrate them into classroom programmes. The degree of challenge this posed for teachers was acknowledged by suspending the requirement for assessment of, and reporting on, the components of the two new strands for the first three years of implementation of the new curriculum (2007-2010). This provided time and space for teachers to trial activities and develop their understanding of key ideas in these two strands. Meanwhile, classroom research exploring progression in these components and pedagogical strategies (Compton & Compton, 2009), as well as resource development to support implementation, was ongoing.

Despite the clearer definition of these two new strands, just adding them to the curriculum does not guarantee that teaching and learning will change. In many New Zealand schools, emphasis remains on developing practical skills and knowledge with concepts of the nature of technology and subsequent development of technological literacy being limited (Compton & France, 2007; Lunt, 2009; Nicholl & McLellan, 2009). Teachers are still developing a robust understanding of technology and technology education and their existing perceptions are still likely to impact on how they incorporate the new strands into their teaching. For example, if teachers view technology education as ‘design and make’ their classroom activities and interactions will likely focus on these skills rather than on developing students’ understandings of aspects of the nature of technology (Buntting et al., 2015). Therefore, the need to support teachers to broaden their perceptions of technology and the nature of technology continues to be a critical factor in ensuring real change occurs.

Funding from the Ministry of Economic Development supported the development of the *Growth and Innovation Framework-Technology Initiative* (GIF-Technology), which enabled considerable investment in resource development and teacher professional development to support implementation of the revised technology curriculum over a ten year period (Jones & Compton, 2009). This investment provided valuable support and encouragement for teachers, and helped to identify and raise the profile of many examples of innovative programmes. This support, as well as more targeted graduate programmes for teacher training in technology education, is beginning to impact on classroom programmes (Jones & Compton, 2009). However, as emphasised by Jones, Buntting and de Vries (2013), continuing professional development remains imperative if progress in this discipline is to be maintained and the aim of a broad, critical technological literacy for all is to be realised.

2.1.7 Current issues in technology education

After years of research and development, a robust curriculum framework for Technology Education has been established in New Zealand (Jones & Compton, 2009). We also now have a recognised external qualification system that is endorsed for university entrance. These factors are gradually raising the credibility and understanding of technology education among technology and other subject teachers as well as students, parents and the wider school community.

However, despite the progress that has been made, the position of technology education in the school curriculum is still considered fragile (Jones et al., 2013). A range of factors continue to impact on the development and implementation of technology education. Jones et al. identify key areas that still need to be addressed as the limited expertise and confidence of teachers, funding for ongoing professional development, and the need to improve assessment and reporting.

Senior secondary qualifications are identified as an issue because of the strong influence that high stakes assessments can have on secondary school teaching programmes (Jones & Compton, 2009). What is defined to be assessed is a strong influence on what students, parents and teachers consider important for learning. The review of the Technology Achievement Standards and their realignment with the revised curriculum, which was phased in over three years from 2011, aimed to address this issue so that curriculum development was not compromised. Importantly, many of the revised and additional standards require an understanding of the components of the two new strands. However, developing teachers' understanding of the revised curriculum remains a major challenge (Jones & Compton, 2009). As Buntting, Williams and Jones (2015) point out, teachers' perceptions of the nature of technology are often entrenched, and changes in curriculum do not automatically change their understandings. Sustained professional development is needed to support the development of more robust philosophical understandings of the discipline.

The need to develop teachers' technology content knowledge and understanding of the nature of technology therefore still remains an issue for technology education in New Zealand, as well as internationally. The interdisciplinary nature of technology education; the importance of teaching in relevant and authentic contexts; the individual project-based approach at senior secondary level; and the need to explore historical as well as contemporary technologies and innovations and to forge ongoing relationships with practising technologists, communities of practice and other stakeholders all present considerable challenge to teachers in providing the breadth of knowledge students need access to in their technological practice as well as for expanding their own knowledge as technology teachers. The nature of the Internet and its increasing accessibility has the potential to effectively and conveniently meet many of the resourcing needs of technology education. For instance, rapid and flexible access of WBRs meets the need for just in time access to information to support the diverse knowledge needs of students undertaking technological practice (and developing their understanding in components of the other two strands), which often cannot be predicted. Furthermore, the need for technology students to work within relevant and authentic contexts also demands currency of information and access to communities of practice – needs that can often be more conveniently met by WBRs.

Creating links between teachers and technological communities has been strongly recommended since the first technology curriculum in New Zealand as a valuable means of developing teacher knowledge and concepts of technology, as well as providing enriching and authentic learning experiences for students (Buntting & Jones, 2012; Compton & Bell, 2012; Compton & Jones, 1998). Despite the value of accessing a community of practice, it poses significant difficulties for teachers, such as the time involved in establishing and maintaining effective relationships, and health and safety regulations impacting on industry visits (Buntting & Jones, 2012), as well as timetable constraints and the administration involved in taking a class off campus. Consequently, establishing a virtual link with communities of practice provides a more flexible and sustainable alternative (Buntting & Jones, 2012). Education websites such as the Biotechnology Learning Hub, the Science Learning Hub and Technology Online; industry and research institute websites; social media formats such as YouTube; and communication systems, such as email and Skype offer a wealth of opportunities for accessing communities of practice and possibilities are ever-increasing as Internet-based software continues to develop. However, developing the knowledge and skills required to integrate the Internet effectively in the classroom to enhance teaching and learning is far from a straightforward process.

2.2 Theoretical perspectives of learning

As the focus of this research is on teachers learning to integrate WBRs effectively in their classroom, it is necessary to discuss learning theory and to explain the theoretical perspective underpinning this research. Therefore, this section discusses how theories of learning have changed since the early twentieth century, in particular, how constructivist and sociocultural theories of learning have evolved. The section goes on to discuss learning theory as it relates to changes in the use of ICT in education, and positions this research in a sociocultural theoretical perspective.

2.2.1 From behaviourism to constructivism

When formal schooling began in the nineteenth and early twentieth centuries, little was known about how people learn (Sawyer, 2006). Education focused on basic literacy rather than how to think critically and solve complex problems (Bransford, Brown, & Cocking, 2000). Knowledge was perceived as a collection of facts – something static to be stored for later use and passed down through generations (Gilbert, 2013). The goal of education was to transmit knowledge to students, whose role it was to acquire the knowledge (Sawyer, 2006). This approach to schooling was based on the dominant views of knowledge and theories of learning at the time, and was considered appropriate for the industrial economy. In the twenty first century, preparing students to participate in a Knowledge Society demands vastly different and more complex knowledge and skills. At the same time, advances in the science of learning have resulted in new ways of thinking about learning more appropriate in a Knowledge Society (Sawyer, 2006).

Underpinned by advances in ICT and the Internet, information and knowledge are growing more rapidly than ever before. It is no longer possible for education to provide all the knowledge required to live and work successfully in contemporary society. Rather, education needs to help students to develop the necessary skills and abilities to be lifelong learners (Bransford et al., 2000; Sawyer, 2006). In a contemporary view, knowledge is conceived as dynamic and constructed through the process of solving authentic problems (Bolstad et al., 2012). It is only considered ‘knowledge’ when it produces something new (Gilbert, 2013). Closely aligned with changes in perceptions of knowledge are new theories of learning that have emerged from research in the latter part of the twentieth century.

Three broad learning theories were evident in education throughout the twentieth century: behaviourism, cognitivism and constructivism. These three theories align with the epistemological traditions of objectivism, pragmatism and interpretivism respectively (Dede, 2008; Siemens, 2004). In the objectivist tradition reality is assumed to be external and knowledge is gained through experience. In the pragmatist tradition, reality is interpreted and knowledge is negotiated through experience and thinking. Interpretivism assumes that reality is internal and knowledge is constructed.

Behaviourism was well established in education by the beginning of the twentieth century. Behaviourists viewed learning as observable behaviour change in response to external stimuli (Bransford et al., 2000). In this theory motivation to learn was assumed to be driven by rewards and punishment. The mind was viewed as a 'black box' with no consideration of thought processes occurring within it. Knowledge was considered to be a collection of facts and procedures. The teacher's role was to know these facts and transmit them sequentially to the learners. The learner's role was to absorb the knowledge and store it for later use. Models of pedagogy in this paradigm are sometimes referred to as instructionist or transmission models (Lai, 2008). Testing for success is based on what can be remembered by students. Key ideas about Behaviourism were formed from behavioural research with animals, with influential researchers including Pavlov, Thorndike, Watson and Skinner (Bransford et al., 2000; Mergel, 1998).

The influence of cognitivist theories emerged in the second half of the twentieth century. Contributing theorists included Bruner (1960), Mayer (1977) and Norman (1980) (Dede, 2008). In cognitivist theory the mind is no longer viewed as a black box, rather, the importance of internal mental processes is acknowledged. Learning is understood as processing information by identifying relationships between facts and building cognitive structures to store information for later recall (Good & Brophy, 1990). Learning is assumed to occur in the mind with little attention to the context in which occurs (Schunk, 2008). Pedagogy in both behaviourist and cognitivist approaches largely involves the transfer of predetermined content.

Constructivism is a broad theoretical perspective that represents a shift from an objective to a subjective view of reality. Constructivism was influenced by researchers such as Dewey, Piaget (Dede, 2008) and Vygotsky (Schunk, 2008) and began to impact education in the latter part of the twentieth century. Constructivist theory posits that learners construct personal meaning based on prior knowledge and beliefs, and new experiences. Primary assumptions of constructivist theory include that knowledge is embedded in the situation of its use and people are active learners who must construct knowledge for themselves. In a constructivist perspective, integrated curriculum and learner-centred principles are emphasised, and the teacher's role is not to deliver instruction but to structure learning experiences and challenge students' thinking to enable them to construct new knowledge (Dede, 2008; Schunk, 2008).

Constructivism has evolved to incorporate social constructivism, which recognises the role of social interaction in the learning process, and sociocultural theory, which focuses on the influence of the social and cultural context. Sociocultural theory was heavily influenced by the work of Vygotsky, which included development of the concept of the Zone of Proximal Development and the role of the more knowledgeable other. Sociocultural theory incorporates a range of interrelated and overlapping perspectives including situated cognition (J. Brown, Collins, & Duguid, 1989; Hennessy, 1993; Lave, 1991), distributed cognition (Cole & Engestrom, 1997), cognitive apprenticeship, the social nature of learning, and communities of practice (Collins, 2006; Lave & Wenger, 1991).

Theories of situated cognition (J. Brown et al., 1989), more recently referred to as situative perspectives (e.g., Greeno, 2006; Putnam & Borko, 2000), challenge earlier assumptions that cognition and learning are processes that occur in the individual and are independent of the context in which they occur. Rather, situative perspectives assume that the physical and social contexts in which learning takes place are an integral part of what is learned. Situative perspectives highlight the importance of authentic activities, defined by Brown et al. (1989) as those that are similar to what actual practitioners do rather than school activities, which tend to be unrelated to the culture of a subject domain out of school.

Sociocultural theory highlights the social nature of learning and the important role of others in the learning process (Lave, 1991; Lave & Wenger, 1991; Resnick, 1991). Rather than learning requiring individual construction of knowledge, people's interactions with others and the environment are considered to play a key role. The social nature of learning and the importance of enculturation in the discourse and practice of a particular community is highlighted in literature focusing on learning through participation in communities of practice (Lave, 1991; Lave & Wenger, 1991).

Important studies informing sociocultural theory explore young children's learning of their first language, learning in non-school settings and how apprentices learn on the job (Sawyer, 2006). The research shows that learning outside of school happens in a complex social environment through collaborative social interaction in authentic situations through continued situated use (J. Brown et al., 1989). Brown et al. argue that in contemporary schooling students engage in the culture of school life rather than the culture of the subject domain. This prepares them to pass exams but not to use domain knowledge in authentic practice. These views signify the importance of authentic contexts for learning in schools.

2.2.2 Learning theories and ICT

Research over thirty years of ICT use in education indicates that different approaches to using ICT align with the changing theories of learning. Lai (2008) describes the changes as evolving from the initial computer-assisted instruction (CAI), involving drill and practice in the 1970s and 1980s, to computer-enhanced instruction, including intelligent tutoring systems (ITS) and ICT as a tool to enhance classroom tasks, such as word processing to enhance presentation and spreadsheets to add efficiency. From the mid-1990s and beyond, the Internet has enabled communication, networking and self-publishing, and is now increasingly being used to support problem-based learning and knowledge-creating learning environments.

The first of the above approaches, CAI, used educational software that was developed based on behaviourist theory. An example of this is 'drill and skill' instructional programmes, which present a series of problems to which incorrect responses receive immediate feedback such as a message or animation to indicate a wrong answer (Dede, 2008). The emphasis of CAI approaches is on transmitting factual knowledge and simple skills and procedures. In this approach, the computer is used as a tutor to supplement or replace conventional teaching (Lai, 2008). As Dede points out, this approach falls short of enabling the more complex knowledge and skills with real-world application expected in contemporary education.

Intelligent tutoring systems (ITS) allow more complex processing and are designed to support problem-solving and reasoning. ITS approaches align with cognitivist theory, but, they have not been widely used (Lai, 2008). From the late 1980s, ICT has been mostly used to enhance classroom tasks, such as the use of word processing and presentation software – also known as computer-enhanced instruction (Lai, 2008). In contrast, computer-supported collaborative and knowledge-creating approaches enabled by the Internet reflect social constructivist views of learning and are more in line with the transformational vision for ICT (Dede, 2008; Lai, 2008).

Computer-assisted and computer-enhanced instruction reflect *technocentric* approaches to integrating ICT, where ICT is essentially an add-on to teachers' traditional practice and pedagogy remains largely unchanged. *Technocentrism* is a term coined by Papert (1987) and reflects a focus on technical skills and acquiring information rather than fostering independence and empowerment. Technocentric approaches are also referred to as low-level uses of ICT, or what Hughes (2005) refers to as replacement and amplification approaches. Hooper and Rieber (1995) align such low-level uses with the first two stages (Familiarisation and Utilisation) of their five step model of technology adoption. In these two approaches technologies are viewed as machines to support established classroom practices, largely based on behaviourist pedagogies. The contemporary vision for ICT in education is for transformational (Hughes, 2005), high-level uses of ICT that require future-oriented pedagogies and reflect the transformational impact of ICT on our lives outside of school. In Hooper and Rieber's model, these high-level uses align with stages four and five of technology adoption (Re-orientation and Evolution), which reflect more constructivist pedagogies.

Constructivism and social constructivism are widely viewed as more relevant theories in contemporary education and a significant body of literature links the vision for effective ICT integration with constructivist pedagogy (e.g., Albion & Ertmer, 2002; Becker & Ravitz, 2001; Ertmer, 2005; Palak & Walls, 2009; Sawyer, 2006). Emerging theories, which focus particularly on the transformative affordances of ICT, include connectivism (Siemens, 2004), navigationism (T. Brown, 2006) and knowledge building (Scardamalia & Bereiter, 2006).

It is also important to acknowledge that cognitive science continues to evolve (Bransford et al., 2000; T. Brown, 2006; Scardamalia & Bereiter, 2006; Siemens, 2004), and that social, economic, political and technological change is ongoing; as is education research and reform. These areas all contribute to recent literature exploring learning needs for the twenty first century and a Knowledge Society (Bolstad et al., 2012; Bransford et al., 2000; Voogt, Erstad, Dede, & Mishra, 2013). Hence, the term *twenty first century learning*, which encompasses key assumptions of constructivism and the need for a more holistic view of learning, is increasingly used in contemporary education research and policy. Emerging technologies are acknowledged as integral to a future focused education system.

In summary, a broad vision for ICT use in education is underpinned by constructivist theory, in particular social constructivism and sociocultural theory and all the perspectives they encompass. Sociocultural views of learning including situated cognition, distributed cognition and cognitive apprenticeship are not only highly relevant in Internet mediated learning, but also align with the ideals of the New Zealand Curriculum (Ministry of Education, 2007), theories underpinning technology education in the New Zealand Curriculum and teacher professional development. Hence, a sociocultural perspective is adopted in the design and methodology of this investigation.

2.3 ICT in education

This section explores literature focusing on ICT integration in education. The disparity between a transformative vision for ICT in education, the technocentric uses that are dominant in classrooms and the learning theories underpinning different approaches are considered. The significant challenge that integration poses for classroom teachers, both in terms of the broader knowledge base required and the teacher's role in effecting high-level uses of ICT, is discussed and provides insights into the current status of ICT in education.

2.3.1 Terminology

Section 2.1.1 highlighted the distinction between *technology used in education* and *technology education* – the discipline area of the participants in this study. This section considers a range of terms and the various interpretations that are used in literature with reference to computers and the Internet, and their use in education.

General terms such as *technology* and *educational technology* are commonly used in education literature to refer to computers and the Internet. However, they are broad terms that can also refer to any technologies, digital or non-digital, including items such as overhead projectors, televisions, cameras and data projectors. *Information technology* (IT) and *information and communication technology* (ICT) are more specific terms, also commonly used with regard to computers and the Internet. IT refers to anything related to computing technology, such as networks, hardware, software, and the Internet. ICT tends to be used more broadly, referring to technologies that provide access to information through telecommunications including Internet, cell phones, radio and television. The terms IT, ICT and technology are often used interchangeably. Terms such as *digital technologies, digital media, emerging technologies* and *new technologies* are also commonly used in literature relating to IT and ICT and their integration into education.

E-learning is defined in the New Zealand Curriculum as "learning that is supported by or facilitated by ICT" (Ministry of Education, 2007, p. 36). *Online learning* and *web-based learning* both refer to learning that is facilitated by the Internet. These two terms were initially introduced in relation to distance learning and are still commonly used with that meaning. They can both be subsumed into e-learning but their meaning is not as broad. *Online resources, Internet resources,* and *web-based resources* (WBRs) refer more specifically to resources that are accessed using the Internet.

Web 1.0 and *Web 2.0* are terms coined to refer to different iterations of the World Wide Web. *Web 1.0* refers to the first generation web introduced in the 1990s. Web 1.0 is largely a *read-only* platform where the user is a passive consumer of information with little opportunity to create content or interact with other users. Over the last decade or so the nature of the Internet has been transformed to a *read-and-write* facility, which became known as Web 2.0 in 2004. Precise distinctions are difficult to make because technologies evolve over time and some sites involve a blend of Web 1.0 and Web 2.0 (Greenhow, Robelia, & Hughes, 2009). However, a key difference is that Web 2.0 allows users to create content and to interact with other users. Social media sites such as Facebook and YouTube exemplify the different functionality of Web 2.0. As Greenhow et al. (2009) explain, in Web 2.0 "knowledge is decentralised, accessible and co-constructed by and among a broad base of users" (p. 247). Further developments in Web technology have led to Web 3.0 and beyond, however, these are not relevant in the context of this thesis.

In this thesis the term ICT is used predominantly as a general term to refer to computers and the Internet, although various other terms will appear as appropriate in reviewing literature. The term WBRs is used to refer to information and resources that are accessed through the Internet. The integration of WBRs, as distinct from ICT, is the focus of this research. However, as for ICT, other terms such as Internet resources and online resources will also be used as they occur in the literature.

2.3.2 ICT transforming society but not education

As highlighted earlier in Section 1.2.2, ICT, particularly since the introduction and rapidly increasing scope of the Internet, has fundamentally changed the way we communicate, work and do business and a similar transformation is expected in education in order to prepare young people to contribute to a Knowledge Society. However, despite the acknowledged potential of ICT and significant investment in digital resources in schools, generally there has been limited change in education (Bolstad et al., 2012; Lai, 2008; Lai & Pratt, 2007; Somekh, 2008).

The shift to a Knowledge Society reflects massive and ongoing economic, social, political and technological changes and exponential increases in the gathering and sharing of information – much of which is mediated by the Internet. It is well established that young people today will need a different set of capabilities to live and work successfully in a Knowledge Society, and that meeting the needs of these learners requires a significant shift in our education system (Bolstad et al., 2012; Gilbert, 2013). In the same way that ICT and the Internet underpin the Knowledge Society, the vision for ICT is integrally linked to changes envisioned for education. This is also reflected in The New Zealand Curriculum (NZC), where the vision is for school leavers to be “young people who will be confident, connected, actively involved, lifelong learners” (Ministry of Education, 2007, p. 7). Furthermore, the *E-Learning Action Plan*, contributes to the Government’s overarching goal “to build an education system that equips New Zealanders with 21^{st} Century skills through the increased use of e-Learning in school” (Ministry of Education, 2006, p. 4).

Papert (1994) aptly describes the nature of the change needed to match the impact of ICT on society as a ‘megachange’ in teaching and learning. This is supported in more recent studies that identify critical gaps between contemporary education and the needs of twenty first century learners (e.g., Bolstad & Buntting, 2013; Noss et al., 2012; Shear, Gallagher, & Patel, 2011). As Shear et al. (2011) suggest, most students today are still knowledge consumers rather than problem-solvers, innovators and producers – capabilities considered critical for our future workforce. It is these capabilities that can be more readily developed by innovative pedagogy that integrates transformative use of ICT.

2.3.3 The reality lags behind the vision

The word *transformation* is commonly used in connection with expectations of the impact of ICT in education. Use of the term implies radical change or metamorphosis, rather than just change or improvement (Fisher, 2006). However, while the vision for ICT integration is to transform education, this doesn’t reflect the current reality. Despite heavy investment in resources and connectivity to support the integration of ICT in schools, a large body of research describes predominantly low-level uses and limited pedagogical change both internationally (e.g., Ertmer, 2005; Harris & Hofer, 2011; Harris, Mishra, & Koehler, 2009; Ho & Albion, 2010; Koehler & Mishra, 2008), and in New Zealand (2020 Communications Trust, 2011, 2014; Lai, 2008; Lai & Pratt, 2007; Wright, 2010).

Early approaches to ICT integration (see Section 1.2.2) reflected a deterministic view of ICT, where the power to improve education is credited to the technology (Fisher, 2006). As Fisher argues, in this view, the role of teachers and the complexities of individual settings are rendered invisible. This approach resulted in ICT being underused in classrooms and low-level uses (as described in Section 2.2.2) dominating. Pedagogy remained largely unchanged and there was little evidence of improved student learning, or radical change in classroom teaching (Cuban, 2001; Cuban et al., 2001; Fisher, 2006). Fisher describes the change that has occurred as infusion of ICT in education, rather than radical change, which use of the term transformation implies.

The need for teacher professional development to support ICT integration is clear. However, early approaches to ICT professional development were mostly generic and focused on how to use hardware and software rather than developing effective pedagogy, and understanding the value of using ICT (Lai, 2001). There was little concern for how needs and uses might vary in different subject domains and classroom contexts (Thompson & Mishra, 2007; Wallace, 2004). These approaches were based on the assumption that if teachers had the resources and had computer skills they would automatically be able to use ICT effectively in their teaching (Wallace, 2004), and also that they should use ICT just because it is available (Lai, 2001). As Lai cautions, teachers will be reluctant to make the effort to integrate ICT if they don't perceive its value for learning.

The limited impact of ICT in education, juxtaposed with the embedding of constructivist and twenty first century learning theories in curriculum policy has led to shifts in focus of research and professional development. As pointed out in Section 1.2.2, a significant body of research now identifies the importance of pedagogy and constructivist theories of learning in effecting transformative use of ICT and better meeting the needs of twenty first century learners (Albion &

Ertmer, 2002; Becker, 1999; Lai, 2008; Lai & Pratt, 2007; Voogt, 2008, 2010; Wright, 2010).

The need for pedagogical change is highlighted by studies of teachers who are frequent and/or exemplary users of ICT. Many of these studies suggest a strong link between teachers' constructivist beliefs and using technology to support student-centred practice (e.g., Becker & Ravitz, 1999, 2001; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Somekh, 2008; Voogt, 2010). Although many such studies have shown the potential of ICT to transform teaching and learning in the way that has been envisioned, the studies are mostly small-scale and often limited to enthusiast teachers. In addition, many of the studies are conducted in schools or classrooms that are particularly well-equipped with ICT and many also involve considerable support from outside experts. Voogt (2008) attributes the difficulty of scaling-up successful projects to regular classrooms to the fact that ICT use is generally limited and embedded in traditional pedagogical approaches more aligned with behaviourist and cognitivist theories, which remain dominant in education.

Now that twenty first century skills are increasingly recognised in curriculum policy, Ertmer et al. (2012) suggest that administrative support for implementing strategies to help students develop these skills may also increase. Ertmer et al. argue that with ICT use being integrally linked with twenty first century learning and becoming more ubiquitous in our lives, it is possible that as teachers develop their pedagogy towards twenty first century ideals they may begin to view ICT as a more relevant and valuable tool for supporting student learning. As all these changes evolve, more teachers may become empowered to use ICT in transformative ways. As Bolstad et al. (2012) point out: "The role of new technologies in transforming teaching and learning for the twenty first century is heavily dependent on educators' abilities to see the affordances and capacities of ICT in relation to all of the features of twenty first century learning" (p. 59).

A substantial UK study by Noss et al. (2012) explored the affordances of digital technologies to support twenty first century learning and suggested 12 key themes and recommendations. Themes such as *connect, share, apply,* and *construct*, and their subsequent recommendations suggest means of exploiting the affordances of ICT in ways that better align with contemporary learning theory. For example, expanding the use of personal ‘smart’ devices is recommended to increase connectedness in education enabling students to be engaged in productive learning both within and beyond the classroom. Use of social media is promoted as an effective means of making learning more socially constructed, and better supporting sharing and collaborative learning. Digital technologies can provide expanded opportunities for students to apply new knowledge to solving real problems making learning relevant and authentic (e.g., using computer-based simulations and augmented reality). Furthermore, computers now make it possible for anyone to construct things that could previously only exist in people’s minds (e.g., with 3-D graphics and 3-D printing). Constructing something provides a tangible entity “to talk about, reflect upon and ultimately learn with” (Noss et al., 2012, p. 55).

Although such studies highlight potential uses of technology such as those outlined above, there is evidence that these are not yet being widely exploited in the classroom, as mentioned earlier in this section. Developing the knowledge and skills required to integrate new technologies in transformative ways is far from a straightforward process and many barriers continue to hinder the vision for ICT being widely realised in classrooms.

2.3.4 ICT integration in New Zealand schools

A key focus of the New Zealand Government’s national ICT strategy launched in 1998 was to build capacity in schools (see Section 1.2.2). This led to the establishment of a number of centrally funded projects to support teachers’ skill development and increasing classroom use of ICT over the following decade.

In the Ministry of Education’s first ICT strategy publication in 1998: *Interactive education: An Information and Communication Technologies strategy for schools*, the government committed to the development of ICT capability and infrastructure in education (Ham, 2010). Key projects funded under this initiative included a professional development programme for principals, a three year teacher professional development programme in 23 school clusters (ICT PD

School Clusters) and the development of an online resource centre for teachers, *Te Kete Ipurangi* (TKI). A second strategy document published by the Ministry of Education in 2002: *Digital Horizons: Learning through ICT* committed to the continuation of previous projects, and a number of new initiatives – two of these were the *e-Learning Fellowships* and the *TELA Laptops Scheme*. The third key policy document was *Enabling the 21st Century learner: An e-Learning action plan for schools, 2006-2010* (Ministry of Education, 2006). The focus of this strategy document was similar to previous ones but with more emphasis on supporting e-learning collaborations between schools and communities, reflecting the emergence of Web 2.0 technologies.

The impact and implementation of the national ICT strategy is reviewed in the book: *eLearnings: Implementing a national strategy for ICT in education, 1998-2010* (Ham & Wenmoth, 2010). In this book, while Lai (2010) reported improvements in teachers' ICT knowledge and skills, and changes in attitudes towards using ICT, overall he identified a lack of evidence about the impact on teaching and learning. Lai warns that increases in teachers' knowledge, skills and confidence may not necessarily translate into changes in pedagogy. He suggests deeper analysis of the impact is needed in order to evaluate teacher beliefs and any change in pedagogical practices. A three-year study investigating the teaching and learning effects in 26 secondary schools in Otago (2001-2004) suggested there was little change in teachers' pedagogy (Lai & Pratt, 2007). Rather, the greatest impact was perceived as increased efficiency of management and administration, and teachers considered improved presentation was the greatest impact on student learning.

Similarly, Billowes and Alexander's (2010) evaluation of the ICT PD Clusters' programme, indicated that in the first decade, although some schools focused on pedagogy, there was a significant emphasis on building infrastructure and skill development in many schools, particularly prior to the TELA Laptops scheme. While the TELA Laptops scheme and the ICT PD led to a general increase in teachers' ICT skills (Cowie et al., 2007), Billowes and Alexander point out that more than fifty percent of teachers still identified technical upskilling as their main goal for professional development. They attributed this partly to the age of many teachers (around fifty percent aged 40-59 years) and partly to the rapid and ongoing development of ICT. Billowes and Alexander advocate for a shift in the focus of professional development away from technical skills to developing pedagogy. In support of this they maintain that as long as teachers have enough skills to guide classroom activities, they don't need to be ICT experts.

As mentioned in Section 1.2.2, the national survey of ICT in New Zealand schools suggests that classroom ICT access may still be limited, with student computer ratios remaining unchanged since 2007 (2020 Communications Trust, 2014). The 2014 report indicates that increasing student or parent ownership of digital devices may be influencing schools' decisions not to increase spending on computers for students. In addition, there is evidence of schools beginning to introduce *Bring Your Own Device* (BYOD) policies, although this is still in its infancy, which may lead to a decrease in the number of computers schools purchase for students in favour of increasing use of student or parent-owned digital devices in the future.

Teachers' adoption of ICT was categorised in the New Zealand surveys using an instrument developed by Christensen and Knezek (1999). In 2011, 46 percent of secondary teachers were identified as being at Stage four (familiarity and confidence) on a six point scale, 31 percent at Stage five (adaptation to other contexts), and 10 percent at Stage six (creative application to new contexts) (2020 Communications Trust, 2011, p. 99). This represented a decrease of teachers at Stage five or six since 2009, with corresponding increases at the lower stages – Stage three (understanding and application of the process) and Stage four. In 2014, results indicated a further decrease at Stage five (18%) and six (3%), similar numbers at Stage four, and increased numbers at Stage three compared to 2011 (2020 Communications Trust, 2014, p. p.81). A suggested reason for this regression in teachers' adoption of ICT was the rapid and ongoing development in technology.

Furthermore, national survey data in 2011 and 2014 indicated that student use of WBRs in schools was not extensive, and while e-learning was reported to be generally engaging students, findings suggested that impact on student achievement was more limited (see Section 1.2.2).

Research clearly suggests that many barriers continue to hinder the transformative vision for ICT being realised in the classroom, as explored in the next section.

2.3.5 Barriers and enablers

A large body of literature has identified barriers that inhibit teachers' use of ICT in education and sustain the low-level uses that dominate (e.g., Ertmer, 1999; Hew & Brush, 2007; Jones, 2004). Identification of barriers has led to various strategies being proposed for overcoming the barriers and supporting more effective integration of ICT.

Barriers

Barriers are often classified as either external, also referred to as first order, or internal, second order barriers (Ertmer, 1999; Hew & Brush, 2007; Jones, 2004). First order barriers are factors relating to the school. They are extrinsic to teachers and hence generally outside their control. They include lack of resources, ineffective training, lack of support and lack of time to develop skills and confidence (Ertmer, 1999; Hew & Brush, 2007; Jones, 2004; Mumtaz, 2000). Many studies also identify curriculum and assessment as external barriers, as despite shifts in learning theory, curriculum and assessment policy has remained largely unchanged from industrial age approaches where prescribed content and high stakes assessment dominated (e.g., Hennessy, Ruthven, & Brindley, 2005; Hew & Brush, 2007; Somekh, 2008). In addition, subject culture, according to some researchers, can create resistance to using ICT in some subjects and a sense of ownership in others where there is greater connection between the subject's history and ICT practice, such as business studies (Hew & Brush, 2007; Selwyn, 1999).

Second order barriers are intrinsic to the teacher. They include lack of teacher knowledge, skills and confidence in using ICT and negative teacher attitudes and beliefs about the value and use of ICT in education (Ertmer, 1999; Hew & Brush, 2007; Jones, 2004; Knezek & Christensen, 2008; Mumtaz, 2000; Somekh, 2008).

Attitudes relate to people's positive or negative feelings towards something, and are generally underpinned by people's beliefs and values (Hew & Brush, 2007). Teachers' pedagogical beliefs include beliefs about cognition and learning, the purposes of education, the purposes and nature of their subject and how their subject should be taught. These beliefs influence teachers' pedagogical practices. Teachers' beliefs about the relevance and value of ICT also influence their attitudes towards ICT for teaching in general and their subject in particular.

First order barriers are considered more straightforward to address than second order barriers as generally they can be overcome by providing more resources and training. However, as already mentioned (see Section 1.2.2); simply providing more resources, which was the focus of much of the early intervention to enhance integration, does not automatically lead to significant change in pedagogy. Rather, first order changes on their own often lead to only minor adjustments to teachers' practice (Ertmer, 1999). As Wright (2010) cautions "teachers who use digital tools to replace older technology, but use them without altering their pedagogy, will have minimal effects on learning" (p. 38). These approaches reflect technocentric uses and leave teachers' underlying beliefs unchanged. Hence they fail to achieve the transformative vision for technology integration.

Second order barriers are generally considered much more difficult to address than first order barriers because they involve challenging teachers' fundamental beliefs about pedagogy (Ertmer, 1999, 2005). Teachers' beliefs are likely formed through personal experience over many years, first as a school student, and later as a teacher, where they are reinforced by routines of practice in their subject discipline and by the expectations of students (Albion & Ertmer, 2002). Beliefs act as filters when people process new information and therefore early experiences impact on people's perceptions of subsequent events. People filter new information through their belief systems before gradually constructing new knowledge, and therefore changing beliefs is a slow process (Ertmer & Ottenbreit-Leftwich, 2010). For teachers who continue to hold more traditional pedagogical beliefs, a radical shift is required to integrate ICT effectively. For these teachers, addressing first order barriers alone is insufficient, as it is the combination of the technology tools and teachers' pedagogy that is at the heart of effective integration (Wright, 2010). Hence, teacher beliefs are critical in effective technology integration.

While the provision of ICT resources and connectivity in schools has significantly increased in New Zealand and many other countries in recent years, research suggests that these and other external barriers still exist (2020 Communications Trust, 2011, 2014; Becker, 2000; Bolstad et al., 2012; Ertmer et al., 2012; Somekh, 2008). Hence, even when teachers already hold student-centred beliefs, first order barriers such as pre-determined curricula and assessment practices, as well as time and access constraints can inhibit the use of student-centred classroom practices when integrating ICT (Somekh, 2008).

Many studies also show that complex interrelationships exist both within and between various internal and external barriers (Ertmer, 1999; Hew & Brush, 2007; Jones, 2004; Zhao & Frank, 2003). These interrelationships add to the complexity of devising strategies to increase and enhance integration of ICT. They may also help to explain why it is so difficult for teachers to integrate ICT, and hence why the pace and nature of change has been limited. Clearly, addressing one barrier alone without considering how it may interact with other barriers is unlikely to achieve significant change.

Enablers

A significant body of literature identifies enabling factors and strategies that support effective integration of ICT. Often enablers are the opposite of barriers but, as suggested above, no single enabling factor on its own is likely to lead to significant change. Rather, strategies for overcoming barriers generally include various combinations of factors.

Change in teacher pedagogy is clearly the ultimate requirement for effective integration of ICT and there is considerable consensus that focusing on changing teacher beliefs is central to developing more student-centred pedagogies (e.g., Bolstad et al., 2012; Ertmer et al., 2012; Ertmer & Ottenbreit-Leftwich, 2010; Falloon, 1999; Voogt, 2010). Generally, research identifies a range of factors, both external and internal, together with changing teacher beliefs, as important in enabling successful integration. These include:

- developing teachers' ICT knowledge, skills and confidence;
- teachers being professionally engaged and committed to student learning and to their own self-development;
- positive teacher attitudes towards ICT and perceptions of the relevance and value of ICT to their subject;
- teacher support and professional development;
- convenient and equitable access to ICT for teachers in all subject areas;
- better alignment of curriculum and assessment policy with social constructivist and twenty first century views of learning; and,
- school vision and leadership.

Teacher beliefs about the value and relevance of ICT for teaching in their subject affect their attitudes towards technology and are also considered to be influential in their decisions about if, when and how to use ICT in the classroom (Baggott La Velle, McFarlane, & Brawn, 2003; Christensen & Knezek, 2008; Ertmer, 1999; Ertmer et al., 2012; Hew & Brush, 2007; Somekh, 2008; Zhao & Frank, 2003). Because a large proportion of current teachers did not experience using ICT in their own schooling, it is unlikely that they will have prior experiences upon which to build conceptions about how it should be used in teaching (Ertmer, 2005). Hence teachers' perceptions and beliefs about using ICT are likely to differ in terms of how they view the relevance, value and purpose of using ICT in education and how it might be used in the classroom.

Research also indicates close links between teachers' beliefs and attitudes and their competence and confidence using ICT (Christensen & Knezek, 2008; Ertmer et al., 2012; Ertmer & Ottenbreit-Leftwich, 2010). In a small study of award-winning ICT-using teachers Ertmer et al. (2012) concluded that increasing teachers' knowledge and skills may be the best way to enhance integration because of the potential this has to positively influence teachers' attitudes and beliefs. However, some researchers suggest that teacher self-efficacy may be the most critical factor (Albion & Ertmer, 2002; Ertmer & Ottenbreit-Leftwich, 2010). These researchers argue that even though a teacher may believe in the value of integrating ICT, this may not be sufficient if they lack the confidence to implement it in the classroom. Christensen and Knezek maintain that computer anxiety is less of an issue for teachers now except for those who are true novices in terms of their ICT knowledge and skills.

Three strategies suggested for increasing teacher confidence align with suggested strategies for promoting change in teacher beliefs about teaching and learning in general, and about ICT specifically. These include: personal experiences, vicarious experiences and sociocultural influences (Albion & Ertmer, 2002; Ertmer, 2005; Ertmer & Ottenbreit-Leftwich, 2010). When teachers have opportunities to gain personal experiences that are successful, this can increase their confidence and lead to changes in beliefs. In particular, observing how ICT can facilitate student success can be a powerful motivator for change. Vicarious experiences, such as observing others' successful teaching, can increase teachers' perceived need for change and help to convince them that change is possible and beneficial. Furthermore, teachers' practice and beliefs are not only shaped by their own experiences but also by those around them and therefore they can be influenced by others in the sociocultural setting. It is also possible that attitudes may generally become more positive over time, with ongoing training and experience helping to increase competence for many teachers (Christensen & Knezek, 2008; Cowie et al., 2007).

A combination of adequate teacher ICT knowledge and skill, sufficient classroom access to computers and student-centred pedagogy is commonly identified as important for successful integration (Becker, 2000). Teacher motivation and commitment to student learning, as well as teacher professional engagement and commitment to their own development, are also identified as contributing factors (Becker & Ravitz, 2001; Mumtaz, 2000; Voogt, 2010). Becker and Ravitz describe professional engagement as frequent involvement in professional activities, such as substantive conversation and classroom observation with peers, participation on committees, mentoring and giving workshops.

Some argue that the affordances of digital technologies themselves may help disrupt teacher-centred practice and support change in the teacher's role in the classroom, gradually influencing pedagogical change (Baggott La Velle et al., 2003; Becker & Ravitz, 1999; Somekh, 2008; Webb & Cox, 2004; Wright, 2010). For example, Becker and Ravitz's (1999) survey research in 153 schools in the United States showed a clear link between teachers' sustained use of computers and the Internet, and an increase in constructivist teaching practices and potentially also their underlying pedagogical beliefs. However, Becker and Ravitz (1999) indicated that there were favourable conditions in the participating schools involved in terms of technological infrastructure and social support networks, which must also be taken into consideration. Furthermore, they suggest there is uncertainty about whether these teachers were already inclined towards a constructivist pedagogy and access to technology supported this shift, or whether the experience itself led teachers to change their pedagogic philosophies. Wright (2010), in her e-learning literature review, suggests that student-centred pedagogies may develop because they are a better fit with the way students prefer to use technologies. While Webb and Cox (2004) also agree that there is evidence of this effect, they suggest that it may not be widespread and it is likely that teachers' beliefs as well as their knowledge of affordances of ICT are contributing factors.

Teacher support, both external and in-school, is commonly identified as a contributing factor in successful integration. Many studies emphasise the importance of leadership and creating a shared vision for ICT integration in schools (e.g., Cowie et al., 2007; Ertmer & Ottenbreit-Leftwich, 2010; Hew & Brush, 2007; Somekh, 2008). Also recommended are professional learning networks, and opportunities to collaborate with other teachers both in their own and other schools. Onsite collaboration, such as ongoing conversations with colleagues, shared planning and sustained supportive networks, are important in supporting teachers to critically analyse and improve their practice (Ertmer, 1999; Ertmer et al., 2012; Hennessy et al., 2005; Mitchell, Bailey, & Monroe, 2007; Voogt, 2010). Cowie et al.'s (2007) evaluation of the New Zealand TELA laptops scheme also found that teachers identified collegial support as the most valuable professional development for using ICT, especially when it was from same-subject colleagues. Some researchers advocate for teacher support and ICT professional development to have a more explicit focus on developing teacher pedagogy (Billowes & Alexander, 2010; Bolstad et al., 2012; Palak & Walls, 2009).

In terms of developing teachers' pedagogy and perceptions of the value of ICT, some argue that the best approach is to provide time for teachers to explore the affordances of ICT through play (Somekh, 2008; Zhao & Frank, 2003). These studies suggest that by exploring the affordances and gaining experience using ICT, teachers begin to build mental models of their use, which enable them to imagine new ways of using them. Zhao and Frank (2003) also suggest that teachers may change their pedagogical beliefs in this way and begin to see more uses for and benefits of using ICT in their teaching. They suggest that when teachers do not have sufficient time or access to explore the tool they begin by trying to fit it into their existing practices, which results in low-level uses. Having flexibility in where and when teachers could use their laptops was also reported as an important factor in supporting teacher development of ICT knowledge and skills in the New Zealand TELA laptops scheme (Cowie et al., 2007).

While huge investment has been made in increasing access to ICT and the Internet in schools over several decades, and on the whole it is considered to be less of an issue in recent times, access is still considered a constraint by many teachers. Hence, improved access is commonly included with other enabling factors in successful integration (Baggott La Velle et al., 2003; Becker & Ravitz, 2001; Bolstad et al., 2012; Hew & Brush, 2007; Jones, 2004; Mumtaz, 2000). However, as already mentioned, as BYOD policies (still in their infancy in New Zealand schools) are increasingly implemented in schools, access barriers may decrease (see Section 2.3.4).

Access to resources is more complex than just providing computers in schools. How those resources are organised is also important. Selwyn (1999) stresses the importance of making ICT easily accessible for all subjects to use. When computer access is only available in computer labs, this can make them much less accessible for some subject teachers than for others, as was the case in this study.

Research suggests that having computers in both labs and the classroom more effectively supports integration in non ICT classes (classes where ICT is not the subject focus), (Becker & Ravitz, 2001; Jones, 2004; Selwyn, 1999; Zhao, Pugh, Sheldon, & Byers, 2002). Becker and Ravitz (2001) found that providing four or five computers in each classroom led to more frequent use than when access was only available in computer labs. Papert (1994) asserts that the initial establishment of computer labs occurred when more computers became available in schools and the organisation became the responsibility of administrators. According to Papert, the resulting introduction of computer labs controlled by specialist teachers, and ICT as a separate subject, were influential in the focus on teaching decontextualized computer skills. Jones (2004) suggests that ICT access in secondary schools may be more effectively organised around the particular needs of individual departments. However, he also suggests that the success of either approach will be dependent on effective classroom management.

Selwyn's (1999) research highlights the significant influence of subject cultures on ICT use in schools. While this is an older study, the influence of subject culture is relevant to the findings presented in this thesis. Selwyn suggests a hierarchy exists in terms of subject access to computer labs, with ICT subject classes generally having priority access and dominating the use of these facilities and some subject areas considered higher priority than others. In addition to access difficulties, subjects were found to differ in their cultures of interest in ICT. As Selwyn points out, just as people's views of subject areas are socially constructed, so are their views of the nature and value of ICT use in education. For many students and teachers, computer use was found to be inherently at odds with their conception of learning in their subject area.

Voogt (2008) further suggests that realising the full potential of ICT in the curriculum will require review of curriculum content, goals and assessment, which are largely beyond teachers' control. While policy makers emphasise the important role of ICT in preparing students for the Knowledge Society and challenge education to change, at the same time they require evidence about the impact of ICT on student learning based on current curriculum goals that only partially align with twenty first century goals. This view is well supported in research literature (e.g., Bolstad et al., 2012; Cuban et al., 2001; Ertmer et al., 2012; Somekh, 2008).

The focus of this thesis is specifically on integrating WBRs in the classroom as opposed to other ICT applications. In particular, it focuses on integrating WBRs in the subject discipline of technology education at secondary school level. While the barriers and enablers described in this section apply to ICT in broad and general terms, they are equally relevant to the integration of WBRs.

2.3.6 The role of the teacher in ICT integration

As the previous section highlights, teachers play an important role in successful integration of ICT in education, and it is well established that ICT resources themselves will not transform education. Ultimately, it is teachers' pedagogical decisions and actions in relation to using ICT in the classroom that determine the nature and extent of ICT integration (Angeli & Valanides, 2009; Bolstad et al., 2012; Wright, 2010). As Wright claims, improved student learning is more likely when good teaching is combined with appropriate e-learning technologies. As already discussed, good teaching in contemporary education (with or without ICT) aligns with constructivist and sociocultural theories and involves a change in the role of the teacher in the classroom. This section discusses how the role of the teacher changes in a student-centred classroom. It also highlights the complexity of the teacher's role in managing the wide range of variables in the classroom environment in order to support student learning needs, and the significant additional knowledge that effective ICT integration demands.

Putting student learning at the centre

Inherent in social constructivist views of learning is the need for more student-centred and collaborative pedagogies, requiring a change in the traditional roles of teachers and learners in the classroom (Bolstad et al., 2012; Lai, 2008). Similarly, it is widely acknowledged that constructivist, student-centred teaching approaches are essential for effective integration of ICT (e.g., Lai, 2008; Voogt, 2008, 2010; Wright, 2010).

What is generally understood as the 'traditional' role of the teacher, as in a teacher-centred pedagogy, is underpinned largely by behaviourist theory and reflects the industrial age approach to teaching. In this approach the teacher's role is to transmit knowledge and the learner's role to receive and absorb knowledge.

In student- or learner-centred teaching approaches the learner rather than the teacher becomes the central focus. The teacher's role becomes more of a facilitator or 'guide on the side', facilitating students' construction of knowledge. When pedagogy is learner-centred, teachers are more likely to integrate ICT in transformative ways because their focus is on supporting learning rather than on the technology, as in technocentric uses described earlier. This indicates a need to change teacher pedagogy in order to achieve higher level uses of ICT and hence more effective integration. Although, as Schunk (2008) notes, teacher-centred approaches may still be appropriate in some learning situations and it is important to determine the most appropriate theoretical perspective for the particular type of learning required.

In learner-centred, constructivist teaching approaches the learning environment, or pedagogical setting (Kennewell, 2001), and how it contributes to student learning is a central concern (Sawyer, 2006; Schunk, 2008). Salomon (2006) describes a learning environment as a "real place with physical attributes where deliberate instructions are provided and where learning is supposed to take place" (p. 255). Learning environments generally include a range of variables, including: people (teachers, learners and others) with individual traits and habits; an organisational layout; learning resources, including ICT; learning activities; social interaction and relations; and subject and classroom culture and routines (Kennewell, 2001; Salomon, 2006; Sawyer, 2006). Schunk (2008) summarises the common pedagogical features of a learner-centred environment as likely to include students taking an active role in the learning process; the use of a range of different instructional approaches, such as small groups, peer collaboration, reciprocal teaching, scaffolding and apprenticeships; differentiated classroom structure involving different students doing different tasks; working on authentic rather than contrived problems; and providing multiple representations of content.

Managing a complex environment

Clearly the learning environment is complex and the teacher's role within that environment is equally complex (Shulman, 1987). The teacher's role is to design, structure and manage all the components and features of the environment in such a way that students are supported and challenged to construct meaning and gain deep understanding within a subject domain, while also catering for differing individual cognitive, motivational, developmental, social and cultural needs (Schunk, 2008). The teacher therefore needs to provide scaffolding to maximise students' learning in their Zone of Proximal Development (Schunk, 2008). This scaffolding needs to be added, modified and gradually removed according to individual learner needs, and includes such things as teachers' questions, prompts and hints to help students figure things out themselves (Sawyer, 2006).

The process of teachers' decision-making in managing the learning environment and scaffolding learning involves pedagogical reasoning (Shulman, 1987; Webb & Cox, 2004). Pedagogical reasoning is a complex and dynamic process. Shulman focuses on the use of knowledge as the grounds for the pedagogical decisions and actions teachers take. Defining a knowledge base for effective teaching is also complex. Shulman (1986, 1987) describes a range of types of knowledge and their interactions which underpin effective teaching. His knowledge base incorporates content knowledge, pedagogical knowledge and pedagogical content knowledge (PCK). Shulman's PCK construct has been widely used and adapted in education research as representative of key knowledge for effective teaching. While Shulman focuses on the knowledge base for pedagogical reasoning, beliefs and values also strongly influence teachers' pedagogical reasoning, as highlighted in the enablers identified in Section 2.3.5.

The complexity of teacher pedagogy has increased over time with developments in understanding of cognition and learning. Loveless (2011) asserts that these developments have moved our understanding of pedagogy beyond Shulman's early characteristics of teacher knowledge. According to Loveless, Shulman's conception of teacher knowledge reflects static knowledge rather than construction of knowledge within a complex, interactive, sociocultural context, reflecting social constructivist theories. The integration of ICT further adds to the complexity (Webb & Cox, 2004), especially given its rapidly expanding and evolving nature. As Ertmer & Ottenbreit-Leftwich (2010) aptly suggest, learning about ICT is like aiming at a moving target. Teachers can never have complete knowledge as ICT is always in a state of flux. Therefore, even experienced teachers can feel like novices in their efforts to integrate ICT (Ertmer & Ottenbreit-Leftwich, 2010; Wallace, 2004).

It is clear that effective integration of ICT requires significant additions to teachers' knowledge base, and subsequently adds to the complexity of teachers' pedagogical reasoning (Baggott La Velle et al., 2003; Ertmer & Ottenbreit-Leftwich, 2010; Webb, 2005; Webb & Cox, 2004). In addition to the knowledge they have always needed for teaching, which is largely defined by PCK, teachers also need knowledge of ICTs and how to use them, knowledge of specific affordances of ICT and how these relate to their subject-based teaching objectives, understanding of pedagogical practices appropriate for teaching with ICT, as well as understanding of how to vary the uses of resources to meet the varied learning needs of individual students. Furthermore, teachers need to be able to make decisions about when and how to use these resources.

Bower (2008) suggests an affordance analysis approach whereby you identify the affordance requirements of the learning task and match these with the affordances of the ICT application. Thinking about the affordance level brings the focus to the underlying attributes of the technology and how it can support collaboration and cognition. However, as Bower emphasises, there is no absolute formula. Being able to design appropriate tasks in the current era of rapidly increasing availability of ICT implies that the teacher needs to have a "portfolio of approaches for identifying, describing, analysing and allocating technologies for deployment" (p. 15).

Many researchers emphasise the importance of considering both affordances and constraints when thinking about how to teach with ICT and the Internet (e.g., Baggott La Velle et al., 2003; Hennessy et al., 2005; Kennewell, 2001; Koehler & Mishra, 2005; Niess, 2008; Thompson & Mishra, 2007). According to these authors, effective use of ICT involves the teacher being able to take advantage of the affordances, as well as understanding and applying constraints where applicable to control the level of the affordance, effectively providing scaffolding. Constraints in this sense, are complementary to affordances but equally important to achieving the outcome because they provide guidance and structure to control how easy or difficult the task is for the individual student (Kennewell, 2001). For example, the Internet provides the affordance of accessing a wide range of information and resources. This can be a limitless task, but teachers can impose constraints, such as providing a list of relevant and appropriate websites or allocating specified websites to individual students to later share in a group. Teachers may also need to differentiate the degree or number of constraints imposed to meet individual student learning needs.

The teacher's role is crucial to 'orchestrate' the affordances and constraints of ICT and all the elements of the classroom environment to mediate and scaffold student learning (Kennewell, 2001; Webb, 2005). Teachers may need to scaffold not only students' hands-on use of the computer but also associated intellectual tasks of the students away from the resource (Baggott La Velle et al., 2003; Lai, 1997; Webb, 2005). In line with sociocultural theory these associated tasks may include interaction, reflection, dialogue and collaboration among students and teacher to support and scaffold construction of meaning. Several researchers stress that the depth of interactivity, with or without ICT, is key in stimulating learning, and advocate for further research to explore ways to use ICT to support interactivity (Kennewell et al., 2007; Mitchell et al., 2007).

Careful planning is essential to effectively orchestrate the learning environment to maximise the likelihood of meaningful learning (M. Cox & Marshall, 2007). Teachers need to assess what scaffolding students need in order to use the affordances offered by ICT, the other elements in the classroom and their interactions. Niess (2008) emphasises the need for teachers to scaffold students' learning about content while also scaffolding learning about the technology, considering prerequisite lessons that allow students to learn about the technology. Missing this step can result in a lesson that misses its purpose, focusing on learning about the technology rather than learning about the subject using technology as a tool. Kennewell (2001) points out that teacher orchestration of the environment includes not only proactive strategies, which are planned in advance; but also reactive strategies, which are spontaneous and contingent on the classroom situation and events as they unfold; as well as delegation to other resources, including other students.

As highlighted in this section, the role of the teacher in a student-centred classroom is complex and dynamic. Teachers' decision-making draws on a broad knowledge base that builds throughout their career. ICT adds to the complexity of the teacher's role and to the diversity and dynamic nature of the knowledge required to make decisions about if, when and how to integrate ICT resources to support learning.

2.3.7 Technological Pedagogical Content Knowledge (TPACK)

The importance of PCK to effective teaching is widely recognised. However, a significant body of literature highlights that in order to improve learning beyond what can be achieved with effective use of non-digital resources, teachers need to further develop their PCK to take account of ICT (Angeli & Valanides, 2009; Cowie et al., 2007; Kennewell et al., 2007; Mishra & Koehler, 2006; Niess, 2005; Wallace, 2004).

At the time of Shulman's (1986, 1987) work, computers and the Internet were not widely used, or even accessible – particularly in education. Although his PCK construct does not explicitly exclude ICT, the rapid expansion and accessibility of digital technologies today requires knowledge beyond what Shulman defined for effective integration of ICT in education. The concept of Technological Pedagogical Content Knowledge (TPCK) (Koehler & Mishra, 2008; Mishra & Koehler, 2006) has emerged more recently, as a result of ongoing research for a means of preparing teachers to teach effectively with ICT. TPCK is a framework for understanding the broader knowledge base teachers need to integrate digital technologies effectively in their teaching. TPCK, now known as Technology, Pedagogy and Content Knowledge (TPACK) (Thompson & Mishra, 2007), expands on Shulman's PCK construct to incorporate a third core knowledge component, that of *technology knowledge* (TK). Koehler and Mishra (2008) argue that because technology is now such an integral part of society and changing so rapidly, there is a need for this third domain to be added to PCK.

In the TPACK model, TK includes both analogue and digital, as well as new and old technologies. However, Koehler and Mishra (2008, 2009) acknowledge that the focus is on newer and digital technologies because of their inherent properties that make them difficult to apply in education. They describe traditional technologies as characterised by specificity, stability and transparency of function, whereas digital technologies are protean (usable in many different ways), unstable (rapidly changing) and opaque (the inner workings are hidden from users). This explanation helps to illustrate the level of challenge that digital technologies present to teachers and supports the need for the additional knowledge domain in the TPACK framework. This point is revisited later in this section.

As Koehler and Mishra (2009) point out, many teachers trained before digital technologies were used in education. These teachers generally don't have sufficient experience or skill in using technology and often don't appreciate its potential value in education. Acquiring the skills and knowledge needed is challenging and time consuming. Training is often inadequate, using a generic one-size-fits-all approach (see Section 1.2.2) and ignoring the diverse contexts teachers work in as well as the varying needs and applications of ICT in different subject domains (Hughes, 2005; Thompson & Mishra, 2007; Wallace, 2004).

The addition of TK in the TPACK framework introduces three new intersecting areas of knowledge to PCK (see Figure 2.2): *technological content knowledge* (TCK), *technological pedagogical knowledge* (TPK) and in the central area where all areas overlap, *technological pedagogical content knowledge* (TPACK). As with PCK, the TPACK framework recognises the unique and integrated nature of content and pedagogical knowledge in different subject areas as well as the interdependence of each of the TPACK knowledge components.

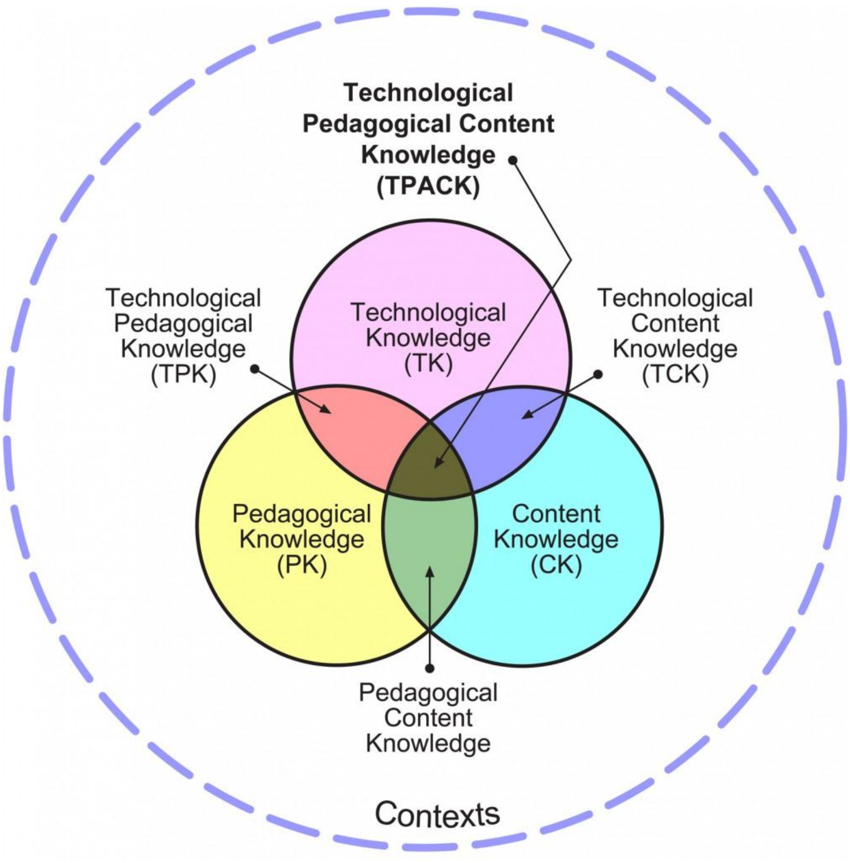

Figure 2.2. Technological Pedagogical Content Knowledge

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The components of TPACK that are additional to those in the PCK framework (Koehler & Mishra, 2008; Mishra & Koehler, 2006) are summarised below:

- *Technology knowledge* is always in a state of flux and hence rather than being an end state it is an understanding and capability that evolves over a lifetime. Koehler and Mishra base their definition of technology knowledge on that of Fluency of Information Technology (FITness) as proposed by the U.S. National Research Council (1999). FITness proposes that a broad understanding of information technology is needed, such that people can apply it productively, recognise when it can assist or impede them in what they are doing, and continually adapt to changes. This implies a deeper understanding and mastery of ICT than computer literacy.
- *Technological content knowledge* is an understanding of how technology and content influence one another. As well as their subject content,

teachers need to know how the subject content can be changed by using technology and which specific technologies are best suited to learning specific content in their domain. For example, in technology education WBRs afford access to a broad range of examples of technological products and processes, presented in multi-modal format, which would not otherwise be possible in a classroom situation.

- *Technological pedagogical knowledge* is an understanding of how teaching and learning changes with the use of particular technologies. It includes knowing the pedagogical affordances and constraints of a range of technological tools and how they relate to teaching in a particular subject discipline, or even an area within a discipline. An important part of TPK is developing creative and flexible ways of using tools available to suit the pedagogical purpose and not being constrained to the predominant use. As most software is designed for business purposes rather than education, teachers need to be able to adapt it to suit their pedagogical purpose.

- *Technological pedagogical content knowledge* is the understanding that comes from the interaction between content, pedagogy and technology knowledge and underpins effective teaching with technology. There is no single solution for every teacher or every classroom situation. Rather, the teacher needs to be able to flexibly navigate the space defined by the three core elements and the complex interactions among them. Mishra and Koehler's (2006) explanation reflects the dynamic and complex nature of this knowledge:

> TPCK is the basis of good teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing

> knowledge and to develop new epistemologies or strengthen old ones. (p. 1029)

Each component of TPACK is further influenced by contextual factors, such as culture, demographics, and school structures, which is indicated by the outer circle (see Figure 2.1) (Koehler & Mishra, 2008). This acknowledges the complex and highly situated nature of TPACK with the result that TPACK is not easily learned or applied (Harris et al., 2009).

Viewing the knowledge requirements of effective technology integration through a TPACK lens shifts the emphasis away from technocentric approaches, which focus on mastery of specific technology tools devoid of subject and curriculum application. It highlights instead the need for teachers to develop a nuanced understanding of all the knowledge components and, in particular, their complex interrelationships (Koehler & Mishra, 2008; Mishra & Koehler, 2006). According to Niess (2008), TPACK defines the body of knowledge needed by twenty first century teachers in order to teach with and about technology in their subject area. She captures the complex and dynamic nature of TPACK in this description:

> TPCK is a way of thinking strategically while involved in planning, organising, critiquing, and abstracting, for specific content, specific student needs, and specific classroom situations while concurrently considering the multitude of twenty first century technologies with the potential for supporting student learning. (p. 224)

TPACK as a research construct

Although TPACK is a complex concept, the framework offers a useful tool for communication, development and analysis of the knowledge needed for effective integration of ICT. Further, it supports the shift from technocentric to transformative approaches to technology integration by focusing on the connections among technology, content, and pedagogy as they play out in classroom contexts (Koehler & Mishra, 2009). As Polly and Brantley-Dias (2009) point out, TPACK provides a holistic perspective encompassing both what teachers *know* and *do* in effective ICT integration. In their view, this addresses limitations with earlier constructs, such as Hooper and Rieber's (1995) model of technology adoption in the classroom, which focus on the process of developing ICT integration skills based on levels of use.

Interest in the TPACK framework from the education research community has grown considerably since its inception, as reflected by a number of literature reviews (e.g., Abbitt, 2011; Niess, 2011; Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2013), a handbook (Koehler & Mishra, 2008), and a website (www.tpack.org) focusing on scholarly work in the field. There appears to be consensus that TPACK stems from Shulman's PCK construct (e.g., Graham, 2011; Koehler & Mishra, 2009; Mishra & Koehler, 2006; Niess, 2011) and in the same way that PCK lacks clarity and has a range of interpretations and definitions, there is similar critique of TPACK.

A comprehensive overview of the evolution of TPACK highlights a range of visual and verbal descriptions of the framework leading up to Mishra and Koehler's 2006 model (Niess, 2011). Niess likens the emergence and development of various understandings of TPACK through research, implementation, and scholarly debate, to the evolution of PCK. She highlights the value of the evolving representations of the construct in developing a more comprehensive understanding within education and research communities. Niess also suggests that at some point in the future we may revert back to PCK where the 'technology' component will be assumed to be one of many other resources teachers have access to for teaching. However, for now, she concurs with Koehler and Mishra (2008) that the integration of technology presents a 'wicked problem' for teacher education in the twenty first century and hence supports the need for a conceptual framework beyond PCK.

Other researchers argue that lack of clarity and consensus in defining the various components of TPACK is a weakness that needs to be addressed in order to develop a more robust theoretical framework to support future technology integration research. Graham (2011) suggests that, like PCK, TPACK is easy to understand at a superficial level but the apparent simplicity of the model hides its underlying complexity. He argues that the complexity is partly due to all the components being broad and ill-defined. Cox and Graham (2009) and Angeli and Valanides (2009) further argue that while the framework provides a common language, the 'fuzzy' boundaries between the components need clarification in order to better support ongoing research.

Angeli and Valanides (2009) also argue that the epistemological aspect of TPACK is neglected in Mishra and Koehler's work, specifically, the lack of clarity about whether TPACK is a unique body of knowledge – the transformative view – or whether it is integrated from other components of teacher knowledge – the integrative view. They concluded from their research that growth in the constituent components does not automatically lead to growth in TPACK and hence, they support the transformative view. This view is also supported by Niess (2011).

The definition of TK in the TPACK framework is also subject to many different interpretations (Voogt, Fisser, et al., 2013). Given that the rationale for TPACK as a theoretical framework distinct from PCK is the addition of the TK knowledge domain, one might expect a common understanding of what it needs to comprise. However, use of the broad term *technology* in itself can be misleading as described in Sections 2.1.1 and 2.3.1. Mishra and Koehler's (2006) definition discussed above includes all educational technologies, which fits with the term technology. However, it has been argued that many of these technologies are implicit in PCK and this has led to some researchers limiting their definition of TK to knowledge of ICT, digital technologies or emerging technologies, (e.g., Angeli & Valanides, 2009; S. Cox & Graham, 2009).

Further variation in defining TK was found in the type of knowledge TK encompassed. Views include TK as procedural knowledge, which represents a more tool-focused view; TK as both procedural and conceptual knowledge, which includes knowledge of how to use technology for teaching and learning; and TK as functional knowledge (Voogt, Fisser, et al., 2013). In the third view, TK is considered to be conceptual, procedural and meta-cognitive knowledge. As Voogt Fisser et al. (2013) suggest, a functional view seems more robust given the changing nature of technology and better supports the need to include TK as a separate knowledge domain. This view also aligns more closely with the notion of FITness (National Research Council, 1999), which Koehler and Mishra (2008, 2009) use as the basis for their definition.

In a conceptual analysis of TPACK, Cox and Graham (2009) attempt to clarify the definitions of, and boundaries between, the components. They define TK as knowledge of how to use 'emerging' technologies. They suggest that this clarifies the difference between TPACK and PCK. They define emerging technologies as technologies that are not yet transparent and ubiquitous in a particular context, which is similar to Koehler and Mishra's (2008, 2009) description of digital technologies. To explain the idea of 'emerging' Cox and Graham use the example of books, which when first introduced were not widely used and accepted in favour of the scroll. However, over time books have become so ubiquitous that no one thinks of them as a technology anymore. Confining their definition of TK to emerging technologies, Cox and Graham highlight the 'sliding' nature of TCK, TPK and TPACK. They suggest that as technologies become transparent and ubiquitous, TCK, TPK and TPACK transform into CK, PK and PCK respectively. However, they emphasise that as long as there are emerging technologies that are not transparent and ubiquitous, there will always be a need for TPACK. This resonates with Niess's (2011) prediction that sometime in the future PCK may encompass TPACK, and the need for a separate framework may diminish.

As a result of their conceptual analysis of TPACK, Cox and Graham (2009) present an elaborated model that they claim defines more specifically the knowledge comprised in TCK, TPK and TPACK. They define TCK as comprising knowledge of topic-specific representations in a content domain using emerging technologies, independent of knowledge about their use in a pedagogical context. TPK in their model is defined as knowledge of general pedagogical activities using emerging technologies, for example, how to motivate or engage students using a specific technology. They describe TPK as independent of any specific content or topic. Their definition of TPACK refers to knowledge of how to coordinate the use of subject-specific activities with topic-specific representations using emerging technologies to facilitate student learning.

In this way they clearly delineate between the constituent components of the framework.

Lee and Tsai (2010) assert that using the Web in teaching may demand more advanced knowledge than TPACK. They suggest a separate, more specialised knowledge framework to support effective teaching using the Web, which they name Technological Pedagogical Content Knowledge-Web (TPCK-W). Their framework builds on the ideas of both PCK and TPACK, adding 'Web' knowledge (W), to the core components of PCK instead of 'T' knowledge as in TPACK. Hence their integrated knowledge components focus specifically on WCK, WPK and TPCK-W as opposed to ICT in general.

Despite critiques of TPACK there appears to be agreement that there is a need for a framework to support the development and assessment of teacher knowledge for effective integration of ICT (Abbitt, 2011; Niess, 2008; Polly & Brantley-Dias, 2009). As Abbitt (2011) argues, TPACK provides a lens to view the role of technology in teacher knowledge while also allowing for the rapidly changing landscape. However, TPACK is a relatively recent theoretical framework and as such there is still a lot to learn about using it, and the need for further research in the field is emphasised in literature (e.g., Abbitt, 2011; S. Cox & Graham, 2009; Polly & Brantley-Dias, 2009).

In this thesis, which investigates how to support teachers to enhance their use of WBRs, TPACK is used as a theoretical framework. First, it is used to simplify communication with the participants of the types of knowledge required to enhance their integration of WBRs in the classroom. As Voogt Fisser et al. (2013) found in their work with practising teachers, despite its complexity, TPACK is an "intuitive and easy-to-communicate concept" (p. 118). Second, TPACK is used as a theoretical lens through which to analyse and describe the participants' development of knowledge and change in practice in their use of WBRs.

2.4 Teacher professional development

The previous section began by exploring the limited impact of ICT in education, despite the transformative vision predicted by education reformers and policy makers. Barriers and enablers commonly associated with ICT integration were identified and the critical role that the teacher plays in effective integration was emphasised. Finally, the emerging TPACK framework and its value for defining and developing teacher knowledge for effective integration were explored. Despite more than three decades of ICT use in education it is clear that teachers still need support to develop their knowledge, skills and beliefs to enhance their use of ICT to support student learning.

The focus of this section is on teacher professional development. It begins by aligning contemporary views of effective professional development with constructivist and sociocultural theories of learning and discussing key characteristics commonly associated with effective professional development. The section goes on to discuss literature that identifies various stages in teachers' professional development, and then literature pertaining to ICT professional development is reviewed. Finally, professional development specifically related to using WBRs is discussed.

2.4.1 Learning theory and teacher professional development

Changing perspectives of knowledge and learning implicit in contemporary education policy and reforms, and the transformative vision for ICT in education internationally, are underpinned by constructivist, social constructivist and sociocultural learning theories, as described in Section 2.2. Research has highlighted the need to apply these perspectives not only to student learning but also to teacher learning as it is the teacher who is ultimately responsible for enacting change and facilitating student learning in the classroom (Bransford et al., 2000; Fishman & Davis, 2006; Leahy & Torff, 2013; Putnam & Borko, 2000). *Professional development* and *in-service teacher education* are general terms used to refer to various forms of teacher learning once employed in a teaching position. By contrast, *teacher education* and *pre-service teacher education* generally refer to teacher learning in tertiary institutions prior to qualifying as a teacher.

The failure of early approaches to in-service professional development likely reflects a lack of alignment with social constructivist and sociocultural perspectives of learning. Features of these approaches generally included one-off workshops with lack of follow-up support and time for change to occur, top-down approaches with courses designed and delivered outside of the school setting, lack of relevance to teachers' interests and classroom practice, and lack of consideration of teachers' individual contexts (Hargreaves & Fullan, 1992). Although these approaches may still be relevant for particular purposes of professional development, on their own they are inadequate to effect the significant change in teachers' beliefs and practices required to promote more effective student learning. A clear shift away from these approaches is evident in contemporary research on teacher learning and development (e.g., Avalos, 2011; Bransford et al., 2000; Fishman & Davis, 2006; Kwakman, 2003; Putnam & Borko, 2000; Timperley, Wilson, Barrar, & Fung, 2008).

Teacher professional development is a complex process that brings together many different elements and occurs in varying school cultures – some being more conducive to learning than others (Avalos, 2011). Complexity is also implied in Timperley et al.'s (2008) use of the term *black box* to describe understanding of how teachers translate their learning from professional development into changes in teaching practice. As Avalos stresses, the complex range of interacting variables involved in terms of teachers' background contexts and learning needs implies that there is no single recipe that will be relevant and effective for all teachers and contextual situations. Hence, Avalos highlights the need for ongoing research to identify unifying elements across diverse but effective approaches.

Contemporary research highlights a range of characteristics that contribute to the most effective professional development. Influenced by new ideas about cognition and learning, many characteristics associated with high quality professional development align with sociocultural theoretical perspectives. In particular many reflect situated cognition, the social nature of learning and communities of practice (Avalos, 2011; Bransford et al., 2000; Kwakman, 2003; Putnam & Borko, 2000; Timperley et al., 2008).

Applying situated cognition theory to teacher professional development suggests the importance of situating teacher learning within the school environment and closely aligning or embedding activities in classroom practice. Putnam and Borko

(2000) consider that situated activities include activities at school sites as well as those that involve teachers bringing their classroom experiences to professional development activities. They argue that a combination of approaches situated in a variety of contexts is necessary in order to achieve multidimensional change in practice. The importance of teachers working collaboratively, participation in discourse communities within and between schools, as well as involvement in professional learning communities are also commonly recommended for effective teacher professional development (Kwakman, 2003; Lawless & Pellegrino, 2007; Putnam & Borko, 2000; Timperley et al., 2008). All the above characteristics are encompassed by Bransford et al.'s (2000) approach to describing effective learning environments, which they apply equally to teacher learning. They describe effective learning environments as learner-centred, knowledge-centred, assessment-centred, and community-centred.

It is also well documented that extended time frames are necessary to enable deeper learning and change of beliefs deemed necessary for significant and sustained change of practice (Avalos, 2011; Bransford et al., 2000; Lawless & Pellegrino, 2007; Timperley et al., 2008). Indeed, the need for longer periods of time is inherent in the characteristics identified above. However, as Timperley et al. argue, providing a longer time frame does not automatically translate into effective learning. Rather, in their Best Evidence Synthesis (BES) commissioned by the New Zealand Ministry of Education, they identify seven contextual elements important to promote professional learning, some of which overlap with the list of characteristics above. In addition to extended time, they suggest the need for external expertise, teacher engagement, challenging prevailing discourses, opportunities to participate in a professional community of practice, consistency with wider policy and research trends, and active school leadership.

The value of mediation, in particular the involvement of external expertise, as identified by Timperley et al., has been a focus in many studies of successful teacher development (e.g., Avalos, 2011; Guzey & Roehrig, 2009; Putnam & Borko, 2000; Timperley et al., 2008). Professional learning communities that include academics, researchers and teachers provide opportunities to explore new theoretical ideas and support teachers in translating these ideas into practice. In these collaborative groups, learning occurs through dialogue, conversation and interactions focused on professional situations. Avalos describes mediation in education processes as being “like a springboard that provides impetus for moving from one point to another” (p. 16). However, she warns of the potential for issues of hierarchy and authority to arise within such partnerships and stresses the importance of clearly defining roles. Putnam and Borko also highlight the contribution that teachers’ knowledge of pedagogy, their students and their cultural and classroom contexts can bring to the discourse in these communities. However, they stress that finding the right balance between providing new information and facilitating teachers’ construction of new knowledge can be a challenge.

Professional development with experienced teachers also implies the need to consider principles particular to adult learning (Harris, 2008). While the same learning theory applies to teacher learning as to students, as mentioned earlier, adults also bring unique characteristics such as confidence, independence, maturity, experience, intrinsic motivation, and readiness to learn (Leahy & Torff, 2013). Adult development is voluntary. Hence adults prefer to know why they should learn something and how it will benefit them, rather than situations being imposed on them (B. Bell & Gilbert, 1994). Adults’ diverse life and work experiences influence their thinking and need to be acknowledged. They seek learning experiences that are authentic, relevant, and meet their individual needs (Leahy & Torff, 2013) Therefore they are more likely to be motivated when learning opportunities are aligned with classroom practice and able to be integrated into their work. Taking these principles into account, Harris (2008) recommends professional development that includes a balance of scaffolding that is non-constraining to support the implementation of new ideas while also acknowledging the agency and expertise of experienced teachers.

In summary, key characteristics from literature that are commonly associated with high quality teacher professional development and reflect contemporary perspectives of cognition and learning, include:

- active involvement in authentic activities situated in relevant contexts;

- learner-centred activities that build on prior knowledge and meeting the individual needs and interests of participants;
- cognisance of the particular school culture and infrastructure and the external policy environment;
- inclusion of a range of formats and activities, acknowledging that different contexts and formats result in different kinds of learning and meet different needs;
- opportunities for reflection and collaboration with other teachers;
- participation in communities of practice and professional learning communities;
- extended time frames;
- external expertise/mediation;
- consistency with wider policy and research trends; and,
- non-constraining, acknowledging teacher agency and expertise.

2.4.2 Stages of teacher development

Various stages and dimensions of teacher development have been identified, providing insights into processes of teacher learning and possible frameworks to inform design of professional development programmes. Commonly, sequential stages suggest the need for an initial catalyst to engage teachers in professional development, such as awareness of an aspect of practice that needs improvement (B. Bell & Gilbert, 1994; Evans, 2002; Timperley et al., 2008). Some form of new learning is also often identified as necessary early in a professional development programme (B. Bell & Gilbert, 1994; Kwakman, 2003; Putnam & Borko, 2000; Timperley et al., 2008) followed by a variety of activities or opportunities to apply new learning to classroom practice (B. Bell & Gilbert, 1994; Kwakman, 2003; Timperley et al., 2008). Timperley et al. stress the importance of content and activities being aligned and also the need to include a variety of activities. Further, subsequent reflection on practice and collaboration for support and feedback typically feature in dimensions or stages of development (B. Bell & Gilbert, 1994; Kwakman, 2003; Timperley et al., 2008).

B. Bell and Gilbert (1996) developed a model of teacher development that encompasses all the characteristics of teacher learning identified above as well as many of the characteristics that are associated with effective professional development (see Table 2.2). The model is based on findings from a three year research project investigating New Zealand science teachers' development of constructivist teaching approaches. The model is not a professional development programme, nor is it a recipe that will automatically lead to better learning. Rather, it provides a broad overview of the learning process of teachers underpinned by constructivist and sociocultural theory and characteristics of effective teacher professional development. This representation of teachers' learning offers a guiding framework for planning teacher professional development. It contributed to the design of the intervention in this research, and after the intervention provided a useful analytical tool.

The teacher development model has three main features. First, it identifies three interdependent dimensions of teacher learning that need to be addressed – personal, professional (cognitive and action development) and social, and each dimension includes three stages of development. Second, the teacher development activities are situated within a context that encompasses effective components of a teacher development programme, specifically, support, feedback and reflection. Third, the model acknowledges a loose and flexible sequence in the dimensions and stages of learning. As B. Bell and Gilbert (1996) stress, each component is not intended to be a discrete activity. Rather, there are interactions between the dimensions and stages of development and each stage or activity may not represent a movement forward. The flexible and multi-dimensional nature of the model reflects the complexity of teacher development and the different school, classroom and individual contexts that each teacher brings to the process. It also allows for teachers having different starting points and different trajectories in the change process.

Table 2.2. Summary of dimensions and stages of teacher learning

Personal development	**Professional Development**	**Social development**
1. Accepting an aspect of my teaching as problematic	1. Trying out new activities	1. Seeing isolation as problematic
2. Addressing constraints	2. Development of ideas and classroom practice	2. Valuing collaborative ways of working
3. Feeling empowered	3. Initiating other development activities	3. Initiating collaborative ways of working

The initial personal development dimension of B. Bell and Gilbert's (1996) model reflects the importance of teachers identifying a need relating to some aspect of their practice as a catalyst to participate and provide motivation. This is considered essential in order for teachers to deal with concerns about doing things differently and to change their beliefs (the second personal development), ultimately leading to empowerment and taking responsibility for their own ongoing development (the third personal development). This aligns with Hargreaves and Fullan's (1992) argument that teacher development involves changing the behaviour and the person because a person's behaviour and their beliefs are closely bound. Hence they consider personal development an important element in teacher improvement.

B. Bell and Gilbert's (1996) first phase of professional development emphasises the importance of teachers clarifying an aspect of their teaching that needs development but feeling assured that their teaching overall is not problematic. Important in this phase also is the introduction of new ideas, and trialling and reflecting on new classroom activities. This resonates with research literature that identifies the importance of including some form of theoretical learning (Kwakman, 2003; Putnam & Borko, 2000; Timperley et al., 2008) as well as opportunities for teachers to apply their learning in authentic classroom contexts, essentially translating theory into practice. The dimension therefore embodies theories of situated cognition and the importance of authentic activities in meaningful learning (J. Brown et al., 1989). In B. Bell and Gilbert's second phase of professional development, teachers were clarifying existing ideas, constructing and evaluating new understandings, and using newly accepted understandings in different contexts; and subsequently taking initiatives to continue their own development.

The social development dimension in B. Bell and Gilbert's (1994) model acknowledges the importance of teachers developing collaborative ways of working and constructing meaning through social interaction. This dimension recognises the social nature of learning and the importance of learning through communities of practice (Lave, 1991; Lave & Wenger, 1991). The first phase of social development involves teachers recognising the value of working together with other teachers; and in the second phase, becoming comfortable contributing and sharing and building collegial relationships with the group. In the third social development teachers begin to initiate collaborative activities with other teachers.

A later professional development model by Clarke and Hollingsworth (2002) also identifies the importance of the personal and practice (professional) dimensions in teacher development. Their model is more recently extended by Nielsen (2012) to include the domain of collaboration, recognising the importance of collegial sharing and support, which aligns with B.Bell and Gilbert's (1996) social development dimension.

Ultimately, for teacher learning to be sustained and change to be ongoing, teachers need to reach a stage where they are empowered to continue their own development rather than remaining dependent on a facilitator. B. Bell and Gilbert's model (1996) suggests that for this to occur, teachers need to be supported to reach the third stage of development in each of the three dimensions described above.

2.4.3 Professional development to support ICT integration

Unsurprisingly, literature on effective teacher professional development to support ICT integration highlights similar characteristics to those identified in the previous section for effective teacher professional development in general. In particular, recommendations for effective ICT professional development generally include the need to involve teachers in situated and authentic tasks embedded in classroom practice, and the importance of participating in professional learning communities for discussion, support and feedback (Angeli & Valanides, 2009; Guzey & Roehrig, 2009; Hennessy et al., 2005; Hughes, 2005; Koehler & Mishra, 2009; Loveless, 2011). The need for sustained periods of professional development is frequently highlighted (Guzey & Roehrig, 2009; Koehler & Mishra, 2005, 2008; Koehler, Mishra, & Yahya, 2007; Mouza & Wong, 2009; Wallace, 2004), and the importance of opportunities for teachers to reflect on their practice is also emphasised (Guzey & Roehrig, 2009; Mouza & Wong, 2009). Reflection allows teachers to see the impact of using ICT on student learning, construct meaning from their experiences, and continue to modify their practice

Inadequate early approaches to professional development for ICT integration, tended to focus on developing skills to use ICTs but were lacking any classroom or subject application (see Section 2.3.3). An increasing body of research on teacher professional development for ICT integration emphasises the need to support teachers to integrate ICT into their particular subject area and it is suggested that this is more effective when conducted in collaborative, subject-specific groups (e.g., Harris et al., 2009; Hughes, 2005). This view reflects a situated cognition perspective and also acknowledges the context-specific nature of teachers' PCK and TPACK. As Hughes suggests, when teachers learn about technology from a content perspective they are more likely to use it to support content learning. This contrasts with learning generic ICT skills and knowledge, such as how to use particular software applications, where learning needs to then be translated so that the technology is used in classroom teaching. Further, in collaborative subject-based groups, teachers are more likely to have similar experiences of teaching practice and content-related topics for which ICT might provide a solution. Such groups are likely to provide more common ground and hence more opportunities for teachers to share experiences and provide support, as well as connecting teachers' learning to their teaching context.

2.4.4 Professional development and TPACK

The importance of integrating learning about ICT with both pedagogy and content is emphasised in literature relating to the development and use of the TPACK framework (Hughes, 2005; Koehler & Mishra, 2008; Koehler et al., 2007; Mishra

& Koehler, 2006). Although TPACK is not a professional development model, it has value for planning teacher professional development because it highlights the different types of knowledge teachers need to develop and their interrelationships (Harris et al., 2009), as well as providing a tool to aid communication of this complex concept (Doering, Scharber, Miller, & Veletsianos, 2009; Voogt, Fisser, et al., 2013). In addition, Polly and Brantley-Dias (2009) point out, the value of TPACK lies in its holistic nature and therefore learning opportunities for teachers should be comprehensive, addressing all the TPACK components.

Koehler and Mishra (2008) argue that teachers need to develop understanding that affordances and constraints of technology vary according to content and pedagogical approaches. They highlight the importance of professional development providing opportunities for teachers to practise curriculum design and teaching in order to develop their knowledge. In other words, they advocate for involving teachers in designing and enacting lessons and/or courses that integrate ICT and hence providing authentic experiences for them to reflect on and learn from. As Koehler et al. (2007) point out, learning about technology in contexts that "honour the rich connections between technology, the subject matter (content) and the means of teaching it (pedagogy)" (p. 758) is necessary to help teachers shift beyond technocentric approaches. However, despite a growing body of literature on TPACK, research using it in specific subject domains is still limited (Voogt, Fisser, et al., 2013).

One subject-specific approach to professional development with practising teachers using TPACK is the use of learning activity types (Harris et al., 2009). Activity types are based on research that highlights the importance of Shulman's (1986) notions of PCK. Harris et al. suggest that raising awareness of possible learning activity types in a particular content area and linking these to a range of supporting technologies, both digital and non-digital, provides teachers with a range of activities to select from to meet their students' needs. Activity types are activity segments, which make up an individual part of a lesson. For example, role play is identified as an activity type in social studies (Harris & Hofer, 2011) and lends itself to using video-creation software. The activity types approach focuses on content-specific pedagogy most often used in particular content areas and aligns with Putnam and Borko's (2000) suggestion that teacher knowledge tends to be event-structured and episodic in nature. This approach was initially tested with a small group of secondary social studies teachers in the USA. Teachers' 'TPACK in action' was studied as they used the activity-type taxonomies to support their planning (Harris & Hofer, 2011). Findings suggested that when using this approach, teachers became more conscious and strategic in their selection and use of activity types and technology; they appeared to be more student-centred in their planning, focusing more on student learning than affective factors; and they raised the quality of their technology integration. Although the results are considered promising, it is emphasised that this approach is not yet widely tested. In addition, Harris (2008) posits that this approach is more likely to perpetuate teachers' use of more familiar activity types rather than encouraging the use of unfamiliar activity types that may demonstrate deeper philosophical change. As mentioned earlier, adult learning requires scaffolding that is non-constraining in order to support the implementation of new ideas.

A *learning by design* approach to developing TPACK knowledge encompasses a situated and collaborative approach. (Koehler & Mishra, 2005; Koehler et al., 2007). For example, Koehler and Mishra (2005) and Koehler et al. (2007) examined Masters' students' – many of whom were experienced teachers – development of TPACK as they worked in groups using ICT to design solutions to different educational issues. One example was faculty and graduate students in a College of Education working together to design online courses to be taught the following year. Findings showed that students perceived working on authentic design problems was challenging and fun. Data also indicated a shift in participants' thinking about content, pedagogy and technology from being separate concepts to a more integrated view, which indicated a deeper understanding and a move towards developing TPACK. As Koehler and Mishra (2005) explain, design-based activities provide a rich and meaningful context for learning, reflecting social constructivist ideas. In these types of activities students learn much more than just about the technology, they also learn about design and about learning to learn.

Highlighted in much of the research on pre-service teachers' development for ICT integration are the limitations imposed by their lack of teaching experience (Niess, 2008; Voogt, Fisser, et al., 2013). While they could gain experience in designing technology-enhanced lessons, pre-service teachers had limited opportunities to enact these lessons in classrooms. As well as lacking a repertoire about teaching with technology, pre-service teachers also lack the content knowledge base and PCK that experienced teachers have developed (So & Kim, 2009; Wetzel & Marshall, 2011). Furthermore, experienced teachers have the advantage of ready access to real contexts for trialling approaches to ICT integration, which can be more problematic for pre-service teachers.

A similar argument is made comparing experienced and novice teachers. Experienced teachers' more substantial prior knowledge gives them more knowledge to connect with, allowing them to more readily interweave technology into their existing knowledge and practice (Hughes, 2005; Wetzel & Marshall, 2011). For example, Wetzel and Marshall (2011) suggested that an experienced teacher felt less need to be highly skilled in any particular technology application before trying it out in the classroom. This suggests that experienced teachers' existing PCK may be an advantage in their development of knowledge for integrating ICT. However, teachers' interpretation of the value of any technology for supporting learning is also emphasised as an influential factor (Hughes, 2005), as indicated in section 2.3.5.

2.4.5 Professional development and WBRs

Research relating specifically to professional development to support teachers' use of WBRs in the classroom is scarce. However, some studies investigating various questions or topics relating to using the Internet in classrooms involve some form of professional development while others highlight particular issues and strategies that arise in classroom use of the Internet.

Lee and Tsai (2010) used their TPCK-W framework (see Section 2.3.7) to develop a questionnaire with the purpose of exploring teachers' self-efficacy and attitudes towards using the Web. Although their study does not use the model in professional development, Lee and Tsai suggest that the information gained on teachers' TPCK-W self-efficacy may inform teacher professional development. Findings of their survey of 558 Taiwanese teachers suggest that teachers lack web pedagogical knowledge in particular, and hence they propose that teacher education and further research are needed to address this limitation. They identified a high correlation between teachers' experience of web use and of web-based instruction and their TPCK-W self-efficacy. They also highlight the tendency for older and more experienced teachers to have low self-efficacy in terms of TPCK-W, suggesting that senior teachers may have more difficulty integrating the Web in their teaching than more junior teachers.

Watson (2006) investigated the long term effects on teacher self-efficacy of a funded professional development programme to train teachers to integrate the Internet in science and mathematics classes in West Virginia. The professional development involved an intensive summer workshop supplemented by a range of online courses. Findings indicated that professional development courses increased teachers' self-efficacy for using the Internet in teaching and that their self-efficacy remained high years after the programme. The ongoing contact between the in-service teachers that resulted from involvement in additional courses appeared to contribute significantly to teachers' confidence. This supports the valuable contribution that membership of a professional learning community makes to effective professional development, as discussed in Section 2.4.1 and 2.4.2.

Access to the wide variety of information that the Internet offers is viewed as one of the benefits of ICT, and it is one of the most common classroom uses of ICT (2020 Communications Trust, 2014; Pratt, 2005). However, while benefits for learning are acknowledged, they are not automatic, and it is well established that students' Internet searching skills, and critical use of the Internet is generally poor (Hoffman, Wu, Krajcik, & Soloway, 2003; Kuiper, Volman, & Terwel, 2005; Pratt, 2009; Ruthven, Hennessy, & Deaney, 2005). For example, in a review of literature from 1997 to 2003, Kuiper et al (2005) concluded that students often do not have the necessary skills to search the Internet effectively, and they need support to develop both searching skills and the ability to critically assess information on the Web. This resonates with other studies which claim that although students are comfortable using the Internet and may be actively engaged, they use it naively or simplistically (Hoffman et al., 2003), and their ability to synthesise and evaluate the information is very poor (Pratt, 2009). That using WBRs is complex for both students and teachers indicates that students need extensive support to develop the necessary information literacy skills, and that teachers also need help to develop strategies for teaching with and about these skills.

As Wallace (2004) points out, with so many different resources on the Internet it is "a daunting substantive and technical task to find appropriate, useful resources" (p 450). Using case studies of three high school science teachers, Wallace developed a framework to support teaching with the Internet. He hypothesised that when the practice of teaching and the nature of the Internet interact, they can both support and inhibit teaching and learning. He identified five key features of the Internet, which he suggests offer both affordances and constraints depending on how they are used by the teacher. Although published over 10 years ago, the growth of the Internet and Web 2.0 technologies, make these features still relevant:

- *Boundaries*: Unlike conventional resources such as text books, the Internet provides a limitless information space with neither intellectual nor physical boundaries. While this offers huge potential for learning, it can be challenging for teachers to develop strategies to create boundaries in order to support and structure effective learning.
- *Authority*: Most internet resources are not specifically authorised for classroom use. This can be challenging for teachers in deciding what is appropriate and trustworthy. Students need guidance and support to select and use these resources critically.
- *Stability*: Traditionally teachers have been able to rely on resources such as text books to change slowly over time, in contrast to the rapidly changing nature of the Internet. This offers exciting possibilities but also creates instability for teachers because they can no longer depend on what students will find when they visit a particular site.

- *Pedagogical context*: Teachers develop pedagogical strategies that contribute to their PCK over time, making use of the familiar features of the learning environment. Most Internet resources do not provide pedagogical support in terms of how to use them in the classroom. Teachers need to develop their PCK for using Internet resources - this includes knowing the resource exists and how to use it in their classrooms (TPACK).
- *Disciplinary context*: Text books generally provide subject matter that is organised sequentially to provide age- and developmentally-appropriate disciplinary support for students. This is generally not the case with Internet resources. Teachers need to create their own disciplinary framework in the way they select resources, design activities and interact with students.

2.5 Chapter summary

The research project presented in this thesis investigated how secondary school technology teachers could be supported to expand and enhance their use of WBRs in the classroom. This chapter explored literature relating to four key aspects of the study. First, an overview of the introduction, implementation and revision of technology education in the New Zealand Curriculum was presented. The nature, purpose and challenge of the revisions encompassed in the current version of this curriculum were discussed. Thereby, insights into the context of the participants in this study were provided and the potential value of WBRs for technology education was highlighted.

The second section focused on theoretical perspectives of learning. It provides an overview of the three main learning theories that have been evident in education since the early twentieth century, with a particular focus on constructivism and sociocultural perspectives, which are considered more relevant in contemporary education. Literature linking learning theories to different approaches to using ICT was explored and the sociocultural perspective adopted in the design and methodology of this investigation is justified.

The third area of focus in this literature review was ICT and education. As the main goal of this research was to develop an intervention to support teachers to implement WBRs in the classroom, key literature relating to integrating ICT in education was explored. The literature reveals a disparity between the transformative vision for ICT in education which aligns with contemporary learning theory and the profound impact of ICT on our lives, and the current reality that is predominant in classrooms. The barriers constraining ICT integration and perpetuating the dominant technocentric approach were considered. Consideration of enabling factors associated with effective ICT integration highlighted that no single factor on its own is likely to lead to significant change. Changing teacher beliefs to develop more student-centred pedagogy was identified as of central importance along with various other factors. The significant challenge that integration poses for classroom teachers, both in terms of the broader knowledge base required and their role in effecting high-level uses of ICT was emphasised, providing some insights into likely reasons for the current status of ICT in education. TPACK was introduced as an emerging framework for defining the complex knowledge requirements for effective ICT integration.

The fourth main focus of this chapter was teacher professional development. Contemporary literature identifying a range of characteristics that contribute to effective professional development, including ICT professional development, was reviewed and the alignment of these characteristics with sociocultural theories of learning was highlighted. Several examples using the TPACK framework as a tool to support the development of teacher knowledge were discussed, and a learning by design approach was identified as providing an authentic and challenging context for teacher professional development, resulting in deeper understanding of effective integration. Although literature relating specifically to professional development to support teachers in using WBRs is scarce, this section highlighted some of the issues that the scope and instability of the Internet pose for teachers using WBRs in the classroom, and indicated a need for teacher support in this area.

This study is framed within a sociocultural perspective and as such takes account of components of effective teacher professional development that reflect the situated and social nature of learning. In particular, it is informed by key ideas from contemporary research on teacher professional development for effective ICT integration. These ideas were incorporated into the planning and implementation of the Intervention programme and included: authentic tasks situated in relevant contexts; commitment to a professional learning community for discussion, support and feedback; opportunity for sustained periods of participation in professional development; and opportunities for reflection. Further, TPACK was used as a theoretical framework to support planning for the professional development component of the Intervention and as a tool for communication and analysis of the components of teacher knowledge and their interactions in effective ICT integration.

The next chapter, Chapter 3, explains the research methodology and design underpinning this investigation.

CHAPTER THREE

RESEARCH METHODOLOGY AND DESIGN

3.0 Introduction

This chapter explains the research methodology and design used to investigate an effective means of supporting teachers to enhance their use of web-based resources (WBRs) in secondary technology education classrooms.

Section 3.1 begins by explaining the purpose of methodology. It positions this research in the interpretive tradition and explains the philosophy and common assumptions underpinning interpretive research. Qualitative research is compared and contrasted with quantitative research, and the features, approaches and methods typical of qualitative research are discussed. A case is made for credibility as a more appropriate evaluation criteria for qualitative research.

Section 3.2 discusses issues relating to evaluating the quality of qualitative interpretive research. It discusses issues with applying the criteria of validity and reliability, which originated in quantitative research, to judging the quality of qualitative research. Alternative views that favour diverse approaches and argue that issues of quality are also about emerging criteria are presented, and criteria used to guide quality in this research are explained.

Section 3.3 explains the case study approach used in this research and analyses the methods of data collection employed. The key features, strengths and weaknesses of case study research are described and the parameters of the cases in this research are explained. Then the purposive approach used to select and recruit participants in this research is described and justified.

Section 3.4 discusses the approach used for analysing the data. Data analysis involved coding and interpretation of data from each round of interviews, which were the main source of data; analysis of classroom observations, field notes and teacher planning documents as a means of triangulation; and analysis of audio recordings of the workshops.

Section 3.5 explains the ethical considerations applicable in this research. The ethical considerations include informed consent, privacy and confidentiality, and minimisation of harm. Finally, Section 3.6 provides a chapter summary.

3.1 Methodologies in educational research

The aim of methodology is to guide the inquiry process. Social research and its methods are not neutral (Bryman, 2004); different researchers have different world views and make different ontological and epistemological assumptions about the nature of reality and knowledge and how knowledge is acquired. These views and assumptions govern their methodological decisions in planning and conducting research. Methodology represents the overall framework that guides and structures the research, thereby making all the assumptions and details of the methods explicit and allowing the inquiry process to be understood. It includes the underpinning philosophy and ontological and epistemological assumptions of the researcher, and of the tradition and discipline within which the research is positioned. It informs the analysis of principles underpinning particular strategies and methods and the selection and justification of their use within a particular study. Furthermore, it guides the researcher in planning all the details of the research design, including participant selection, data collection methods, data analysis, ethical considerations and how issues of quality can be evaluated.

A wide range of methodologies are described in academic literature, reflecting different world views within and between disciplines and traditions, dominant theories in different historical periods, as well as evolving interpretations over time. While some of these methodologies have distinct differences, such as those based on positivism and those based on post positivist and anti-positivist philosophies, others have more subtle differences and share some similar characteristics. Various terms are used in the discourse on methodology and many different interpretations of the same terms are evident. As Patton (2002) observes, the boundaries between different perspectives are fuzzy, making it difficult to define one clear set of meanings or categories. However, the variety of methodologies can generally be subsumed into four broad research traditions representing different epistemologies. These traditions are commonly defined as positivist, interpretivist, critical and post structural (Cohen, Manion, & Morrison, 2007; Denzin & Lincoln, 2008; Garrick, 1999; Lowenberg, 1993).

This research is framed within the interpretive tradition in which the main aim is to understand the subjective world of the participants' experience (Cohen et al., 2007; Garrick, 1999). Interpretive theories and practices first emerged in the early twentieth century in reaction against the dominant positivist philosophy at that time (T. Schwandt, 2000). The more recent critical and post structural traditions share this general rejection of positivist philosophy.

The positivist tradition, often referred to as the traditional approach, views social science in the same way as natural science. In this tradition it is assumed that there is an objective social reality 'out there' to be studied and that knowledge is gained through experimental research (Gall, Gall, & Borg, 2007; Lichtman, 2013; Merriam, 1998). Knowledge is assumed to be objective and quantifiable, and reality is considered stable and measurable. The aim is to discover natural and universal laws and truths, which determine the actions of individuals (Cohen et al., 2007). Positivist approaches are underpinned by behavioural theories of learning in which it is considered that humans respond mechanically and deterministically to their environment, and the researcher's task is to make bias-free observations about cause and effect. Positivist approaches involve scientific investigation, which uses mainly quantitative methods of data collection such as surveys and experiments in order to identify, measure and explain relationships and regularities between factors in search of universal laws. Positivist approaches dominated research in education for many years until it became apparent that it was difficult, if not impossible, to capture a single reality that exists 'out there' independent of the researcher (Garrick, 1999; Lichtman, 2013).

In contrast, interpretive approaches focus on understanding the social world from the point of view of the people who are part of the phenomenon being investigated. In this tradition human action is considered inherently meaningful and understanding human activity such as teaching involves understanding the system of meanings and intent behind the action (T. Schwandt, 2000). Knowledge is viewed as personal and subjective and to understand phenomena and interpret the meaning of human activity involves researcher involvement with participants (Cohen et al., 2007). In an interpretive approach, therefore, the key concern is for the individual, and each person's experience and understanding will be different. The researcher needs to allow for the fact that there could be multiple realities in the one environment (Merriam, 1998; Savenye & Robinson, 2004). The challenge for the researcher is to understand the participants' perspectives and resist imposing his or her own beliefs and assumptions on the situation.

Within interpretive research there are a range of approaches and methods reflecting different disciplinary and theoretical influences and interpretations. Various terms are used in the discourse of this tradition including phenomenology, constructivism, ethnography, grounded theory, hermeneutics, naturalistic approaches, and symbolic interactionism. As with the broader landscape of research traditions, interpretation of these terms varies and some terms are used at the level of both methodology and method. Despite the different meanings and interpretations surrounding these terms, in general, interpretive approaches are based on the underlying belief that people are autonomous and therefore have the ability to form their own opinions and make their own choices about how they act. The interpretive researcher can best understand and interpret the meaning of people's experience and the motives behind their actions by being in their social world (Candy, 1991). Hence, it involves doing research *with* people rather than *on* people (Garrick, 1999). Five common assumptions shared by interpretive theorists are:

- any event or action can be explained in terms of multiple interacting factors,
- acceptance that complete objectivity is not possible;
- the aim of inquiry is to develop understanding of specific cases rather than to make generalisations;
- there are multiple realities that are best studied as a whole rather than fragmented, recognising the significance of the context; and,
- recognition of the influence of human values (Candy, 1991).

Using an interpretive methodology this research seeks to answer the overarching question: How can secondary technology teachers be effectively supported to enhance their classroom use of WBRs? The researcher acknowledges that there will be multiple interacting factors impacting and shaping each participant's particular context and experience. The aim is to interpret the lived experience of each participant from their point of view and within the context of their particular school, department, individual classroom, background, and beliefs and values. The intention is not to make broad generalisations to the wider population, although rich description of the various contexts and experiences are provided so that findings may be applicable in other instances where similar contextual elements are present.

Interpretivism is generally a qualitative research methodology and as such it is commonly described and categorised within literature dealing with the broader field of qualitative research (Denzin & Lincoln, 2008; Garrick, 1999; Patton, 2002; T. Schwandt, 2000). Qualitative research methods such as narratives, participant observation, and personal constructs are generally employed; and while it can involve a combination of quantitative and qualitative methods, the emphasis is on understanding particular instances rather than making broad generalisations.

3.1.1 Qualitative research

Qualitative research in its broadest sense refers to approaches to research that favour the use of qualitative data and analysis. Denzin and Lincoln (2008) suggest qualitative research is a field in its own right that cuts across different disciplines, research traditions, and theoretical assumptions. Similarly, Schwandt (2000) refers to it as a reformist movement addressing "multiple espistemological, methodological, political, and ethical criticisms of social scientific research" (p. 189).

Commonly, *qualitative* and *quantitative* refer to the nature of data collected (Gall et al., 2007) and distinctive data collection methods. While quantitative approaches and methods originate in the traditional positivist paradigm and are generally associated with experimental design and statistical measurement epitomising *good* science (Patton, 1980), qualitative research is a much broader concept reflecting the more complex nature of social research. Described as an 'umbrella concept' by some (e.g., Bogdan & Biklen, 2007; Lichtman, 2013; Merriam, 1998), qualitative research encompasses several forms of inquiry, including interpretive, designed to help us understand and explain social phenomena from within their natural setting (Merriam, 1998). Denzin and Lincoln (2011) refer to qualitative research as a situated activity that locates the observer in the world and uses interpretive practices that transform the world into "a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self" (p. 3).

The common themes uniting qualitative approaches are a general rejection of the statistical and experimental quantitative methods that had been considered mainstream science, and a concern with understanding what other human beings are saying and doing (T. Schwandt, 2000). As Lichtman (2013) points out, certain types of research questions in education (questions that ask *what* and *why*) are not easy to answer by test scores, experimental data, and statistical analyses. Rather, they demand qualitative data gathered through observation and in-depth discussions with people in their natural settings, where the researcher gathers and interprets information through his or her eyes and ears.

Bryman (2004) suggests three particular features of qualitative research make it distinct from quantitative research. First, that it is inductive and theory is generated out of the research. Second, it involves an epistemological position described as interpretivist, meaning that the emphasis is on the understanding of the social world through the participants' interpretation. Third, it involves an "ontological position described as constructionist, which implies that social properties are outcomes of the interactions between individuals, rather than phenomena *out there* and separate from those involved in its construction" (p. 366).

Although the emphasis of qualitative research is on words, actions and records rather than numbers (Maykut & Morehouse, 2003), it is important to note that a qualitative research approach does not necessarily preclude the use of quantitative research methods or reporting of quantitative data (Bryman, 2004; Stake, 2010), and mixed methods approaches – those that use both qualitative and quantitative methods – are common. Stake (2010) suggests the distinction between qualitative and quantitative approaches is more a matter of emphasis than a discrete boundary. Rather, the key differences are that qualitative research aims to understand rather than explain, and involves the researcher in a personal rather than an impersonal role. As Patton (1980) points out, qualitative researchers need to be sophisticated in matching research methods to the nuances of the particular research questions and purpose. To do this they need a large repertoire of methods to draw on as they may face the need to use “any and all social science research methods, including quantitative data” (p. 18).

Many authors concur on the general characteristics of qualitative research (Creswell, 2009; Lichtman, 2013; Maykut & Morehouse, 2003; Merriam, 1998) and eight commonly cited characteristics are reflective of this study:

- the researcher is the main instrument for data collection and analysis;
- data collection generally occurs in the natural setting;
- the product is richly descriptive;
- reporting includes researcher descriptions of the context and participants’ data in the form of their own words to support research findings;
- the research design is emergent and flexible;
- sample selection is usually purposeful and small in contrast to quantitative research;
- it involves early and ongoing inductive analysis; and,
- a case study approach is commonly used.

While it is acknowledged that both quantitative and qualitative research methods may be used in qualitative research, qualitative methods only were selected as appropriate for the design and purpose of this study based on the nature of the project and the small number of participants involved.

3.2 Quality issues in qualitative interpretive research

The credibility of a research study is dependent on judgements made about the quality of the findings and analysis (Patton, 2002). In traditional quantitative research, where the aim is to establish one absolute truth, such judgements are generally based on the criteria of internal and external validity, reliability and objectivity. However, there is ongoing debate about the applicability of these criteria for qualitative research approaches, which are underpinned by very different epistemological and ontological positions that generate different, and a broader range of issues around quality. As Seale (1999) argues, the traditional criteria for positivist research are no longer adequate to encompass the full range of quality issues in qualitative research.

The question of how to evaluate quality appears to be one of the most controversial issues surrounding qualitative research. While some suggest the meanings of the traditional criteria may need to be altered and parallel criteria developed (Lichtman, 2013), others suggest that new criteria are needed (Patton, 1980) or that different sets of criteria are appropriate for different qualitative approaches (Patton, 2002). Consequently many lists of criteria have been generated and while many common or similar criteria appear on the lists, each one tends to reflect the individual philosophy of the writer and this presents a challenging landscape for the individual researcher to navigate.

3.2.1 Validity and reliability

Originating in positivism, validity and reliability are generally accepted criteria for evaluating the quality of quantitative research. As qualitative research became more widely used, there was uncertainty about how to judge this type of research so initially these traditional criteria dominated.

Generally validity and reliability are described in terms of internal and external validity and internal and external reliability. Validity relates to the accuracy or trustworthiness of findings, with internal validity being concerned with how accurately the findings describe the phenomena being researched and external validity with the extent to which findings can be applied, or generalised, across different groups and settings (LeCompte & Goetz, 1982). Reliability in quantitative research refers to the dependability, consistency and replicability of a study over time, instruments and different groups of participants (Cohen et al., 2007). Internal reliability is concerned with the consistency of understanding between multiple researchers in a single study and external reliability with the extent to which a study can be replicated by another researcher in a different setting at a different time. As with external validity, reliability is more relevant for quantitative research where the aim is to establish universal laws (Bryman, 2004).

As the nature of the data generated in a qualitative study differs significantly from that of a quantitative study, the means of judging its validity and reliability often differ. Hence, in a qualitative paradigm the meanings of these terms are often redefined and/or other terms are suggested as more reflective of the nature and purpose of qualitative research.

Internal validity appears to be the most relevant of the traditional criteria for applying to qualitative research. LeCompte and Goetz (1982) view internal validity as a strength of qualitative research because the researcher is usually involved in the setting for a sustained period of time allowing for ongoing data analysis and refinement of ideas, and potentially deeper understanding. In addition, because the research is generally conducted in the natural setting it is likely to more accurately reflect the reality of the participants.

On the other hand, external validity or generalisability, which is the main aim of positivist research, is more problematic in qualitative research where human behaviour is viewed as "infinitely complex, irreducible, socially situated and unique" (Cohen et al., 2007, p. 137). In particular, the criteria needed for statistical generalisation can be difficult to meet in qualitative research where selection criteria are generally purposive and the sample size is small (LeCompte & Goetz, 1982). Indeed, Schwandt, Guba and Lincoln (2007) suggest that naturalistic inquirers should abandon the notion that context-free truth or generalisation can be pursued. Rather, external validity for qualitative research relies on adequate identification and description of the main characteristics of the setting and phenomena under investigation in order that the reader can determine which findings can be applied to other situations (LeCompte & Goetz, 1982; Lincoln & Guba, 1985). Alternative terms are therefore considered by some to be more relevant than generalisability for qualitative research, such as comparability, applicability, and transferability (e.g., Lincoln & Guba, 1985). Transferability is dependent on the researcher providing sufficient detailed description and, in addition, assessing the typicality of the participants and setting (Gall et al., 2007; Lincoln & Guba, 1985). Multiple site or multiple case designs, which allow cross-case analysis, are a way of addressing this issue to some degree and therefore can strengthen the external validity (Gall et al., 2007; LeCompte & Goetz, 1982).

External reliability in particular is inherently at odds with qualitative research given that qualitative research occurs in unique natural settings, which cannot be replicated in every detail. The researcher is focused on understanding the complexity of the particular situation rather than controlling the conditions and replicating these in another setting. Research information is also affected by the researcher's social role within the group being studied and this is difficult for other researchers to replicate (Burns, 1994). Internal reliability in the positivist tradition assumes that instrumentation, data and findings can be controlled and replicated by different researchers in the same study (Cohen et al., 2007). As with external reliability this also counters the aim of qualitative interpretive research, which is to understand a particular case and setting and the subjective understandings of the participants at the centre of the study. Lincoln and Guba (1985) suggest that alternative terms for reliability such as *credibility*, *consistency* and *trustworthiness* are more appropriate for qualitative research.

3.2.2. A case for credibility

LeCompte and Goetz (1982) argue that absolute validity and reliability is impossible for any research model. Rather, the goal of the researcher should be for the study to have credibility in the eyes of the reader. In this sense credibility encompasses both validity and reliability.

A number of strategies are suggested for enhancing the credibility of research, including sustained involvement in the field, which is common in qualitative research; triangulation, including triangulation of methods, sources, investigators and theories; peer debriefing; and member checking, which involves giving participants the opportunity to check the accuracy of transcripts and accounts (Lincoln & Guba, 1985). Patton (2002) adds that credibility is enhanced by the use of rigorous methods that yield high quality data that are systematically analysed; credibility of the researcher; and philosophical belief in the value of qualitative research. In addition, decisions made at the design stage such as sampling strategies can distort the data and these potential limitations need to be considered and reported. Furthermore, Lichtman (2013) suggests it is important to position the study and its findings, that is, to make it clear how the research builds on or contributes to existing research literature; and also to present rich detail of how the study was done, so that others can decide its value.

Many authors stress the importance of the credibility of the researcher in qualitative research because the researcher is the research instrument. In order for the reader to assess this, the report must include detailed information about the researcher, such as the training, experience and perspective they bring, how they gain access to the site, as well as any personal connections; and how these may have influenced the collection or interpretation of data (Patton, 2002). As Lichtman (2013) points out, there is a tension in qualitative research between objectivity and the personal influence of the researcher. Whereas objectivity is a fundamental assumption of quantitative research, where the researcher keeps his/her own biases external to the system, by contrast, in qualitative research the role of the researcher must be acknowledged because they collect and interpret the data, and in this respect, objectivity is impossible. Rather than striving to be objective the researcher should make the subjective nature of their role explicit through a process of reflexivity, that is, self-awareness and reflection on their own biases and how these may have affected the research.

Furthermore, the status position of the researcher in the field can affect the flow of information and therefore the possible effects of this also need to be made explicit in the report. Bryman (2004) suggests four ways the researcher’s perceived status may affect the research: people in the setting may react differently when the researcher is present, the views of the researcher may change over the course of the investigation, the predispositions and biases of the researcher may influence the results, and researcher incompetence.

3.2.3 Emerging criteria for judging research criteria

Seale (1999) argues that quality is an ‘elusive phenomenon’ in qualitative research and rather than opting for one set of criteria, researchers can learn from each one. In his view, methodological awareness from a range of philosophical viewpoints is of greater value than resolving philosophical disputes, and rather than methodological rules, “guidelines to be followed with intelligence and knowledge of the particular research context” (p. 471) are more helpful in moving towards quality. Ultimately, Seale recommends, as a community, social researchers need to respect the strengths of different philosophical positions and develop research skills from across genres, including both qualitative and quantitative.

Lincoln (1995) has a similar view, arguing that all criteria have value in as much as they are a reminder to the researcher that “systematic, thorough, conscious method” (p. 276) is just as important in qualitative research as it is in quantitative inquiry. She views qualitative inquiry as an emerging field that is still being defined and hence considers that issues of quality are also about emerging criteria. She argues that ongoing dialogue about how we make quality judgements makes a valuable contribution to the field and suggests there is a need for such dialogue to continue.

Lichtman (2013) suggests that there has been a degree of consensus among qualitative researchers, which has shifted each decade from pre 1990s, when positivist ideals and criteria still dominated, through the 1990s and 2000s to the present where diverse views, different types of validity and self-criticality are evident and accepted.

While many lists of quality criteria for qualitative research therefore exist, Lichtman (2013) advises that guides are simply guides and it is up to the researcher and the reader to choose their own criteria, whether they are self-developed or adopted from others.

3.2.4 Enhancing quality in this research

Based on the discussion of quality criteria in the previous section, the following criteria were employed in the design, analysis and reporting of this research to enhance overall quality and credibility:

- Sustained involvement in the field: The nature of this study necessitated a sustained period of ongoing contact with participants, including both formal and informal meetings, communication and data collection over a period of a full school year. This ongoing contact helped the researcher to build rapport and establish a trusting relationship with participants. In addition, this afforded the researcher greater insight into the different school and individual participant contexts, as well as greater opportunity to verify the authenticity of accounts and interpretations.

- Triangulation: Triangulation, using multiple sources and methods and reaching similar conclusions helps strengthen the credibility of the findings (Drew, Hardman, & Hosp, 2008). In this research multiple methods were used to generate and triangulate data including interviews, observations, analysis of teachers' planning documents and focus group discussion. Further detail of the research methods is provided in the next section.

- Rich detail: As a small-scale qualitative study it is acknowledged that claims of generalisability cannot be made. Rather, the researcher has endeavoured to provide sufficient rich detail about the participants, the context and settings (see Chapter 5), the conceptual frameworks used (see Chapter 4), as well as the data collection techniques and analysis procedures (see Sections 3.3 and 3.4), so that others can determine the authenticity, credibility and possible transferability of aspects of the study.

- Revealing the role of the researcher: The possibility that the presence and perceived status of the researcher could influence data and findings as in any qualitative study is acknowledged. Efforts were made to be reflexively aware of this possibility throughout the study and to be explicit in reporting any possible influence. Details of the researcher's background, relationship to the participants, role and status in the setting, and possible subjectivity and biases are described in Sections 1.1, 3.3.6, and 4.2.4.

The next section explains the research design and analyses the methods of data collection used in this study, and further detail of specific strategies used to address quality are detailed.

3.3 The research design

3.3.1 Case study approach

This research uses a qualitative case study approach, which is commonly used in education (Merriam, 1998) and is particularly appropriate for individual researchers because it allows in-depth investigation of one aspect of a problem (J. Bell, 2005). In this research the problem being explored is how technology teachers can be effectively supported to enhance their integration of WBRs in the classroom.

A case study is an in-depth description and analysis of a single instance, phenomenon or social unit (Flyvbjerg, 2011; Lichtman, 2013; Merriam, 1998). The specific case is unique and involves real people in real situations (Cohen et al., 2007). In the case of this research, the particular instance under investigation is a group of teachers working in the curriculum area of technology education at secondary school level. The goal of the research is to get rich and vivid descriptions of each case (Cohen et al., 2007) and to understand the experiences and perceptions of the individual participants as they participate in a professional learning programme focusing on trialing and evaluating the use of WBRs in their classrooms. As Lichtman (2013) points out, it is not important for the case to be representative of all other cases because the researcher is interested in insight and interpretation rather than testing a hypothesis or generalisation.

Although commonly used in research, Merriam (1998) suggests there is confusion about what constitutes a case study. She suggests case studies can be defined in terms of “the process of conducting the inquiry, the bounded system or unit of analysis selected for study, or … the end report of a case investigation” (p.43). However, in Merriam’s view the main characteristic is the defining of the unit of study and if the phenomenon being studied is not intrinsically bounded it is not a case. It is up to the researcher to identify the case and define the limits of what will and what will not be studied, which could be in terms of time, quantity of data, the number of individuals interviewed or the types of records examined. In setting the boundaries of the case the researcher needs to be mindful of gathering too much data, which can be difficult to manage, and conversely of generating too little information (Lichtman, 2013).

This research is limited in size to a group of seven secondary school technology teachers. In order to gain a genuine representation of this particular group, that is, teachers who were actually committed to delivering the 2007 technology curriculum as opposed to a more traditional technical skills-based programme, it was necessary to recruit participants from different schools known to be effectively teaching the revised curriculum. Participants were also selected from a range of different technological areas, or specialisations, in order to gain insight into a range of contexts relevant to the focus of this investigation. The participants' specialisations included food, materials and structural technology.

While this investigation explores the unique situation and experience of each participant as a discrete case, findings are presented in the context of the three individual schools, to acknowledge the significant influence that the particular school culture and departmental context is likely to have. Therefore, the study comprises seven individual case studies, which are compared both within and between their three schools. Studying multiple cases is quite common in case study research as comparison between cases can strengthen the credibility of the findings and enhance transferability of findings (Merriam, 1998). In addition to strengthening credibility, the greater breadth of experiences explored has the potential to yield findings with relevance and applicability to a wider audience, in this case within the field of technology education and possibly in other curriculum areas.

This investigation is also defined by time. It is confined to teachers' experiences implementing WBRs in one unit of work, and with the entire data collection stage completed within one school year. It is further defined by place, using schools within a confined geographical area; and by curriculum area, with the focus being on technology education.

According to Lichtman (2013) the case study approach came to education in the late 1980s. Although case studies were often used in the early days of sociology, they were often viewed as less rigorous and not scientific. Renewed interest in case study research emerged when qualitative methods became more accepted in education research. Flyvbjerg (2011) refers to the wide use and low regard as the paradox of the case study. He considers this is brought about by five misunderstandings about the case study, which undermine its credibility. He summarised these misunderstandings as being:

- general theoretical knowledge is more valuable than concrete case knowledge;
- one cannot generalise on the basis of an individual case; therefore, the case study cannot contribute to scientific development;
- the case study is most useful for generating hypotheses, while other methods are more suitable for hypothesis testing and theory building;
- the case study contains a bias toward verification, that is, a tendency to confirm the researcher's preconceived notions; and,
- it is often difficult to summarise and develop general propositions and theories on the basis of specific case studies. (p. 302)

Flyvbjerg (2011) counters these misunderstandings, which tend to reflect a positivist view of research, arguing instead from a qualitative interpretive perspective. His counter argument is summarised below:

- Concrete case knowledge is more valuable than the search for universal theories, which cannot be found in the study of human affairs;
- formal generalisation is overvalued as a source of scientific development whereas the strength of an example and transferability are underestimated;
- the case study is useful for both generating and testing of hypotheses but is not limited to these activities;
- the case study is no more biased toward verification of the researcher's preconceptions than other methods of inquiry; and,
- summarising case studies is often difficult, however, the problems are due more often to the features of the case than to the case study as a research method.

The design of any research should give due consideration to the strengths and weaknesses of various approaches or methods and the selection should be based on what best addresses the nature of the research problem and the particular questions being asked. The key strengths of case study research, which Merriam (1998) considers make this approach particularly suitable for education, are that it allows the investigation of complex social units, it is embedded in a real context and provides a rich and holistic account of the situation, and it provides valuable insights and rich descriptions for the reader. Cohen et al. (2007) add that the results are more easily understood by a wide audience as they are frequently written in everyday, non-professional language; they capture unique features that may otherwise be lost in larger scale data; they provide insights into other, similar situations and cases; they can be undertaken by a single researcher; and they can embrace and build in unanticipated events and uncontrolled variables.

The limitations of case study research include the length and detail of the report, which requires time and effort in reading and interpreting. This also makes it a time consuming and potentially expensive method to undertake. In addition it can be limited by the sensitivity and integrity of the researcher because he/she is the main instrument of data collection and analysis. This can also cause ethical issues (Merriam, 1998). There is thus a need for awareness of possible researcher bias, as well as potential issues of politics and power in relationships. As discussed in the previous section, this is addressed in this research by providing sufficient detail of the researcher's background and role throughout the research, and how these may have influenced the findings, to enable the reader to interpret any possible influence.

3.3.2 Methods of data collection

Research methods are the specific tools and techniques selected by the researcher to gather data to provide insights into the world of the participants (Cohen et al., 2007). The particular methods chosen are guided by the methodology and related theoretical underpinnings of the research.

In interpretive research, multiple methods are used to gain an in-depth understanding of the problem, since objective reality cannot be captured (see Section 3.1). Multiple methods provide a way of triangulating the data, which Denzin and Lincoln (2011) define as "a strategy that adds rigour, breadth, complexity, richness, and depth to any inquiry" (p. 5). Interpretive researchers make explicit the value-laden nature of inquiry and seek meanings that are not experimentally examined or measured, as opposed to positivist research which is considered value-free and emphasises measurement and analysis of causal relationships between variables (Denzin & Lincoln, 2011).

All methods of data collection can be used in case study research, including quantitative, qualitative and mixed methods (Creswell, 2009; Flyvbjerg, 2011). However, some techniques are more commonly used than others, in particular interviews, observation and document analysis (J. Bell, 2005; Cohen et al., 2007; Flyvbjerg, 2011; Maykut & Morehouse, 2003; Merriam, 1998).

The research methods used in this research include interviews and observation. Data collection was organised around the three phases of the intervention, as presented in Figure 3.1 which provides an overview of the research design. The aim of the first phase of the research was to explore the nature and extent of the teachers' current use of WBRs. This phase provided baseline data – answering research questions 1a and b – and informed the design and development of an intervention strategy that would encourage and support more effective integration of WBRs. A one-day group workshop was also part of the first phase and was an important part of the intervention strategy. The purpose of the workshop was to bring all the participants together in order to establish collegial relationships, to develop clear understandings of the expectations of the research, and to incorporate a component of teacher professional development (see Section 4.2).

In this first phase, data were collected through initial individual interviews with each participant prior to the group workshop. In addition, individual and group discussions among participants throughout the group workshop were recorded.

Phase two involved the teacher participants individually planning and implementing a unit of work, which included a focus on integrating WBRs and taking account of theoretical ideas introduced in the first workshop. During this phase data collection included a second individual semi-structured interview with each participant part way through the unit of work and collection of related teaching documents, as well as classroom observation with some of the participants. This phase contributed to answering research questions two, three and four.

In Phase three, the reflection phase, the outcomes of the units of work, and individual and group experiences of the participants were shared and evaluated, and key ides about TPACK were recorded. Data were collected through final individual semi-structured interviews, as well as recording individual presentations and group discussion during the evaluation workshop. This phase also contributed to answering research questions two, three and four.

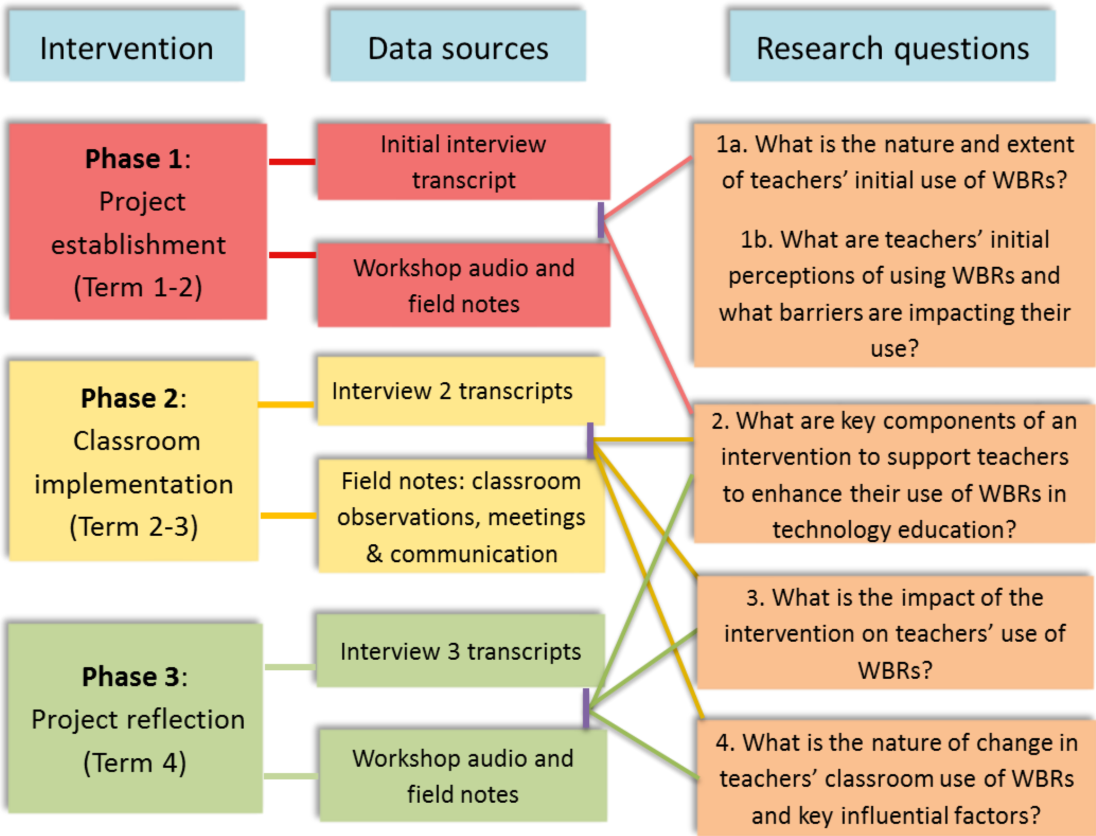

Figure 3.1. Research design

A detailed description of each data collection method used in this research is provided below.

3.3.3 Group workshops

The two group workshops were an integral part of the research strategy and while their purpose was not entirely focused on generating data; group discussions, individual comments, and presentations that formed part of these workshops were recorded for that purpose. Details of these two workshops are presented in Sections 4.2.3 and 4.4.2 respectively.

3.3.4 Interviews

Interviews were the main method of data collection used throughout this research. The interview can be described as a conversation with a purpose (J. Bell, 2005; Powney & Watts, 1987), or an *inter-view,* an interchange of views between two people on a topic of common interest, "where knowledge is constructed in the inter-action between the interviewer and the interviewee" (Kvale, 2007, p. 1). The research interview goes beyond a spontaneous everyday conversation "to a careful questioning and listening approach with the purpose of obtaining thoroughly tested knowledge" (Kvale, 2007, p. 7). Furthermore, the structure and the purpose of the conversation is determined to a greater or lesser degree by the one party – the interviewer (Kvale, 2007). Powney and Watts (1987) also suggest that interviews differ from normal conversations in that an interviewer listens more than speaks; poses straightforward, unambiguous and non-threatening questions; avoids leading the interviewee to particular responses; and avoids sharing their own experiences and opinions.

Interviews are a powerful method for understanding the human situation because they allow participants to convey their situation or experience from their perspective in their own words (Kvale, 2007). Hence, they allow the researcher to delve into the subjective experiences and attitudes of participants, which are otherwise inaccessible (Perakyla & Ruusuvuori, 2011). As Patton (2002) explains "we interview people to find out from them those things we cannot directly observe" (p. 340). We cannot observe thoughts and feelings or behaviours that occurred at an earlier time. To find out such things, we have to ask people questions, and this allows us insights into their perspectives. The challenge for the interviewer is to make it possible for the participants to bring the interviewer into their world (Patton, 2002).

The main disadvantage of interviews is that they are time consuming, which restricts the number of participants that can be involved. Furthermore, there is potential for bias, analysis can be problematic, and wording of questions is demanding (J. Bell, 2005). In addition, Patton (2002) argues that semi-structured interviews in particular (see below) have two main weaknesses, the first being that important topics may be overlooked, and secondly, that the flexibility may result in significantly different responses thus reducing the comparability between participants. These weaknesses can be minimised by thorough preparation before the interviews, and vigilance in conducting them to ensure consistency. Thorough preparation will also help the researcher be alert to what is relevant (Powney & Watts, 1987). Overall it is the responsibility of the interviewer to ensure the interview is successful. However, in the end "the limitations on the information collected in an interview are those imposed by the interviewee. They are the levels of truth that person is willing to disclose to that interviewer on that occasion" (Powney & Watts, 1987, p. 51).

Interview types

There are many different types of interview and they are often described as lying at some point along a continuum. A key difference among interview types is the degree of structure, which reflects the purposes of the interview (Cohen et al., 2007). At one end of the continuum lies the standardised, questionnaire type of interview generating statistical, quantitative data; while at the other end is the completely unstructured and non-directive interview: "The more one wishes to acquire unique, non-standardised, personalised information about how individuals view the world, the more one veers towards qualitative, open-ended, unstructured interviewing" (Cohen et al., 2007, p. 354). The type of interview used will therefore make it more or less suitable for different types of research.

Powney and Watts (1987) differentiate interviews as either 'respondent' or 'informant', depending on where the locus of control lies before, during and after the interview. Respondent type interviews, where the interviewee gives direct answers to very structured questions, align with quantitative research approaches at one end of the continuum. The informant type aligns with the purposes of the more open-ended qualitative type of interview, where the interviewee has more control over the depth and direction of the information given.

A semi-structured interview approach

This research used a semi-structured interview approach, which lies somewhere in the middle of the continuum between the tightly structured questionnaire and the completely unstructured approach, and the participants were more informants than respondents. In this semi-structured approach the aim is to understand the uniqueness of the participants' situation or experiences rather than to measure and compare responses (Cohen et al., 2007). Key characteristics of a semi-structured life-world interview, according to Kvale (2007), include: a focus on nuanced descriptions that represent the many differences and varieties of a phenomenon rather than generating fixed categorisations, a goal of specific descriptions of situations rather than general opinions, an openness to new and unexpected phenomena, curiosity, a sensitivity to what is said – as well as what is not said, and a critical awareness by the interviewer of his or her own preconceptions and hypotheses during the interview.

The interviews in this study had a degree of structure, as in Patton's (2002) 'Interview Guide' approach, since a list of themes and open-ended questions provided a guide to ensure the same key themes were explored with each participant (see Appendix A for indicative interview questions). However, there was also freedom for the interviewer to change the sequence and form of questions during the interview (Kvale, 2007) and to probe, word questions spontaneously, and use a conversational style while maintaining a focus on the particular themes (Patton, 2002). This flexibility and openness "is useful when researchers are not aware of what they do not know" (Cohen et al., 2007, p. 354).

Patton (2002) suggests the strengths of the 'Interview Guide' approach lie in having an outline, which yields more comprehensive data, gives more consistency between participants, and allows logical gaps in data to be closed, but at the same time allows the conversational and situational aspects of the interview to be retained. These were important factors in this research because of the time and access constraints for each interview. The interviews were all scheduled during the school day in a non-contact period or lunch break, so there were limited opportunities for scheduling interviews and the time available was finite and inflexible. A guide was therefore important to help manage the interviews efficiently and ensure all the key themes were covered in the time. Pre-planned prompts also helped with delving for more detail where relevant and keeping the interview flowing. A probe is a “neutral verbal, or non-verbal, way of encouraging the interviewee to answer, or to clarify or extend, an answer” (Powney & Watts, 1987, p. 138). Prompts are often used in qualitative interviews because they can help to gain more depth of information.

It was important to explore similar themes with each participant to allow cross-case analysis, but having flexibility to follow up unique aspects of each case where these emerged was also important. The degree of openness allowed a more relaxed, conversational style to be maintained with the participants, to help them feel more at ease and share their experiences and insights more openly, and in this way increase the depth and breadth of data generated. As Bell (2005) aptly explains:

> Freedom to allow the respondents to talk about what is of central significance to them rather than to the interviewer is clearly important, but some loose structure to ensure all topics, which are considered crucial to the study, are covered does eliminate some of the problems of entirely unstructured interviews. (p. 161)

The flexibility of semi-structured interviews therefore allows access to a richness of data and depth of meaning that would otherwise be difficult to achieve.

Conducting the interviews

Three semi-structured interviews were conducted with each participant in this research over the course of four school terms (see Table 3.1). The interviews were all conducted face-to-face. This had the advantage of allowing the interviewer to observe non-verbal cues (J. Bell, 2005; Cohen et al., 2007), such as body language, facial expression and hesitation. This is a particular advantage in a less structured interview where the interviewer has the flexibility to respond to these cues and delve deeper or spend less time on particular topics as may be appropriate. This may add greater meaning to the data as well as giving clues about when a question may need clarifying. As Kvale (2007, p. 11) suggests:

> The interviewer registers and interprets the meanings of what is said as well as how it is said; he or she should be knowledgeable of the interview topic, be observant of – and able to interpret – vocalisation, facial expressions and other bodily gestures.

The first contact with the interviewee, whether by phone, letter, or face-to-face, impacts on the relationship with the participant (Powney & Watts, 1987) and ultimately affects the quality of the data gathered. In this research, while prior contact had been made with all participants by phone and/or email, and all had received and responded to a formal letter, the initial interview was in most cases the first face-to-face contact relating to the research. Consequently, establishing a good rapport with the participants was a vital aspect of this interview because of the potential to impact on their level of interest and willingness to be involved, as well as the quality of outcomes, not only in this interview but also in each of the following phases of the research. As Kvale (2007) explains, “The social interaction created in the interview is decisive for the readiness of the interviewee to answer the questions of importance to the interviewer, and for the quality of the answers” (p. 65).

The second interview was conducted part way through the unit of work in which the teachers focused on integrating WBRs to enhance teaching and learning. The purpose of this interview was to find out about the participants’ experiences using WBRs, their perceptions of the impact, the challenges they faced, and whether (and how) their beliefs about integrating WBRs had changed (see Appendix A for indicative research questions). The interview was planned strategically for a midway point in order to capture participants’ thoughts and experiences in a timely manner when it was fresh in their minds, to gain some indication of progression, as well as to provide an interim point of contact to help maintain participants' enthusiasm and momentum. It was also an opportunity to identify any problems and provide support if this proved necessary.

The intention for the third interviews was to conduct them as near as possible to the conclusion of the unit of work, and prior to the evaluation workshop. This occurred for all but School C participants for whom it proved more difficult to schedule the final interview – they were interviewed immediately after the workshop. In this interview data were collected on the participants' perceptions of the final outcomes of the unit of work, such as students' learning and engagement, as well as their feelings about the experience; details of what WBRs and teaching strategies were used; how this compared with teaching a similar unit of work previously; successes, problems and what they would change next time; any further change in participants' beliefs about using WBRs; and their thoughts on how they might use WBRs in the following year (see Appendix A).

The location of interviews is an important consideration – it needs to be appropriate for the length and type of interview, convenient for the interviewee and in conditions that are not likely to bias or distract the interviewee (J. Bell, 2005; Powney & Watts, 1987). All the interviews in this research were conducted in the participants' schools. The exact location was left to the interviewee so that it was most convenient for them. Locations were mostly either teachers' offices or classrooms, with two interviews taking place in a corner of the staffroom, but outside of a common break time. The interviews were mostly free of interruptions, although the teachers were still accessible and there were a few individual student queries dealt with during some interviews.

The interviews were all recorded using a digital audio recorder, and approval for this was gained as part of seeking participants' informed consent (see Section 3.5.1). The advantages of recording the interviews were that it allowed the interviewer to keep eye contact with the interviewee, ensure that what was reported was accurate, and allow the interviewer to better maintain concentration and keep up with the conversation thereby resulting in more data being collected (Powney & Watts, 1987). The alternative method of capturing interview data, note taking, has the advantage of not requiring the time and expense of transcription and also of being less intrusive than a recording device (J. Bell, 2005; Powney & Watts, 1987). However, in this research, making the most efficient use of participants' time was a major concern, and also the participants readily agreed to the use of a digital recorder.

Ensuring quality

Strategies used to ensure depth and accuracy of data gathered throughout the interviews in this research, drawn from the discussion above, included:

- establishing and maintaining rapport with participants;
- convenient scheduling of interviews to suit participants;
- attentive listening throughout interviews to ensure accurate interpretation of responses and to identify where possible clarification or further information may be needed and followed up;
- neutral probing and interaction with participants to avoid possible researcher bias influencing responses; and,
- member checking: returning of transcripts to participants to check for accuracy as soon as possible after each interview.

3.3.5 Observation

Naturalistic observation "takes place *in the field*" [original emphasis] (Patton, 2002, p. 262) and it is referred to using a number of different terms, such as fieldwork, qualitative observation, participant observation, and even ethnography which can refer to both a research method and the written product of that method (Bryman, 2004). A distinctive feature of observation is that it allows data to be gathered from actual situations as they happen and therefore has the potential to add a high level of authenticity and credibility to data as people's reporting of events can differ from what actually happens (Cohen et al., 2007).

As with interviews there are many variations of observation, including the degree of structure, the role of the observer, insider versus outsider perspective, the level of role disclosure to others, the duration of observations, and the focus – from narrow to broad (Bryman, 2004; Cohen et al., 2007; Patton, 2002). As with any research method the most appropriate features need to be selected to best meet the purpose and nature of the research. Each approach has advantages and disadvantages that need to be considered in deciding which to use. Highly structured observation has a precise agenda, which is predetermined, whereas in unstructured observation the agenda more open and the researcher has to observe the situation before deciding on what is significant (Cohen et al., 2007).

In this investigation, observation provided a useful method of triangulating and enriching the data gathered through interviews, allowing the researcher to move beyond participants' perception and interpretation to observing actual events, with the potential to discover things that might otherwise be overlooked.

Although observation was considered desirable to add depth and richness to the study, the constraints imposed by the small-scale nature of the research, the fact that there was only one researcher, and the limitations of access and timing presented logistical barriers. Consequently, classroom observation was presented as a potential data collection method in the information given to participants. Therefore, although actively encouraged, ultimately it was left to the discretion of the participants to invite this level of participation. In the end, four of the participants invited the researcher to observe a lesson, but timetabling constraints only allowed three of these to be scheduled.

Observation sessions in this investigation were relatively unstructured, which is in keeping with the qualitative nature of the research. The observation episodes were short (a single lesson), as well as a one-off opportunity, so the focus was necessarily broad, and the main aim was to provide a rich description of the situation as it occurred (Bell, 2005; Cohen et al., 2007). Where observations were conducted, they were immediately followed by the second interview with the participant, which was a valuable opportunity to follow up on and/or make reference to situational or behavioural aspects of the observation session and add richness to the interview and observation data as a result. The observations also allowed the researcher to better understand the individual contexts, which contributed more to a holistic perspective (Patton, 2002).

The role of the researcher in observation can range from that of full participant in the setting, as in ethnographic research to that of total observer (Cohen et al., 2007). In this study the researcher's main aim was to gain a holistic overview and rich description in a short timeframe and therefore her role was mainly that of observer. However, her presence and purpose were overt, which enabled a degree of participation and visibility, and the opportunity to gain a fuller sense of the environment.

Taking notes during the observation was important to help with recall at a later point when they could be written up in more detail: "Because of the frailties of human memory, ethnographers have to take notes based on their observations" (Bryman, 2004, p. 417). Field notes should include detailed summaries of events and behaviour as well as the researcher's reflections, and should be written up more fully as soon as possible after the period of observation, including details such as date and time (Bryman, 2004). Notes can be of different types depending on the situation and strategies will also vary depending on the degree to which the researcher has clearly delineated research questions at this point. In this research the main aim was to observe and record the physical details of the classroom, including layout, resources, and student groupings; details of the lesson and its sequence, including what WBRs were used, what particular teaching strategies were used; as well as details of teacher and student actions and interactions.

3.3.6 Selecting and recruiting participants

Selection of participants in this study was purposive, as is common in qualitative case study research where the aim is to understand particular cases and not to generalise to the wider population. The goal of purposive sampling is to select participants who are relevant to the research purpose and questions (Bryman, 2004). As Merriam (1998) points out, when the aim is to discover and understand, the researcher must select a sample that is likely to provide the most insight into the particular problem or situation.

The sample size was determined mainly by what was considered manageable for one researcher conducting the investigation on a part time basis, and also allowed for attrition (Cohen et al., 2007). In small-scale research such as this it is important to select the best possible informants to ensure that rich insights can be gained. Key criteria in selecting participants included accessibility for the researcher in terms of proximity and travel; their commitment to implementing the technology curriculum; their interest in the area of focus, that is, using WBRs in technology education; and their likely willingness to participate in the research and share their views with the researcher. In addition, a range of views were sought (Bryman, 2004; Powney & Watts, 1987), which was addressed by using different schools as well as technology teachers with a range of specialisms. The wider population relevant to this study is secondary school technology teachers, which includes those in each of the technological areas: food, materials, structures, design and visual communication, electronics and digital. This would provide greater insight and understanding of the broader context of technology education. Although the full spectrum of technological areas was not represented, a range of areas were covered: food, materials, and structures.

Another factor in selecting participants was to include more than one teacher from each school so that there was collegial support within each school. With the schools being geographically relatively distant from each other and from the researcher, this was expected to help maintain motivation and momentum throughout the implementation phase when there was no planned face-to-face contact other than the interviews.

The researcher's knowledge of the local Technology Education New Zealand (TENZ) network was used to identify key people in different schools that would meet the above criteria. These teachers were contacted initially by email and invited to participate. Three teachers replied and were followed up with a phone conversation to explain in more detail what would be involved. Two of these teachers were heads of department and one was a school dean. In each case they were keen to involve other members of their department and they subsequently approached and recruited further participants. This snowballing sampling technique is common in case study research (Merriam, 1998). In all, across the seven participants two teachers were present in each of two schools, and three teachers in the third school.

The three initial contacts and two of the other participants recruited were known to the researcher in a professional capacity, through subject association meetings and conferences, and in some cases through NCEA marking and moderation. This was circumstantial, but also difficult to avoid because of the number of years the researcher had been involved in the TENZ network. In addition, the professional association of the researcher with the participants was considered an advantage. I believed that being identified as a recently practising classroom technology teacher by the participants was likely to make me seem less threatening, reduce hierarchical barriers and possibly support the credibility of the researcher.

3.4 Data analysis

There are many guidelines but no absolute rules for qualitative data analysis; the challenge lies in making sense of massive amounts of data (D. Gray, 2014; Patton, 2002). Analysis therefore involves reducing the volume of information, separating out what is significant for the particular inquiry from what is less relevant, identifying patterns and themes, and building a framework for communicating the findings. As Patton suggests, the main goal should be for the researcher to strive to represent the data and communicate the findings fairly. Similarly, Cohen et al. (2007) suggest the researcher should be guided by the issue of fitness for purpose.

According to Cohen et al. (2007), there are five ways of organising and presenting data analysis. The first two are by people – individuals and/or groups, the third is by issue, the fourth by research question, and the fifth by instrument. In this research three of these approaches were used at different times in the analysis process. First, interview data were analysed and presented in separate matrices for each individual participant. Second, they were combined for the whole group so that similarities and differences between participants within and between schools could be identified. Data were also organised by instrument with analysis of interview data, which was the main source of data, and separate analysis of classroom observations and field notes, which provided a means of triangulating and enriching the interview data. Documents such as classroom activity sheets and teacher planning documents, which were gathered where possible, also provided a means of triangulating, and in some cases adding more detail to interview data.

Each round of interviews was transcribed as soon as possible after the interviews were conducted, and sent to participants for member checking. Classroom observation notes were written up in the form of a narrative soon after they took place, and field notes related to meetings and communication were written up promptly. Notes were written during and after the workshops, and audio recordings of the workshops were listened to and notes made of key ideas and quotes deemed relevant and useful.

Analysis began with identifying and coding key ideas and themes in the interview data, as recommended in various guidelines for qualitative analysis (Bryman, 2004; Cohen et al., 2007; Ryan & Bernard, 2000; Stake, 2010). Coding involves identifying key ideas, sorting and grouping similar ideas together, and classifying them according to topics, themes and issues that are important to the study. The process of coding forces the researcher to think deeply about the data and to begin to make judgements about meanings (Ryan & Bernard, 2000). It also helps to gradually reduce the quantity of data and make it more manageable. It is advisable to start coding data as soon as possible to increase understanding of the data at an early stage, and to help avoid being overwhelmed by the volume of data (Bryman, 2004; D. Gray, 2014). Having three separate sets of interviews in this research provided the ideal space for early coding to begin on the first set of interviews to allow initial ideas and themes to be identified at an early stage, and allowed time for follow up questions to be added to the next round of interview questions if required.

For each round of interviews analysis was an iterative process. Transcripts were revisited many times as codes and themes were reviewed and amended (D. Gray, 2014). Categories and themes related to the overall aim of the research were derived from review of the literature (which also informed the interview questions), and induced from the text itself (Ryan & Bernard, 2000). With each subsequent round of interviews previous interview data were revisited to identify evidence of progression and change in teachers' perspectives and pedagogy, and factors that influenced these.

Coding of key ideas and themes was done using the *Track Changes* function in Microsoft Word. This was done separately for each round of data collection and was reviewed and refined a number of times. Following this, relevant data were transferred to matrices where categories, themes, and evidential quotes were recorded. Where data were relevant to more than one category or theme, they were duplicated. As mentioned, matrices were generated for both individual participants and for all participants combined. Separate matrices of individuals allowed a whole picture of each participant to be presented and interpreted (Cohen et al., 2007), while the group matrices allowed comparisons to be made between participants and schools. Interview summaries were written for each individual interview as well as an overall summary of each round of interviews. This helped to provide a concise overview, which enabled the data to be more easily compared and contrasted between the participants and the schools.

Coding is only the starting point of analysis. The researcher still needs to interpret and synthesise the data, and reflect on the significance of the findings for the research questions and in relation to the research literature (Bryman, 2004). Although, as Ryan and Bernard (2000) point out, once the researcher has identified and refined themes a number of times, a lot of interpretive analysis has already been done, as was the case in this research.

After coding the first round of interviews, contextual data were interpreted and used to write a narrative about each participant and school context, which helped stimulate deeper thinking about the data and emerging themes, and provided a fuller picture. These narratives were sent to participants for feedback if they wished to. Key details from these narratives are reported in Chapter five and summarised in Table 5.1.

Evidence of components of TPACK in participants' reports of their practice was also identified and coded after each round of interviews. Interpretation of data relating to participants' initial TPACK from interview one is reported in Section 5.1, 5.2 and 5.3, and summarised in Table 5.2. Analysis of participants' developing TPACK throughout the research is reported in Chapter six.

Data were further interpreted in writing up Chapter Six, which reports on, and compares and contrasts, findings relating to each participant as they participated in the research intervention. A deeper level of interpretation occurred in the process of writing the discussion chapter, Chapter seven.

3.5 Ethical considerations

Various ethical issues, principles, checklists and guidelines are discussed in qualitative research literature. Commonly-cited ethical issues can generally be classified as one of four overlapping principles: minimising harm to participants, informed consent, invasion of privacy, or deception (Bryman, 2004). However, as Creswell (2009) points out, ethics is more than following a set of guidelines. Principles and guidelines need to be tailored to suit the individual context of the research and researchers need to be cognisant of these principles at each stage of their research, from the initial defining of the problem to the final report (Cohen et al., 2007; Creswell, 2009). Importantly, Cohen et al. (2007) warn that the distinction between ethical and unethical behaviour is not dichotomous. Rather, judgements about ethical behaviour lie on a continuum and must be interpreted in terms of the research context. Ultimately, it is the researcher’s responsibility to use empathy, intuition, intelligence, and experience in perceiving emerging dangers and avoiding intrusion (Stake, 2010). Lichtman (2013) also highlights the importance of the researcher establishing rapport and friendliness to ensure a trustworthy environment and being sensitive to any status position they may hold with their participants.

This research acknowledges the researcher’s responsibility to protect and respect the rights of the participants and to plan for and remain aware of potential ethical issues throughout. The study conforms to the requirements of the University of Waikato Ethical Conduct in Human Research and Related Activities Regulations 2008. Ethics approval was received from the University of Waikato Human Research Ethics Committee 23 July, 2010, with approval of a subsequent request to add another round of interviews, 18 November, 2010 (see Appendices D and E). The main considerations are summarised below in relation to the general principles of obtaining prior informed consent from participants, respecting participants' privacy and confidentiality, and minimisation of harm.

3.5.1 Informed consent

Informed consent involves a person being free to choose whether or not to take part in research after being provided with all the information upon which to make an informed decision (Cohen et al., 2007). As Bryman (2004) points out, this is not as straightforward as it seems because of the difficulty of providing all the information that a participant may need in order to make a fully informed decision. Bryman suggests most social research includes some minor transgressions, such as underestimating the length of time an interview may take so that participants are not put off taking part.

In this research, informed consent was obtained first from the Principal via a formal letter (see Appendix B), in order to conduct the research in the school, and with the particular teachers selected. The letter explained the nature and purpose of the study; the extent of participant involvement, including the types of activities and data collection methods, how many and the approximate timing of these; the participant's right to decline or withdraw and the procedures for doing so; the form in which the findings would be published; the participant's right to access personal information; and procedures for secure storage of data.

Once consent was obtained from the Principals, informed consent was also sought from the teachers via a formal letter along similar lines to the letter to Principals (see Appendix C). Details of participant involvement and researcher expectations were also included and reinforced in email and phone communication, and as part of the initial group workshop.

3.5.2 Privacy and confidentiality

Participants' right to privacy and confidentiality must be respected throughout the research process and in any subsequent publications or dissemination of findings. This involves ensuring that participants cannot be publicly identified, and taking due care to prevent unauthorised access or disclosure of any personal information. In addition, any organisation involved (such as the three schools in this study), must also be protected from identification (Lichtman, 2013). Furthermore, any stored data that could identify participants must not be kept longer than the required period.

In this study the identity of participants and their schools is protected by using pseudonyms for the participants and schools in all reporting of data and findings. However, as Bryman (2004) points out, in qualitative research it can be difficult to entirely eliminate the possibility of identification, and it is acknowledged that descriptions of the unique context of individual schools in the report may be identifiable by people in the school community who are aware of the research. In this way it is also possible that an individual participant could be identified. This risk is minimised by careful reporting of such details.

3.5.3 Minimisation of harm

Researchers must endeavour to identify any potential harm or negative consequences that participants may suffer as a result of their involvement in the study, and to plan and follow procedures to minimise these. In social research, harm is rarely physical. Rather, possible harm includes stress, fatigue, exposure, humiliation, embarrassment, loss of respect and self-respect, and loss of standing in a group.

Participants have the right to expect that the researcher will not be too intrusive on their time, space, and personal lives (Lichtman, 2013). In this study it is recognised that the teacher’s school day is busy and constrained by rigid timetables, and thus the extra demand of fitting in an interview, being observed, or attending a workshop could cause harm by adding stress or fatigue. This was an important consideration in planning and conducting this research, as discussed earlier in this chapter.

3.6 Chapter summary

This chapter described the methodology and design of this research. The research was positioned in the interpretive tradition and the underpinning philosophy and assumptions were explained. The main aim of interpretive research was described as understanding the subjective world of participants, which involves the researcher becoming immersed in the participants' social world in order to understand and interpret their experience and motives.

The qualitative approach employed in this research was discussed and issues relating to quality in qualitative interpretive research were identified. The criteria used to guide quality in this research were identified and explained. The criteria included: sustained involvement in the field, triangulation of data, providing rich detail, and revealing the role of the researcher.

The case study approach and data collection methods used in the research were described and the purposive approach used to select and recruit participants was justified. The approach used for data analysis was described before explaining the ethical considerations that were relevant to this study, and how they were observed.

The next chapter presents an overview of the intervention design and provides details of the components of each of the three phases.

CHAPTER FOUR

THE INTERVENTION

4.0 Introduction

The overall aim of this research was to design, implement and evaluate an intervention to support technology teachers to enhance their integration of web-based resources (WBRs) into their teaching. The intervention involved seven teachers in three different secondary schools participating in a sustained programme of professional development and classroom implementation of WBRs. A brief overview of the three phases of the intervention was presented in Section 3.3.2 (see Table 3.1). This chapter provides a more detailed description and explanation of the design of the intervention. It includes an overview of the general principles that guided the design and details the components and purpose of each of the three phases of the research intervention.

4.1 Intervention design: guiding principles

The overall design of the intervention was framed within a sociocultural perspective of learning (see Section 2.2.1). The inclusion and nature of various components of the intervention were thus informed by principles of sociocultural theory, as well as principles associated with quality teacher professional development, and recommendations for effective ICT professional development (see Section 2.4). The intervention design was also guided by B. Bell and Gilbert's (1994) model depicting the learning process of teachers and signifying the need to address three interdependent dimensions of learning – personal, professional and social – for change in practice to occur. Their model also indicates a loose and flexible three stage process of development in each of the learning dimensions (see Section 2.4.2). The three stage process of teacher learning described in their model closely aligns with the three phases of the intervention.

The overriding principles guiding the design of the intervention are summarised below:

- formation of a subject-based professional learning community and school-based collegial networks;
- introduction of new theoretical ideas – using TPACK as a framework to support teachers in developing understanding of the knowledge and skills required for effective integration of WBRs;
- inclusion of situated and authentic activities embedded in the teachers' own classroom practice;
- flexibility and teacher autonomy; and,
- an extended time frame.

4.2 Phase one

There were three interrelated aims in the first phase of the intervention: to establish a subject-based professional learning community among the participants, stimulate teachers' reflection on their practice, and provide professional development with the introduction of theoretical ideas. These aims were addressed through the three components in this first phase, which included an initial individual meeting and interview with each of the participants, a preparation task for the teachers to complete prior to the group workshop, and a one-day group workshop. The three aims were interdependent and therefore applied to all three components of this first phase.

The importance, for effective teacher development, of teachers working collaboratively in professional learning communities is well documented (see Section 2.4). Such communities reflect sociocultural perspectives and the social nature of learning (Lave, 1991; Lave & Wenger, 1991). They provide opportunities to introduce new theoretical ideas and offer support for teachers in processing new understandings and challenging beliefs (Timperley et al., 2008). The importance of subject-specific communities of practice for supporting ICT professional development in particular, is also recognised in literature (see Section 2.4.3). Learning in subject-specific communities reflects a situated cognition perspective of learning (J. Brown et al., 1989) and recognises the unique nature of content and pedagogy in different disciplines and subsequently the subject-specific nature of teachers' PCK and TPACK.

4.2.1 Initial meeting and interview

The initial meeting and interview with each participant took place several weeks prior to the group workshop. Meeting with the participants at this initial stage provided an opportunity for the researcher to begin to build a relationship with the participants – an important first step in establishing a professional learning community. It was also important to establish rapport with the participants from the outset, to clarify their understanding of the expectations of the project and allay any apprehension they may feel about being involved. Participant involvement in the research was voluntary and would involve time and effort over an extended period of time, over and above their full-time teaching roles. Establishing positive relationships with the participants was therefore vital, not only to secure their initial commitment to the project, but also to help sustain their willing participation for the duration of the research project.

The initial interview, in addition to gathering data, was intended to encourage participants to reflect on their existing practice. It was anticipated that this reflection would cause participants to examine their current practice and beliefs with regard to the value of using WBRs in their teaching and their relevance for technology education. As mentioned in the literature review (see Section 2.4.2), an important first stage in teachers' professional learning is identifying a need or problem in their own practice as a catalyst to engaging in professional development. Although the participants' acceptance of the invitation to join the group suggested a level of interest in the project it could not be assumed that this would automatically lead to acknowledging a need for change in their practice. In addition, in the contemporary educational environment in which the expected transformational impact of ICT is generally not being realised in the classroom (Harris & Hofer, 2011; Ho & Albion, 2010; Lai, 2008; Voogt, 2008), teachers are cognisant of expectations to increase their use of ICT. This context could have influenced the participants' initial decision to be involved without them necessarily identifying a problem in their practice. However, as already discussed (see Section 2.3.5), effective integration of ICT requires significant change in practice for many teachers and multiple interacting variables continue to constrain many teachers' efforts and motivation to integrate ICT. It was therefore anticipated that the participants would readily identify a personal need that was closely aligned with the aim of the project and that there was some professional benefit to be gained from their involvement. Acknowledging a need for change would signify that initial personal development had occurred (B. Bell & Gilbert, 1994).

4.2.2 Preparation for the workshop

At the conclusion of the initial interviews the participants were given an academic paper to read and reflect on in relation to their own practice prior to the workshop. The paper introduced the concept of TPACK (Mishra & Koehler, 2006) as a framework for understanding the components of teacher knowledge that contribute to effective integration of WBRs and other ICTs. Despite its complexity, TPACK is relatively easy to communicate and provides a conceptual framework to help teachers make links with their practice (Voogt, Fisser, et al., 2013). This reading task provided an initial introduction of new theoretical ideas (B. Bell & Gilbert, 1994; Timperley et al., 2008).

The reading task was designed to further stimulate the participants' critical reflection on their practice as well as to introduce the concept of TPACK and its related terminology prior to the workshop (see Appendix F for Abstract). This was intended to help avoid the participants being inundated with new terminology in the one-day workshop and possibly being put off, as well as making it easier to communicate and unpack the TPACK concept in a shorter time, allowing more time for interactive discussion.

The preparation task also invited participants to identify an example of their practice using WBRs in the classroom and attempt to link this example with the components of TPACK. The task was intended to help the participants make links between their knowledge and experience of classroom practice and TPACK, and therefore to help bridge the gap between the reality of classroom and school contexts and more academic theoretical ideas. The participants were asked to come prepared to share their example in the group workshop. The preparation was designed to enhance teacher interaction in the workshop and help ensure contributions were reflective and purposeful.

4.2.3 Group workshop

The one-day group workshop was held in the first week of the second school term in 2011. It was designed to be only one day because of the cost of releasing teachers from their classes. It was deemed important to conduct the workshop on a school day rather than ask participants to attend in their own time as this would help show that the time and effort of their voluntary involvement was valued. It was also anticipated that this would help maintain a positive relationship with the participants and retain their interest and willingness to be involved.

Planning the agenda for the day (see Appendix G) was therefore challenging as there would be no second opportunity to bring the teachers together in the early stages of the project, and it was a short time frame to achieve the intended outcomes. There was a need to have a good balance of activities so that teachers had opportunities to share ideas and experiences, process new ideas and co-construct new understandings about integrating WBRs, contribute to discussion and interact with one another. The range of activities was designed to facilitate collegial relationships among the group members and establish a professional learning community. The day would also support the first stage of the participants' social development and professional development to occur (B. Bell & Gilbert, 1994).

The tight time frame for the workshop necessitated prioritisation of the intended outcomes and careful planning to ensure the outcomes could be achieved efficiently. The intended outcomes were for participants to:

- get to know one another and develop positive relationships both with each other and with the researcher (initial social development);
- understand the expected outcomes of the research, the commitment required, their role in the research and the role of the researcher (initial social and personal development);

- feel affirmed and valued as teachers, motivated to be involved, and supported by and encouraged to work collaboratively with the other members of the group (initial personal and social development);
- develop an understanding of key ideas in the literature about effective integration of ICT in education, including TPACK, to provide support with planning how and where to integrate WBRs in their teaching (initial professional development); and,
- have opportunities to contribute and share their experiences (initial personal and social development).

There were two parts to the professional learning component of the workshop. First, an overview of the current situation in terms of technology integration was presented so that participants could consider the general trends and the challenges facing teachers and relate these to their individual situations. This included:

- key findings from literature that indicate the transformational potential of technology and the largely contrasting reality of minimal change in classroom practice and student learning; and,
- participants sharing their individual classroom, department and school contexts, including challenges and support in their use of technology.

Second, key concepts identified in the literature as underpinning effective integration of technology were introduced to provide new ideas and strategies for participants to discuss and later draw on in their planning and implementation of a unit of work. These included:

- unpacking the concept of TPACK as a framework for understanding what teachers need to know about technology, pedagogy and content and their interrelationships, and discussing the challenges for teachers developing their knowledge in each of these components;
- participants sharing an example of their own practice using WBRs (preparation task) followed by analysis and linking with the components of

TPACK in smaller groups and reflecting on their own strengths, weaknesses and areas for development;

- introducing the concepts of affordances and constraints of technology, their complementarity and interrelationship with other classroom elements and how these relate specifically to WBRs;
- discussing the critical role of the teacher in managing affordances and constraints to optimise learning for individual students; and,
- working in small groups to critique a self-selected WBR and presenting back to the whole group advice for teachers on how to use the resource in the classroom with reference to components of TPACK, and examples of teaching strategies to scaffold learning.

Clarifying roles and expectations

Researcher and participant roles and expectations were clearly communicated in the workshop so that participants were fully aware of the tasks they were expected to undertake before returning to their schools. Understanding roles was expected to eliminate notions of a hierarchical structure, help participants feel more comfortable and supported in their endeavours, and contribute to the sense of belonging to a professional learning community.

The researcher’s role across the three stages of the research intervention was multi-faceted. First, there was a managerial aspect of planning, communicating and facilitating. A second aspect of the role was to provide some expertise in terms of relevant theoretical and practical ideas. A third aspect was that of a co-learner alongside the participants. There was also a support and encouragement aspect to the role, an important component of successful teacher development, in order to sustain the participants’ interest and willing participation for the duration of the intervention and through to the final evaluation. Importantly, the researcher’s role was also to evaluate the outcomes in terms of teacher learning and change in practice.

The role of the participants was to process, trial and evaluate new ideas and strategies for integrating WBRs in the classroom as co-learners, and secondly to collaborate with the other participants to provide support and encouragement and enhance learning. Explicitly defining the participants' role as co-learners was expected to convey the sense that their contributions could lead to valuable insights and new knowledge, and that their experience and ideas were valued and important. It was intended that this would help the participants to view their involvement in the research as learning rather than remedial (B. Bell & Gilbert, 1994).

4.3 Phase two

4.3.1 Classroom practice

The second phase of the intervention was situated in the participants' individual schools where they were asked to choose a suitable unit of work to plan or modify with a focus on effective integration of WBRs, and implement it in the classroom. This involved the teachers taking account of some of the theory and strategies relating to effective use of WBRs that were explored in the workshop when planning what, when and how they would integrate WBRs. There were no prescribed activities or strategies imposed on the participants and no restrictions on the class level or unit duration.

Embedding the main activity in the teachers' usual classroom practice ensured that the task was situated and authentic. This aligns with theories of situated cognition (J. Brown et al., 1989), which assume that the physical and social contexts in which learning takes place are an integral part of what is learned, and emphasises the importance of authentic activities – those that are closely related to what teachers usually do. When tasks are situated and authentic, teachers are more likely to perceive a need and to be motivated to learn (Harris, 2008). It was also anticipated that this type of activity would be the least intrusive on teachers' time and be perceived as directly relevant and beneficial to their practice. This would contribute to the task being self-sustaining, and to maintaining teacher motivation and engagement for the duration of the research project.

The participants were given flexibility and autonomy to choose the timing, nature and extent of WBR integration that best suited their individual needs. This was important in allowing for their differing needs, prior knowledge and abilities, classroom programmes and school contexts. Essentially they were able to customise the task to ensure that it was relevant and achievable for them within the particular constraints of their school and classroom contexts. The flexibility and autonomy of this phase of the intervention acknowledged the agency and expertise of the participants as experienced teachers, which is an important consideration in teacher learning (Clark, 1992; Harris, 2008). The development and enactment of new ideas and changes in classroom practice in this phase align with Bell and Gilbert's (1994) second stage of teacher professional development (development of ideas and classroom practice). The overcoming of restraints that were integral to changing their practice and integrating WBRs, aligns with the second stage of teacher's personal development (dealing with restraints).

4.3.2 Support, reflection and feedback

A second individual interview was planned for the second phase of the intervention, as well as classroom observation if this was deemed appropriate and convenient at the time. In addition to gathering data at this point, the purpose of the researcher visit and interview was to encourage teachers to critically reflect on their practice and to provide any necessary support and feedback to help sustain commitment, motivation and change.

At first, the participants were asked to contact the researcher when they were part way through implementing their planned unit. The reason for leaving this open was to maintain flexibility and autonomy for the participants. The researcher also sent email reminders to the participants, but most of them were slow to respond to these. At the end of the second term the researcher followed up individual teachers, by email and phone, to enquire about their progress and to arrange a date to visit. In School A, which was the closest school to the researcher, this contact resulted in an extra interim visit to attend a department meeting.

Having more than one participant in each school was considered particularly important in this phase, when participants would otherwise be very isolated from the larger group context. A collegial network within their school would offer opportunities for participants to work collaboratively and provide ongoing support and feedback for each other. Such networks are important for effective teacher professional development and reflect the social nature of learning (this phase of the intervention was also designed to support teachers in reaching Bell and Gilbert's (1994) second stage of social development. Communication between all group members throughout this phase was considered ideal and this was planned and trialled through an online forum. However, the participants had difficulty logging in to the forum the first few times they tried and they found dealing with the problem each time was too time-consuming for them to manage. Despite subsequently trying a different online platform it proved too difficult to re-engage the participants in this activity after their initial difficulties and consequently it was not sustained.

4.4 Phase three

The third phase of the intervention included a final school visit and interview late in term four and a half day evaluation workshop at the end of the school year.

4.4.1 Final school visit and interview

The final school visit and interview was important not only for gathering data but also for maintaining relationships with the participants. Participants' awareness of this visit towards the end of the project also contributed to sustaining their commitment and change trajectory throughout. The third interview encouraged participants' ongoing reflection on their practice.

4.4.2 Evaluation workshop

The evaluation workshop was designed to bring all the participants together again to share and evaluate their experiences and learning over the three terms. This workshop was critical to maintaining the participants' sense of belonging to a professional learning community and to recognising the value of working collaboratively in this way. It also contributed significantly to sustaining their commitment and motivation to the project throughout the school year.

The majority of the workshop was focused on the participants sharing their experiences and learning. A final discussion focused on key knowledge the participants deemed to be important for effective integration of WBRs in technology education. These ideas were collaboratively categorised using the components of TPACK. In this activity the participants assumed a lead role in the workshop. The workshop therefore provided an opportunity for them to gain a sense of achievement from having their contribution validated and valued and also to learn from the other participants' experiences.

4.5 Chapter summary

This chapter described the design of the intervention. The key principles that guided the design were explained. The principles included: the formation of a professional learning community and school-based collegial networks, the introduction of new theoretical ideas, the inclusion of situated and authentic activities embedded in classroom practice, flexibility and teacher autonomy, and an extended time frame. Details of the three phase structure and the components within each phase were discussed. The purpose of each component was described, and the various roles of the researcher and the participants within each of these components were explained.

The next chapter presents the findings of phase one of the research.

CHAPTER FIVE

TEACHER PARTICIPANTS AND SCHOOLS

5.0 Introduction

The previous chapter provided an overview of the guiding principles underpinning the design of the intervention and discussed details of the components and purpose of each of the three phases. This chapter presents findings from Phase 1 of the research and draws on data from the initial interview (Ii) and the initial group workshop (Wi). This phase of the research sought to better understand the existing situation for each of the participants at the start of the research and addresses the research sub-questions:

- What is the nature and extent of secondary technology teachers' current perceptions and use of WBRs in classroom?

- What are teachers' existing perceptions of using WBRs in technology education and what barriers are impacting on integration?

The chapter is divided into four sections – the introduction, and one section for each of the three participating schools. As explained in Section 3.3.1, presenting the findings in this way acknowledges the significant influence that individual school contexts are likely to have. Section 5.1 presents findings from School A and its participants, Alison, Agnes and Ashley; 5.2, School B and its participants, Brenda and Brian; and 5.3, School C and its participants, Carla and Cheryl. The initial letter of participants' names are matched to the letter allocated to each school to simplify identification for the reader.

Sections 5.1, 5.2 and 5.3 each begin by describing school details, which include key demographic information, how technology education is implemented, technology department and classroom ICT access, and staff professional development in ICT. This is followed by participant details, which include demographic information, how participants were using WBRs at the start of the research and the researcher's interpretation of their initial TPACK.

All participants were experienced teachers and all were committed to teaching technology education, although they had been teaching the new curriculum for varying lengths of time. They all had limited access to computers and the Internet in their individual classrooms and varying levels of access to computer suites and Computers on Wheels (COWs) in their schools. For ease of reference, Table 5.1 provides an overview of the participants, their access to ICT in their individual schools and classrooms, and their initial use of WBRs. Table 5.2 presents a summary of the participants' initial TPACK. The TPACK summary excludes the participants' PK, CK and PCK because they were experienced teachers and hence it was assumed that their knowledge in these components was already developed. It was also not a focus of this research.

Table 5.1. Summary of participants' profiles

Teacher	School	Years teaching	Technological area	Permanent classroom computers	Internet in classroom	Data projector in classroom	Access to COWs for classroom use	Access to computer suites	Frequency of WBRs use
Alison (HOD)	A Rural Sec school	>25	Food	3	Yes	Shared	2 sets bookable	Bookable Limited availability	Occasional
Agnes		>25	Food	0	Yes	Shared			Rare
Ashley		7	Textiles	1	Yes	No			Rare
Brian	B Rural Sec school	11	Structural	0	Yes	No	No	Bookable Limited availability	Never
Brenda		>15	Textiles	1	Yes	Yes			Occasional
Carla (HOD)	C Urban Yr 7-13 sch	>25	Food & Textiles	0	Yes	Yes	No	1 suite for technology department	Frequent
Cheryl		>25	Food & Textiles	0	Yes	Yes			Rare

Table 5.2. Summary of participants' initial TPACK

	Initial use of WBRs	Technological Knowledge (TK)	Technological Content Knowledge (TCK)	Technological Pedagogical Knowledge (TPK)	TPACK
Alison	Occasional use of YouTube videos to show food processing methods. Occasional use for independent student research	Limited experience using ICT and WBRs and subsequent lack of skills, knowledge and confidence to support classroom use	Knowledge of a narrow range of WBRs that could support understanding of specific content in technology education	Teacher-directed, technocentric approaches using WBRs in class Limited knowledge of how WBRs could enhance teaching approaches and student learning	Undeveloped
Agnes	Very occasional use for student research, mostly in small groups which were rotated in order to access one computer at a time in an adjacent classroom.	Very limited experience using ICT and WBRs Impacted by lack of access at home and school Subsequent lack of skills, knowledge and confidence to support classroom use	Limited knowledge of WBRs that could support understanding of specific content in technology education Development impacted by lack of access and lack of TK	Very limited experience and subsequently limited knowledge of how WBRs could enhance teaching approaches and student learning	Undeveloped
Ashley	Very occasionally might direct individual students to a particular website to support their individual research.	High level of skills, knowledge and confidence for personal ICT use Very limited experience or motivation to use in the classroom	Little attempt to develop knowledge of WBRs that could support understanding of specific content in technology education	Lack of belief in the value of WBRs for learning in technology education inhibiting classroom use and development of knowledge of how WBRs could enhance teaching approaches and student learning	Undeveloped
Brian	No classroom use of	Limited skills, knowledge	Limited knowledge of WBRs	Strong belief in value of	Undeveloped

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	WBRs. His senior students used the Internet extensively for project research and also ‘Sketch-up’ for drawing, but all in own time using personal computers and skills.	and confidence using ICT Very limited experience using ICT in the classroom	that could support understanding of specific content in technology education	WBRs for learning in technology education but very limited access preventing classroom use Lack of experience limiting development of TPK	
Brenda	Occasional use of short YouTube videos as lesson starters to broaden students’ thinking relating to what they were doing, or to introduce a new idea.	Steadily increasing ICT skill and confidence	Developing knowledge of WBRs that support understanding of specific content in technology education	Developing knowledge of ways WBRs can enhance teaching approaches and student learning	Developing
Carla	Extensive classroom use of WBRs for independent student research.	Reasonable level of skill and confidence using ICT and WBRs	Developing knowledge of WBRs that support understanding of specific content in technology education through frequent in-class use	Very dependent on WBRs to support student research. Lack of teaching strategies to scaffold student learning using WBRs	Developing
Cheryl	Very occasionally (with technical help) showed an excerpt from a TV documentary, or ‘Click view’ videos which the school subscribed to online.	Very limited experience using ICT and WBRs No personal use of ICT Subsequent lack of skills, knowledge and confidence to support classroom use	Limited knowledge of WBRs that could support understanding of specific content in technology education Development impacted by lack of access and lack of TK	Very limited experience and confidence using ICT and subsequently limited knowledge of how WBRs could enhance teaching learning	Undeveloped

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5.1 School A

School A is a state co-educational secondary school in a rural New Zealand town. The school catchment area extends to rural areas up to 50 kilometres from the town and a large percentage of the students travel to school by bus. At the time of the research it was a decile 6 school with a roll of 1230 and an ethnic composition of 26% Māori, 70% Pakeha and 4% Other. The school had a strong focus on Māori achievement and worked closely with the local Māori community.

Broadband Internet was not accessible in much of the rural area surrounding School A, so many families who subscribed to the Internet had to rely on dial-up access. The consequence of this was that many of the students attending School A could not do any work using the Internet at home:

> We did a survey a couple of years ago and we discovered that most of the kids had a computer at home but most of them didn't have Internet access. Their house might have Internet access but they weren't allowed to use it because they were on dial-up. We've got a huge number of kids on dial-up so they just … can't work at home. It's just too slow. (Ashley, Ii)

5.1.1 *Technology education at School A*

Technology education is not compulsory at School A, so courses in this area are optional at all levels. At the start of this research, technology-related programmes were delivered by two separate departments in the school, the food and textiles department and the hard materials department. The two departments operated independently and were located on opposite sides of the school campus.

The three teachers who participated in this study were the full complement of teachers in the food and textiles department. Alison – the Head of Department (HOD) – and Agnes delivered the food-related programmes. Ashley delivered the textiles technology programme.

When technology education was first introduced in New Zealand in 1995 (see Section 2.1), School A retained its traditional skills-based programmes in the technology area. Consequently, in the food area the focus remained on home economics for many years, with hospitality and childcare programmes also offered at Year 12 and 13. However, in recent years they had started moving to more of a technology focus in their junior classes and were gradually introducing technology into the senior school: “once we found our feet we’ve developed units that are technology based, and we are developing more and more of that language in our junior school” (Alison, Ii).

The year data were collected for this research (2011), the school was introducing technology education at Year 11. Key factors influencing this change in focus were that technology education had become a university-approved subject and student demand for courses that offer Achievement Standard-based assessments, and therefore provide credits towards University Entrance, was increasing (see Section 2.1). As Alison explained, “We’ve found this year that students have been told not to come to this area [food technology] because of not doing Achievement Standards, and so that’s another focus is that technology is university-approved so that’s made a difference” (Ii).

In the textiles area, Ashley, having completed her teacher training more recently (since the implementation of the technology curriculum), had introduced technology education in the textiles area several years before the food area. Consequently, the senior textiles classes had been using Achievement Standards related to the technology curriculum for a number of years.

5.1.2 *Technology department ICT access*

In the foods area, Alison’s class had three computers in the classroom with wireless Internet access. Agnes was teaching in an adjacent room but had no permanent computers in her classroom. Agnes’s only computer access was a teacher laptop, which she kept in the shared teachers’ office space. The wireless Internet connection in Agnes’s classroom was less reliable than it was in Alison’s room. The department had one data projector on a trolley that could be moved between the two adjacent food rooms.

Ashley’s classroom was separate from the two food rooms and located in a different school building. Ashley had only one computer in her classroom, which she used mainly for administration, and she had no data projector or screen in her room. The room was very old and quite small and didn’t lend itself very easily to setting up computers or a data projector and screen.

School A had several computer suites. These were timetabled for ICT classes in the first instance. Although they could be booked for other classes in the unallocated periods, there were not many available spaces. As Agnes commented, “The computer suite is almost impossible to get into” (Ii). The school also had some computers in the library, although not enough for a whole class, and it had recently invested in two sets of Computers on Wheels (COWs). These were also available for booking. The COWs had 20 laptops contained on a trolley that could be wheeled to individual classrooms.

At the start of this research the school was in the process of upgrading their Internet access and this was expected to provide faster and more reliable broadband access.

5.1.3 *Staff professional development in ICT*

Increasing teachers’ use of ICT in the classroom had been identified as a priority in School A. In pursuit of this, the school had been proactive in providing staff professional development (PD) sessions. One compulsory and one optional PD session focusing on ICT was offered per term for the whole staff, and departments were also encouraged to use meeting time to focus on ICT skill development. Some of the whole staff sessions focused on how to use particular ICTs, such as the smart board, and also upskilling in the use of the school student administration programme. However, some sessions provided opportunities for more content-specific learning for teachers. For example, in the first interview Alison reported:

> The last one we had, we went onto a site that was with TKI [Te Kete Ipurangi], and it was amazing. And I found something on digestion and I thought, yeah, this is good for the food … And I said to the girl who was running that course that I want to do this

> unit on Pestos. Well, she just went dit dit dit, and then she had five different YouTube videos on Pestos, which was just amazing. And she was so quick, whereas I'm still learning that searching stuff. (Alison, Ii)

School A had one teacher available to provide technical support on a part-time basis. However, there seemed to be a high level of collegial support among the staff. Teachers often sought help from colleagues whom they had identified as having the ability to help and whom they perceived to be able to explain things at the level they needed.

5.1.4 Alison

At the beginning of this research project Alison was HOD, Food and Textiles Technology, at School A. She had been teaching in the department for 15 years and had been HOD for six.

Alison trained as a home economics teacher and taught in a variety of schools during the first four years of her career, specialising in both the food and textiles areas, before taking a break to have a family. She returned to teaching some years later to a position at School A.

Alison was a very experienced teacher. She was known by the researcher to have been an active and leading member of her subject association at the local level for many years. She was also known for her enthusiasm and her drive to get her students to excel. For example, she encouraged her students to enter into subject-related competitions each year and they regularly achieved success in these. From the researcher's observations of Alison's interactions with her students and her department staff during the research it was evident that Alison had a very caring and positive relationship with her students.

Involvement in the project

Alison was an enthusiastic teacher keen to keep up to date and improve her teaching. She was particularly focused on implementing the new technology curriculum, moving away from the more traditional skills-based programme she had been delivering. Also, integrating ICT in the classroom was a school priority. Alison felt that being involved in the research would help her address all these foci. At the first group workshop Alison reflected:

> I am here to try to motivate myself to have the courage to continue to use computers in my teaching. This year I'm extremely proud of what I've done already and I think it may have been the fear of coming to this workshop – so it's motivated me to take that step. (Wi)

As an HOD she felt it would be beneficial for the other two members of her department to be involved as well. Alison's school Principal was very supportive of her department's involvement in the research as it aligned with the school's priorities. For this reason Alison and her two staff members were able to use their involvement in this project to meet their PD obligations for the year.

Alison's use of web-based resources

When computers were first introduced at School A, Alison said she found them challenging and lacked confidence in asking for help because she didn't feel she would be able to understand. However, in the first interview she reported that she had gradually developed a level of skill in using computers and the Internet such that she felt more confident trying to use them in the classroom and asking colleagues and students for help when needed:

> I think possibly now I feel confident and that I can ask, and that's helped me to learn, whereas before I didn't feel confident asking, you know, I thought I'd never understand it. It's picking the right person to show you is the secret. (Alison, Ii)

Alison reported in the first interview that she felt the recent school upgrade, which provided more reliable Internet access and higher speed broadband, would help her to feel more confident using WBRs in the classroom. Prior to the upgrade she had often been let down by interrupted or unreliable access, which made her feel a loss of control in the classroom and impacted on her confidence in using WBRs in the classroom.

Alison was positive about the value of WBRs in the classroom. At the beginning of this research, she reported that she found her students were more engaged when she used WBRs in the classroom. However, she also qualified this by making the point that they needed to be used as part of a mix of resources:

> I think the kids are enjoying the variety in your teaching techniques. So when I use online stuff they're leaping at it whereas when I have two or three days where you're using it they're coming in on the third day with the glazed look. And I think even though they love that learning, I think they like the variety. (Alison, Ii)

Alison also believed that WBRs had potential to greatly enhance learning. However, she had found during her early experiences using WBRs for student research that to enhance learning it was important to provide scaffolding for the task. Without this she found the tendency was for students to just 'cut and paste' and not think deeply about the information. As a result, she reported that she sets clear expectations and guidelines, as well as incorporating other resources to support students to think deeply about the information. In other words, Alison had found that students' information literacy using the Internet could not be assumed.

> Last year, my Year 13s, they did a research project and this year they've done the same project but I gave them three books and I gave them a worksheet, and they could go online and I said they weren't allowed to cut and paste. And the work they've done this year is tenfold compared to last year. So, what they presented last year was just purely stuff off the Internet and they didn't understand. Whereas this year they have had to tie it up with the books they've read and the information they've found. (Alison, Ii)

Alison's use of WBRs in the classroom at the start of the research was predominantly for student research and the occasional use of YouTube videos, for example, to show a food processing method. Her research lessons using WBRs were very tightly planned to ensure that she felt confident in her ability to manage the lesson. When using the three computers in her classroom she would often bring up the pre-selected website beforehand so students didn't have to search:

> I'll often give them a couple of websites that I like them to go to and check on because I think it's safer, and if we're going to the computer room I like to be very, very particular about what they've got to do and give them more than what they've got time to do so they haven't got time to be idle. (Ii)

Her classroom use of WBRs was usually integrated with a number of paper and text-based tasks, which students rotated around. This approach allowed her to manage tasks with only a few computers.

Alison reported that lack of time was the main constraint limiting her integration of WBRs. "The time to find stuff – yeah, it simply is that. It's just making the time. I've just got to budget the time and stick with it" (Alison, Ii). She also reported that she found it difficult to find WBRs that were appropriate and relevant to her programme. She felt this was because she was not very skilled at searching and therefore she could spend a lot of time searching and still not find what she wanted.

Alison had used the school computer suites occasionally, but found the booking system difficult to use and did not feel comfortable teaching her class in these facilities. She felt better able to manage her classes in her usual teaching room and felt the students were less distracted there where established routines and expectations were understood.

Technological pedagogical content knowledge (TPACK)

As an experienced teacher, Alison's Pedagogical Knowledge (PK) was well developed, as were her Content Knowledge (CK) and Pedagogical Content Knowledge (PCK) in the traditional home economics discipline (based on her leadership role in the subject). However, given that Alison had only recently begun implementing the technology curriculum it was possible that her CK and PCK in technology were not as well developed as they were in the traditional home economics discipline. However, as implementation of the technology curriculum was not the focus of this research, specific data on this aspect were not collected.

The nature and extent of Alison’s use of WBRs at the start of the research, described above, indicated that her Technological Knowledge (TK) was still quite undeveloped. For example, when introducing herself at the first workshop Alison commented, “I have a little dabble and then something happens and I run back to the tried and true method” (Wi). Alison’s lack of TK was impacting on her confidence to use WBRs in the classroom, and consequently, she didn’t use them very often. Her limited experience using them in the classroom was restricting her ability to develop Technological Content Knowledge (TCK) and Technological Pedagogical Knowledge (TPK).

In summary, to develop her TPACK in technology education it appeared that Alison would need to focus on developing all three areas – TK, TCK and TPK – more or less simultaneously. Increasing her confidence and experience using WBRs in the classroom would likely help her to develop her knowledge and skills in each of these three components of TPACK.

5.1.5 Agnes

At the start of this research project Agnes was teaching food technology at School A and had been teaching in this position for three years.

Agnes had more than 25 years teaching experience. She initially trained and started her teaching career as a primary school teacher. She began teaching home economics after spending several years away from teaching raising a family. She was asked to take over a secondary school home economics teaching position temporarily before this became a permanent role. Agnes found she really enjoyed teaching the subject and continued teaching in that field from then on. Until she took up her current position at School A, Agnes had spent most of her teaching career as an HOD of home economics and subsequently, aligned with the implementation of the technology curriculum, as HOD Food Technology. She reported that she had progressively built her content knowledge. Agnes had also recently completed the required G3 qualifications to maintain her degree equivalent status. The primary teacher-training course Agnes completed was a non-degree course. In the 1980s teachers in secondary schools could gain degree equivalent status, and therefore pay parity, by having prior qualifications assessed (such as trade certificates), and completing university papers or training courses to generate a number of points, which met criteria for degree-equivalence. These criteria were revoked in 2002 and further study and an oral examination were required to redeem this status. The study involved up-skilling in pedagogy and curriculum, and consequently this is likely to have impacted Agnes's CK and PK.

Involvement in the project

Agnes was encouraged to be involved in the research by Alison, her HOD, who had also volunteered. Alison was keen to have all members of her department involved because she wanted to make it a PD goal for her department. The school Principal was also supportive of all three teachers being involved.

Agnes was positive about the value of using WBRs in the classroom and for this reason she was motivated to be involved in the research, seeing it as an opportunity to develop her skills.

Agnes's classroom use of web-based resources

At the start of the research Agnes reported that her access to WBRs in the classroom was quite limited. She had no computers or data projector in her classroom, and while it was possible to wheel a data projector in from Alison's adjacent classroom, this was not always convenient and her wireless connection was not always reliable:

> Alison has better wireless in her room than I do in mine, and she has access to more computers than I do. I have my laptop, and it's in my office, so sometimes that can be a bit of a [distracting location] you know, when you've got kids going in and out, teachers going in and out – sometimes your concentration isn't good. (Agnes, Ii)

In the initial interview, Agnes reported that her skills in using computers and the Internet were not well developed but she was consistently building on these all the time and was comfortable asking colleagues for help when she needed it. Introducing herself at the group workshop, she expressed that one of the things she hoped to gain by being involved in the project was to be better able to trouble shoot when using computers. The following comment reflected her lack of skills: “I get so frustrated – I just seem to touch one of those things [pointing to a computer] and it seems to go ….[mutter, mutter, hands waving]” (Wi).

Agnes did not have a personal computer or Internet access at home and therefore spent very little time using the computer outside of the hours she spent at school. This had clearly impacted on her development of computer skills. Agnes was also very aware that not all students had computer access, and that not all had well developed computer skills. She reported that when using computers in the classroom she would tap into the skills of the more competent students, both for her own development and for peer teaching other students:

> More often than not it’s like “[student name], can you come over here and show [another student]?” So it’s probably peer teacher more than anything, and then I’m over the shoulder just checking and then I can pass that knowledge on as well. And I do that quite a lot – I’ll teach you and you teach …. (Agnes, Ii)

When asked about her use of WBRs in the classroom in the initial interview, Agnes reported that her classroom use of WBRs was minimal:

> Not a whole lot at this stage other than for research. I might give them [students], you know, whatever we’re doing and they’ll go and sort out whatever they need to find, but they have to go into Alison’s room for that. Otherwise you’ve got to book into the library, and there aren’t enough computers for a whole class anyway. (Agnes, Ii)

Despite the challenges of the situation, as an experienced teacher, Agnes had developed her classroom management skills such that she was able to adapt her classroom organisation effectively to manage a range of different situations. This had allowed her to manage some computer use with her classes despite difficulties with access. For example, as indicated above, Agnes had small groups of students go into Alison's adjacent classroom to use a computer for research, and rotated groups through this keeping tight control on timing so that all students had a turn.

At the start of the research Agnes was positive about the value of integrating WBRs into her teaching. She reported that she felt that WBRs allowed more individualised learning programmes:

> Because they can actually find the depth they want to go into – if there's someone who wants to be challenged a bit more they can actually see something and get excited about that, and start finding more stuff out. Whereas, before you had to try and teach to the middle and hope that everyone picked up on it. (Agnes, Ii)

Agnes also highlighted that she viewed WBRs as an essential resource for student research, particularly in technology education, because they provide more up to date information than books.

Agnes reported that, on occasions when she did use WBRs in the classroom, her role in the classroom changed. She found it enabled her to teach students a lot more in small groups or individually rather than as a whole class, lecture-style, which had been the dominant approach in her earlier years of teaching. Agnes viewed this as a real benefit of using WBRs in the classroom, and considered that students learnt more and got more excited about their learning. She found it met individual student needs better, and students took more responsibility for their own learning. Reflecting on how using WBRs changed classroom management, Agnes commented:

> It probably has [changed], in that I don't have them all doing the same thing at the same time. They have a set amount of stuff to work on and they work at their own pace, and then if someone's needing a little bit more they can go and do that, or if someone needs more help I can spend time with them. So, I'm not teaching

> them as a [whole class] group, I'm teaching them more as either smaller groups or individual groups and stretching them that way. (Agnes, Ii)

From the researcher's observations and conversation with Agnes during the research, it was evident that she had a very deep knowledge of her students and their individual needs, and that she tried to set tasks and interact with students accordingly to support and challenge their learning. She saw computers as being a particularly useful classroom tool for differentiating tasks in this way and meeting individual learning needs, particularly for challenging the more able students.

Technological Pedagogical Content Knowledge

With many years of teaching and experience as an HOD, Agnes was a very experienced teacher. As such her PK, CK and PCK, in particular in home economics, was considered to be well developed and this was evident in researcher observations and interactions with Agnes and the other staff in the department during the research.

The above analysis of the nature and extent of Agnes's use of WBRs at the outset of the research project indicates that her TK was still largely undeveloped. Her limited access to computers and the Internet, both personally and in the classroom, were impacting on her ability to build her knowledge and experience and in so doing to develop greater confidence to use WBRs in the classroom. As with Alison, it was evident that Agnes needed to develop her TK and her classroom experience of using WBRs in order to develop her TCK and TPK.

In summary, Agnes was in a similar position to Alison in terms of developing her TPACK in technology education. Her development of TPACK was likely to be dependent on developing her knowledge in the three components of TK, TCK and TPK in an integrated way. Developing this knowledge would require more experience with, and critical reflection on, using WBRs in the classroom.

5.1.6 Ashley

Ashley was teaching predominantly textiles technology classes in the year data were collected, and was the only teacher at the school teaching in this area. She had been in this position for six years.

Ashley had initially completed a degree in fashion design and worked in a variety of positions in the fashion industry before training as a secondary school technology teacher. In contrast to Alison and Agnes, Ashley had trained after the introduction of the technology curriculum. Ashley completed her first year teaching in another school before taking up her current position. Prior to doing the fashion design degree she had worked in secretarial positions and done a lot of desktop publishing work.

Ashley’s fashion design experience had equipped her with sound knowledge and skills in the textiles domain as well as first-hand industry experience. In her first year teaching Ashley worked with teachers more experienced in delivering technology education, but in the six years in her current position she had been very isolated. With the department continuing to focus as a whole on a skills-based programme rather than moving to a more technology-oriented programme, the other two more experienced staff had not developed their understanding of the technology curriculum and consequently were unable to offer much leadership or PD for Ashley in the technology curriculum. As the only teacher delivering the technology curriculum in the school, Ashley felt quite isolated and had to develop all her own resources and keep up to date with curriculum changes without much collegial support, which she had found challenging. Although she had had little mentoring in implementing technology education, it was likely through her teacher training and her seven years of teaching that she had developed a reasonable level of CK and PCK in technology education ,– although this was not a focus of the research.

Ashley had a wealth of experience with computers, having grown up with them from a very young age – even before many people had them for personal use. She had also gained a lot of computer skills from her secretarial experience. In addition, Ashley described her husband as a ‘computer geek’ so she had continued throughout her working life to be surrounded and influenced by people with a deep interest and experience in computers, and also with a wide array of hardware and software enabling her to broaden and deepen her own skills and knowledge. Consequently Ashley was very comfortable and confident with using computers and WBRs:

> I'm not scared … I've been using ICT for a long time. I did a computer course when I was about 12, so you know, when they were brand new. I use it all the time, I've always got a laptop in front of me and [husband] is a computer geek, so there's everything we need at home and every kind of programme you can imagine. (Ashley, Ii)

Involvement in the project

Ashley became involved in the project through Alison, her HOD who had herself volunteered and was the researcher's first point of contact in this school. Although initially it was only Alison and Agnes who volunteered to be involved, the Principal was keen for all three in the department to take part. Ashley did not volunteer initially because she wasn't really using WBRs and felt that she may not have anything to contribute. However, she was prepared to begin trialling the use of WBRs in her classroom, and subsequently agreed to participate despite her current limited use.

Ashley's use of web-based resources

Despite Ashley's extensive experience and skill using computers and the Internet, at the start of this research she was rarely using WBRs in her classroom:

> I would only use them to research for resources for me to teach from, I don't use them in any interactive way with the kids. I would only go look for, or help the students look for, research. Like the Year 12s are researching second world war so I might direct them to a website. (Ashley, Ii)

Ashley reported that she felt quite comfortable with her teaching and the traditional resources she was using, and expressed that she hadn't felt the need to incorporate anything new such as WBRs. She also reported that she felt her teaching time was dominated by the practical component of the textiles technology programme to the extent that there was not sufficient time to fit in much else:

> To be honest I think if the computers were in the back of the room we'd hardly ever use them, mostly because I'm desperate to get practical experience into the girls. That's the biggest thing, is the practical experience. Time is so short that that mostly takes priority. (Ashley, Ii)

Some years prior to this research, when Ashley had taught some classes in the foods area, she had used some WBRs as she had found time and opportunities to fit these in around the practical component of the foods programme.

Despite stressing that she didn't feel the need to use WBRs in her programme, Ashley did comment, however, that her students might find WBRs engaging. She reported that she had observed instances in other classes where WBRs were used and noticed the relevance and student engagement, which indicated that she had given it some thought:

> I think that what I do is fine but that if I did branch out a bit more it might be more interesting for the students, more relevant, if I used more things that they have a connection with. I think that definitely is the case because occasionally when I go into another class or see what someone else is doing I think, oooh yeah, they like that, they might connect with that. Not that I have a problem with my kids now. (Ashley, Ii)

In Ashley's senior classes (Year 12 and 13), her students used computers as part of their design research, most of which was independent and self-driven. Ashley provided some guidance in using the computer for research, but informally, and as she was very skilled at this herself she tended to use a fairly off-the-cuff, teacher-centred approach to this, rather than planned, interactive skill development. This may well also have been due to her concern over lack of time in the programme.

Her lack of access to computers and the nature of her classroom were also a constraint to using WBRs. Having a very small classroom with no computers, data projector or screen, Ashley was dependent on access to a school computer lab, or to one of the two school COWs, and reliable Internet:

> The limits really will just be access to the computers, getting the COW available. It'll go, as long as the wireless works, … and the other thing of course is at the beginning of every lesson it's very slow because if all the labs are on and all the COWs are on, it's very slow. And the other limit is if anything goes wrong, you're out. (Ashley, Ii)

Although Ashley could identify opportunities and benefits of using WBRs, she felt there was a greater need and relevance in other subjects such as social studies to be able to access WBRs, and that it was less relevant for technology education:

> I think that I have enough resources to cope without it. It's not like I was teaching, say, social studies and needed it to talk about tornadoes, for example, because it's not relevant to me. (Ashley, Ii)

Technological Pedagogical Content Knowledge

Ashley was the least experienced teacher participating in this research, even though she had seven years teaching experience. However, it was evident from the researcher's observations of Ashley in the classroom and her interactions within the department that her PK was well developed. Ashley appeared to manage her class in a confident and organised manner. She also appeared to have established very positive relationships with her students and to have gained their respect.

As outlined in the description above, Ashley's TK was well developed as she had been using computers and the Internet for many years, mainly in her personal life. However, despite her considerable TK, Ashley rarely used WBRs in her classroom teaching. This lack of experience using WBRs in the classroom had prevented Ashley from developing her TCK or TPK. In order to develop her TPACK in technology education Ashley would need to develop her knowledge in these two components.

It appeared that the key factor limiting Ashley's use of WBRs and therefore her development of TCK, TPK, and TPACK in technology education, was that she did not believe that there was significant advantage for her students or her teaching to be gained from using WBRs in the classroom – not sufficient to outweigh the challenges of fitting it into a busy practical programme, and in a context with limited computer and Internet access.

5.2 School B

Two teachers from School B were participants in the research: Brenda, who taught textiles technology and Brian, who taught structural technology.

School B is a coeducational secondary school situated in a rural township close to several major cities and catering for Years 9-13 students. The students in the surrounding primary schools also attended technology classes at the school in Years 7 and 8. The school had a roll of 660 students at the time of this research project and was decile six.

The school serves a predominantly farming community, and there is strong community support for the school. Both Brian and Brenda highlighted the high expectations the school has of its students. As Brenda reported: "The Charter runs how the school operates and we have high expectations of the students, not just academically, but of their behaviour. As a result it makes teaching pretty easy" (Ii).

5.2.1 Technology education at School B

At the time of the research, the technology department was a large department with a wide variety of ages and backgrounds among the teachers. Some teachers in the department had embraced the technology curriculum and some had not, or didn't really understand it, which Brenda thought was fairly typical of schools around New Zealand at that time. The teachers worked largely independently but as Level 1 of the new technology NCEA standards had become compulsory that year, more of the teachers were working together to develop their understanding. Brenda and Brian tended to lead the department in terms of the technology curriculum and shared a lot of the resources they developed with the other teachers.

> [Brian] and I are probably the leaders and we come up with resources, and that just seems to help everyone out. But it's a very interesting department, and I think you'd find that everywhere around New Zealand for technology, because there are so many backgrounds and issues that come with the subject. (Brenda, Ii)

Brenda reported that overall she felt that the department was very successful – they were getting good results and had high student numbers taking their courses.

Brenda described the department implementation of the technology curriculum as "a work in progress" (Ii), and the department was not yet able to track progression in technology coherently across the department. As Brian reported:

> We've been chatting about the matrix [charting teacher coverage of generic technology achievement objectives across the department] forever and a day and we're still waiting. But now we've got the new technology at Level 1, we're now demanding that we have it so that we want to be absolutely crystal clear who's doing what – covering what area of the strand that we're doing, so that we're not repeating. And we need to work on it, and we haven't. We've been very lax in that area in the past. So, it's like we're working independently and it's not what it should be. (Brian, Ii)

5.2.2 Technology department ICT access

At the start of the research, the technology department's access to ICT facilities in the school was very limited. Most classrooms had no access. Although Brenda had recently been provided with one computer and a data projector, as well as Internet access in her classroom, she reported that she found access to computers for a whole class of students very difficult:

> [It's] very, very limited. I have in my classroom a computer and a data projector, and I'm pretty lucky to have that. And the other problem we have is ICT is on when I have Year 9s and Year 10s. To be able to get access to computers *en mass* is extremely difficult. (Brenda, Ii)

Brian had no computers in his classroom and the issue of the dusty environment in the workshop meant that it was unlikely to be fitted with any permanent computers. Brian described his access to ICT as "hopeless, absolutely hopeless" (Ii).

There were pockets of computers in the school, some computer suites and some smaller pods of computers, which Brenda and Brian had both accessed occasionally. The school had recently introduced a booking system for using these, which Brian and Brenda felt made them harder to access. Brian also found the booking system didn't fit well with teaching technology because his students worked on individual projects, and it was difficult to know ahead of time when students would need access, which is typical in technology education:

> We've got three computer suites, four including the Hub and I think it's pretty dire to be honest because of what I do with technology, we need it just like that because of where students are at. And I don't know when to book the suite. (Brian, Ii)

Consequently, at the start of the research, most of the work Brian's and Brenda's students were doing using WBRs was done for homework. If students didn't have access at home they were provided with alternative resources, or could access computers in the library outside of class time. Some students in Brian's senior classes brought their own laptops to school to work on. In the structural technology area, the only CAD system available for students' design modelling was Sketch-up, which could be downloaded free from the Internet. Brian's students taught themselves to use the software and used it extensively in their portfolio design work.

5.2.3 Staff professional development in ICT

School-wide professional development with ICT at School B had been limited to training in the use of the school management system software. Beyond that it was left to teachers to develop their own skills. Both Brian and Brenda reported that they found they mostly had to teach themselves the skills they needed.

5.2.4 Brenda

Brenda taught classes in textiles technology in School B, and was also a Dean, indicating a strength in pastoral care. She had been teaching in the school for nine years.

Brenda originally trained as a dietician and worked in that field in several hospitals before training as a technology teacher. Brenda had been teaching for over 15 years, and in that time she had worked in a variety of schools and taught food and textiles technology as well as human biology. Brenda was committed to keeping up to date with changes in education generally, and technology education in particular, as well as striving to extend her own learning and improve her teaching. As such, she was committed to increasing her integration of ICT.

Brenda reported that she had found her confidence with using ICT was increasing as her experience increased, and as computer use such as email became more of an essential part of everyday life. Also, as her awareness of the possibilities and resources increased and she recognised the usefulness, her experience and confidence increased accordingly. Brenda reported that her own children were very helpful in showing her how to do things, “We’ve got a couple of computers and my children are at an age where they can show me or actually do it for me and that sort of gets me through” (Ii).

Brenda also reported that she found her students were always keen to help when she had any difficulty in class and she was happy to ask for their help:

> Often what will happen, because I’ve only got one computer in my room, I’ll say to the kids, “Look, this is what I want to do, has anyone got any idea how to do it?” And it’s interesting because you’ll get two or three kids that’ll come and show you what to do,

> and because they've done it at a more basic level, I'm actually more likely to work out how to do it. So I've certainly got a lot better. (Brenda, Ii)

Involvement in the project

Brenda was approached by the researcher to be involved in the research. The researcher was already acquainted with Brenda on a professional level, having been involved in national assessment and moderation of technology education with her on several occasions. Brenda was known as an enthusiastic teacher, committed to the new technology curriculum and with a strong desire to keep up to date with new developments, such as curriculum development and integrating ICT.

Brenda's classroom use of web-based resources

At the start of this research, Brenda was very positive about integrating WBRs into her teaching. She believed they provided valuable, authentic and engaging learning resources and had particular relevance to the new technology curriculum. Brenda reported that she was using WBRs (mainly video clips from YouTube) occasionally in her classroom – mostly as lesson starters. She selected clips to link into what the students were doing, and used them to introduce a new idea, provide insight into a factory or a manufacturing process, or to analyse existing technologies:

> For example, in Year 9, looking at the McDonalds' failures and so introducing the whole trialling and testing and modelling stuff there. Sometimes it's a video or YouTube clip to show what it's like inside a factory and what the processes might be for my more senior students, because I can't take them to a factory around here. (Brenda, Ii)

Brenda reported that she considered herself still at the entry level in terms of using WBRs in the classroom in that she needed to build up a bank of relevant resources. She realised that it would take time to build her knowledge of a wide range of WBRs and also to improve her skills in searching and finding relevant and appropriate resources, "I'd have to say we're still probably at the entry level of that, mainly because it's about finding resources I can use that will fit into my programme" (Brenda, Ii).

Brenda found that playing a relevant YouTube clip at the start of a lesson helped garner students' interest and promote thinking and discussion. Brenda generated discussion after showing a video to help students think about the concepts and make links to their own projects:

> Often I'll generate a discussion after they've seen it. For example, we might see a clip of the factory processes, and so how could we break that down into stages and how could we summarise that into some sort of planning tool? And with the McDonalds thing, ok these were the flops, why did they flop and what could they have done better to stop that happening, and how could that help you? This is food and we're doing fabrics – how could this inform your practice? (Brenda, Ii)

Brenda reported that she was trying to incorporate WBRs when she planned new units of work she hadn't taught before. She particularly tried to make links with authentic examples, via the Internet, to create more relevance for students. She reflected that WBRs supported the new curriculum well and she also had the attitude that bringing something new to her teaching was a positive thing to do:

> Because the longer you've been teaching the more lax you get with your planning because you know how things go. So by bringing that in, I guess it gives you a little more structure because you want to make sure you're not just showing a clip and letting that go. Like, let's look at how we can use this information to help us. (Brenda, Ii)

One of the main constraints for Brenda impacting on her use of WBRs in the classroom was computer access. She had only one computer in her classroom and finding access to computers elsewhere in the school for whole class use was difficult, as mentioned earlier. Because of this she had to set any independent tasks using WBRs for students to do for homework.

Time was also a constraint for Brenda as she found it time-consuming to search for and find relevant resources, and then to plan how to integrate them into a lesson. She found this challenging to fit into her busy daily teaching and pastoral care roles, as well as her family life outside of school:

> So it’s having the time to actually find the information to be able to integrate it, and ‘cause often it might only be a one or three minute thing, it doesn’t have to be the whole lesson. That would be my biggest challenge. To overcome this I just have to spend a lot of time at home finding the resources. (Brenda, Ii)

Technological Pedagogical Content Knowledge

As an experienced teacher, Brenda’s PK was well developed. Her CK and PCK in technology education were also well developed. She had industry experience as a dietician and had committed to teaching the technology curriculum early in its implementation. She had also been involved in national assessment and moderation, which reflected her commitment to ongoing learning and PD in the discipline, and also reflected her competence as a technology teacher through being selected for these roles.

As outlined in the analysis above, at the start of this research, although Brenda described herself as being at the entry level in terms of developing her TK, she was clearly committed to, and making progress with, this development. Since being provided with a data projector and Internet access in her classroom she had started integrating some WBRs into her classroom teaching. It appeared that these experiences had already helped her to develop her TK to some degree (such as, searching for and locating relevant resources), her TCK (such as, awareness of WBRs relevant to what she was teaching), and her TPK (through planning pedagogical strategies to maximise the learning from these resources, for example, structuring discussion to help students link industry examples and practices to their technological practice).

Although it was clear that Brenda was developing her TK, TCK and TPK, her knowledge and experience in these three areas were still limited. As identified for the previous participants, Brenda's development of TPACK would be dependent on further development in these three components.

5.2.5 Brian

Brian was teaching classes in structural technology at Year 7-13 level and had been in this position for eight years. Prior to this, he had taught in a primary school for three years.

Brian began his working life as a professional furniture maker. He trained in England where he gained City and Guilds qualifications. He had always wanted to teach but it wasn't until a friend of his who was teaching in New Zealand suggested that he move to New Zealand and train as a technology teacher that he decided to give it a go. As Brian reported: "The rest is history and I absolutely love the changes I've made for myself. I just love the culture of the school, I love the kids – I think they're great" (Ii).

With his industry background, Brian has a high level of domain knowledge and skill in his specialist technological area and, having trained more recently, he had a good understanding of the new curriculum.

It was clear from the researcher's interactions with Brian during the research that he was passionate about the technology curriculum and the value of the learning for his students, in particular his senior students, who were working on individual product development projects with external clients, as expected in technology education. He reflected:

> What I love about what we do is that we come up with something really special at the end of the year. Especially when we get the community involved as well – like we did a big project for [a church] last year and that was just a phenomenally successful technology project – it was just great! And that same client has come back again this year. (Brian, Ii)

It was evident from Brian’s description of his students’ project work that he knew his students well and that he interacted with them on an individual basis, guiding and challenging them according to their individual needs. He encouraged all his students, including junior students, to consult with an external stakeholder so that they considered other views in the decisions they made about their own product development. Brian needed to be particularly well organised to manage his students in their individual projects, and he established protocols and strategies for managing students’ contact with clients, often during school hours, to enable their progress to continue smoothly.

Involvement in the project

Brian was recommended as a potential participant by Brenda and he subsequently accepted the invitation.

Brian’s classroom use of web-based resources

At the start of the research, Brian believed that using WBRs was really valuable for his students. He commented that in contemporary society, where computers and the Internet are an integral part of everyday life, it is a mode of working students feel comfortable with. He reported that he found the speed and convenience of WBRs suited the students’ ways of thinking, and that WBRs were relevant to what they were doing in the classroom as well as to their life outside of school and their future careers. He found it particularly valuable for his students to be able to gain instant access to up to date information about products and components for their projects and for them to have the ability to communicate directly with technologists to get expert advice, which they did outside of class time:

> It’s so relevant to what they’re doing, and to not just the curriculum but also to their career or their life outside here. It’s management, it’s communication and getting feedback and analysing data and it’s real … so why not use their strengths or the information that they know. (Brian, Ii)

Brian described himself as self-taught in terms of computer and Internet experience. He reported that he lacked time to do the research on the computer that he felt he needed to, that he found it difficult to find the information he wanted on the Internet, and that he lacked confidence in his skill level using computers. Consequently Brian relied on his students to do their own research:

> Internet, for me personally, it's time to do research on it myself – [I] don't have much time to do that. I'm relying on [the] kids. I say, "Right you need to research into such and such – these are the key words, fire them in and what do you come up with?" And then they have to do their own research. But for me personally, to find that information is quite difficult. (Brian, Ii)

At the start of the project Brian didn't use WBRs at all in his day-to-day teaching in the classroom because of the difficulty of accessing them, and his lack of confidence in using them. Brian overcame this difficulty by relying on the students to complete the work at home. He made sure that he provided alternative resources for any that didn't have computer or Internet access at home, by providing books and photocopied information.

As already indicated, Brian's senior students, particularly Year 12 and 13, used the Internet a lot for research for their projects. They also used Sketch-up (computer software for drawing) extensively, and included their drawings in PowerPoint presentations to present their design ideas to clients. Brian highlighted many advantages of using SketchUp, such as the speed and efficiency of producing a design and the accuracy and professional appearance of the finished result. He also recognised the relevance of using this type of software, as students continuing in this field beyond school would likely use similar types of digital tools. Brian reported that he was very impressed by the level of skill his students demonstrated, and although he didn't have these skills himself, he encouraged his students to use them as much as possible:

> I know the students can do it, and I know they've got the resources to do it, and I just encourage them to use that. I'd love to learn it myself, I don't know how to use Sketch up, but the kids do. And I

> just totally encourage them to use what they feel comfortable using, and in today's society they feel comfortable using that sort of media because it's quick and instant. (Brian, Ii)

Brian reported that he found the students generally turned instinctively to computers as their first port of call when seeking information. However, he did comment that he felt his students didn't necessarily think deeply about the information they selected:

> I think it's a case of, "I'll read the first few lines and I'll just copy and paste the rest and just chuck it in", but do [they] understand what the content is? Sometimes I don't think they do. They can just tick the box to say yes, I've found that information … whereas I'll challenge them that the information has to be in their own words, and I do check that. (Brian, Ii)

Technological Pedagogical Content Knowledge

As indicated, Brian's TK at the start of this research project was limited. Although Brian believed strongly in the value of his students using WBRs in technology education and encouraged their use of them, he had not developed his own skill level in this area. The main constraints limiting his development of TK appeared to be lack of time, and significant difficulty accessing ICT for his classes. It seemed likely that his positive belief in the value of WBRs would encourage him to develop his skills and make more use of WBRs in his classroom if he could gain greater access and experience.

In addition to constraining his development of TK, the limited access Brian had to ICT for his students was preventing him from gaining any experience integrating WBRs in his classroom. With little experience incorporating WBRs in his teaching Brian had had little opportunity to develop any level of TCK or TPK in relation to WBRs.

Brian's situation in terms of developing TPACK in technology education was therefore similar to Alison and Agnes in School A. In order to develop his TPACK, Brian would need to make more use of WBRs in the classroom. Through ongoing reflection on these experiences it was likely he would develop his TK, TCK and TPK together, thus enabling him to begin to develop TPACK.

5.3 School C

Two teachers from School C, Carla, the HOD of technology, and Cheryl, were participants in the research.

School C is a coeducational catholic school catering for Years 7-13. It is a Decile eight school with a roll of 960 students. The school is set in an outer suburb of a large city and is relatively new.

5.3.1 Technology education at School C

The technology department at School C has five teachers and provides programmes in food, fabric, structural, multi-materials, graphics and early childhood. Technology is compulsory in the school from Years 7-10. In Year 7 and 8 students have a ‘taster’ of four technology areas, spending one term in each area. In Years 9 and 10 students choose one of the technology areas to study. All students complete a course in ICT at Year 9.

Due to the special character of the school, religious education is a compulsory subject at senior level, which restricts students’ subject option choices to two, due to English and mathematics also being compulsory subjects. This impacts on student numbers opting for technology subjects at senior level.

The technology department was committed to implementing the curriculum and had started to align their programmes more closely across the department over the previous two years. As part of this process they had developed a series of generic lessons in Years 7-10 that they all delivered, targeting the Nature of Technology strand of the curriculum. As part of this process they planned to continue building on their curriculum alignment and developing more generic resources. They were in the process of updating their schemes of work to have a common format, and beginning to develop and share generic templates which they made accessible on the department shared drive.

5.3.2 Technology department ICT access

At the start of this project the school had just installed a wireless Internet connection. While the teachers all had their own school laptops, there was very little permanent computer access in classrooms with most rooms in the department having no computers. Teachers had to carry their laptops in and out and set them up whenever they wanted to use them with a class. The technology classrooms were also quite small so finding space for computers was problematic and the practical nature of most technology classroom use was a constraint, with steam and dust presenting issues in some rooms. As Carla reported:

> We have great difficulty in the food and fabrics room with computer access – particularly the foods room. It's very tight for space and it's not very safe because of water and the way it's geared up. There is one in the fabrics room but it's only been there for about two weeks, and that's only because they were upgrading in another area and we managed to grab one of the old computers. (Carla, Ii)

The technology department had a small computer suite with 17 computers located in the block of adjoining classrooms. In that year the technology department had begun timetabling the computer suite exclusively for their classes. In this way they could ensure some access for all their classes. It was also possible for several classes to share the facility or for individual and small groups of students to be accommodated within other classes. In previous years when they had not timetabled it for their department, they found that it was often booked by other departments, which limited access for their technology classes.

At the start of the research the school was also beginning to invest in class sets of laptops, which were housed on a trolley (COWs). These were to be gradually introduced to one department at a time. Each department was eventually to receive one set.

5.3.3 Staff professional development in ICT

Some whole-staff PD in ICT had been provided at the school, but not on a regular basis and the focus had mainly been on using the school management software. Teachers in the technology department willingly helped each other with ICT so those with lesser skills were able to learn from their colleagues and most were comfortable doing this. The collaborative culture in the department had the potential to provide support with building knowledge of WBRs and teaching strategies that all teachers in the department could benefit from. They had already established a system of sharing resources on a shared network drive.

5.3.4 Carla

Carla was HOD Technology at School C at the start of this research. She was a foundation staff member of the school and had been HOD for two years.

Carla trained as a home economics teacher and had been teaching for more than 25 years. Early in her career she had several years out of teaching when she had a family. She returned to teaching on a part-time basis for many years. She has taught in a wide variety of secondary schools during her career with her current position being the only one she had held in a Year 7-13 school.

Carla had considerable expertise and experience in teaching technology and had been involved in moderation and assessment at a national level in technology education for many years. She had built a considerable repertoire of resources and strategies throughout her teaching career and continued to add to and refine these as her experience grew. This growth included increasing her use of WBRs as her access, experience and awareness increased over the years.

Carla's classroom use of web-based resources

At the start of this research Carla was very positive about the value of using WBRs in technology education and she reported being heavily reliant on having access to them most days in her teaching. Carla was teaching only senior classes in the year data were collected for this research. Her main use of WBRs was for independent student research where students were finding the background information they needed to inform their product development. Carla's Year 12 and 13 classes were using computers for research most days and Carla felt they really couldn't manage their work without this access.

Carla reported that she found WBRs provided a broader range of information that wasn't readily available in other formats:

> At the moment with the students in my Year 13 class they're all looking at different clients – they've all got different needs and they're all trying to find out different information, and yes, you can get it out of a book, but when you've got one looking up anaemia, one's looking at things on diabetes another one's looking up budget recipes – where do you go, you know? (Carla, Ii)

The limitation Carla found with her students' individual use of WBRs was their lack of information literacy, particularly in terms of searching, selecting and synthesising relevant information. Although students seemed very comfortable and confident using computers and the Internet, and seemed very "tech savvy", Carla reported finding that they were not necessarily skilled in finding and using the information appropriately and efficiently – rather, she had found that students' skills were actually quite limited in this area:

> They're not very good at going through and evaluating the information and sorting and sifting and finding the knowledge that is applicable to what they're doing. … They're savvy with the technology but they don't know how to use it or how to apply it. They can find stuff but it's stuff not necessarily pertinent to what they're doing. (Carla, Ii)

There was a tendency for students to cut and paste information without any critical evaluation or synthesis in how they used and applied the information. This was something Carla found difficult to manage.

Carla described herself as fairly confident in using ICT. She had developed her skills mainly through trial and error:

> You know, you learn as you go along, and every day you try and learn something or you pick up other bits and pieces, or I ask the kids. You know, they're pretty savvy a lot of them. (Carla, Ii)

Carla worked collaboratively with her students, often drawing on their skills and knowledge in ICT when needed and appropriate. Carla also strived to share as much as possible with her colleagues to support and expand their use of WBRs. For example, she would put as much as she could onto the shared drive for the other teachers to access, and encouraged them to do the same. She also used a shared drive for her students to provide them with flexible and easy access to information and resources.

Carla sometimes developed structured worksheets and activities to scaffold student learning with WBRs. Sometimes she did this to support the introduction of a topic or when there was a common focus in a project and students were looking at the same resources. Her worksheets often included a list of questions and websites to visit to find particular information, but this was dependent on the topic. However, as the school had grown Carla had found it more difficult to find the time to develop these supporting resources. As she reported: "That was when the school was a lot smaller and you had a lot more time but now you're so busy, it's frantic all the time" (Carla, Ii). Also, in senior technology classes, students were working on individual projects and all had very specific and individual needs in terms of the research information they required. Carla reported that she hadn't yet developed particular strategies to support students with this:

> It's just there's sooo much stuff. And it's hard for some of the students because they can't focus. They'll go on, and they'll start looking here, and then they'll fling off into somewhere else, and then they might try and Facebook or they'll go somewhere else. And there's no filters, you know – there's just sooo much there, and they're constantly flitting. And then at the end of the period: "Oh I haven't done anything because I've been looking there, there and there". So that's really hard to control. (Carla, Ii)

In other words, Carla found the biggest challenge in using WBRs was finding relevant and appropriate resources, or supporting the students to find them. In senior technology classes all the students were working on independent projects covering a broad range of different contexts and Carla found this challenging. She also found it difficult to keep the students focused and to help them all with finding the information they needed efficiently.

Involvement in the project

Carla responded to an email invitation sent out to previous recipients of teacher fellowships. She volunteered herself and her colleague in School C, Cheryl.

Technological Pedagogical Content Knowledge

Carla was an experienced technology teacher and through her many years of teaching, she had developed her PK. Carla began implementing the 1995 technology curriculum when it was first introduced, so she had been teaching and developing her CK and PCK in technology education throughout this time. Carla had also been involved in national assessment and moderation of technology for a number of years. Hence, Carla’s CK, PK and PCK in technology education were likely well developed.

As the data above show, Carla mostly used WBRs for independent student research in order to meet the diverse needs of her students for information in a range of different contexts. Carla had been developing her TK through her personal and professional use of ICT, including her regular use of WBRs with her students. She was also developing her TCK as she gained greater awareness of a range of WBRs that supported her students’ needs in technology education in a range of contexts, both through her own research and through the experience of her students and colleagues. Similarly, her TPK was developing as she reflected on, and developed strategies to better support and manage her students’ use of WBRs in the classroom.

Although Carla was clearly developing her TK, TCK and TPK and she had no hesitation in using WBRs in her classes, her use was still limited mostly to independent student research. The fact that she found it very challenging managing this reflected the need for her to further develop her knowledge and skills in TK, TCK, and TPK, to help develop her TPACK in technology education.

5.3.5 Cheryl

At the start of this research project Cheryl was teaching food and textiles technology at School C. She taught mostly Years 7-10 but she was also teaching food technology at Year 11 for the first time in that year.

Cheryl initially trained as a home economics teacher and had been teaching for over 25 years. Prior to her current position all Cheryl's teaching had been at Intermediate school level, mostly teaching textiles but more recently teaching food technology as well. Cheryl had been teaching at School C for four years.

Cheryl was an experienced teacher and observations during this research indicated that she was a well-planned and organised teacher with well-developed skills in classroom management. She appeared to understand her students' interests, and worked hard to select resources and activities that would engage and motivate her students and keep them focused throughout a lesson. Her prior experience gave her a repertoire of strategies to draw on, but this didn't include experiences with using WBRs.

Cheryl's classroom use of web-based resources

Cheryl had very limited experience with ICT and commented that her only reason for using it was for school: "I don't see it as a personal tool. Not at all" (Ii). Her lack of experience had a direct bearing on her skill level and confidence in using ICT, particularly in the classroom.

At the start of this project Cheryl used WBRs in her classroom very rarely. The extent of her ICT use appeared to be showing excerpts from relevant TV programmes and documentaries that she asked a department ancillary staff member to record for her, and also some online access to subject-related videos:

> There have been a couple…one or two clips from television news programmes that [the department technician] has accessed for me

> and put on my desktop so I can click that up. And then of course we've got the click view little videos and that's basically how I've used it. (Cheryl, Ii)

Her limited skills and experience in using computers and the Internet were a considerable barrier to her trying to integrate WBRs in her classroom. Her lack of skills meant that she found it difficult, time-consuming and often she couldn't achieve what she set out to do.

> To be able to find video clips or whatever that are appropriate – that takes a long time, and that's another reason why I don't like the computer. Because if you want to Google something, you want to go and find whatever, you could spend days looking and it's just so hard to access stuff that's appropriate. (Cheryl, Ii)

She found this frustrating, and it affected her confidence to the extent that she was often reluctant to even try things out in the classroom. Access was also an issue:

> The fact that the classrooms aren't set up with their own computers, already set up with speakers and that sort of thing. … We work in three or four different classrooms, and sometimes we have to carry our laptop from one to the other, plug it in while the kids are getting organised, race back, pick up the speakers, come back – it's just ridiculous. So it gets to the stage where you just try not to *(laughs)* – it's easier to give it away. (Cheryl, Ii)

Cheryl believed that WBRs could help with student engagement, and her occasional use of them in the early stages of this research was mainly centred around their value for engaging students with a new idea or topic, and to stimulate discussion. She also commented on the affordance of repeatability, which allowed individual students to re-access a resource as and when needed, or for capturing and replaying television programmes and news items relevant to a topic or idea:

> Usually as an introduction to a topic, [I'm] trying to think, we've just done stuff on preserving and … basically skills in working in the kitchen. There's also one about threading a sewing machine but

> it's not clear enough for Year 7 kids, so it's a bit of fun for 15 minutes, but it's not got the detail that the kids need. (Cheryl, Ii)

The key issues for Cheryl that impacted on her use of WBRs were the skills and time it took to search for, and find, appropriate resources; limited computer access in the classroom; and fear of things going wrong or not working as expected in the classroom. Most of these constraints could be directly related to her lack of experience and confidence in using ICT.

Cheryl's lack of experience and confidence with using WBRs meant that she had tended to avoid using them use in the classroom. When describing her current usage, Cheryl referred to teacher-centred approaches, such as using WBRs as a "hook" to engage students at the start of a lesson, as "a bit of fun", or as an alternative to demonstrating a process such as threading a sewing machine, or to reinforce some information.

Involvement in the project

Cheryl was invited to be involved in the project by her colleague and HOD, Carla, when the researcher communicated that more than one department member being involved from the same school could provide peer support. Cheryl agreed to be involved in the research, anticipating that her involvement would help her improve her skills. Cheryl and Carla worked closely together at School C and seemed to be leading the department in implementing the new strands of the Technology Curriculum.

Technological Pedagogical Content Knowledge

As an experienced teacher, Cheryl's PK was well developed. She had also developed her CK and PCK in home economics through her many years of teaching. The degree to which Cheryl had developed her CK and PCK in technology education was not explored in this investigation.

As the data above show, Cheryl's TK was very limited and her lack of knowledge and skills in this area were clearly impacting on her confidence and motivation to use WBRs in the classroom. As a consequence, Cheryl had not developed her

TCK or TPK to any degree. It was evident therefore, that her lack of development in these three components was severely impacting on her development of TPACK in technology education.

5.4 Chapter summary

In this chapter, background to the three schools and seven participants in this research project has been presented. This background has provided insights into the individual school and teacher contexts, as perceived at the start of this research. Included in this background are demographic details relating to each school and teacher, each department's implementation and commitment to technology education, the ICT facilities accessible to the participants in each school, the ICT skills and knowledge of each of the participants, their level of use of WBRs in their classrooms and the constraints that they perceived impacted on their ability to integrate them, how they became involved in the research, and a description of their TPACK as perceived by the researcher at the start of the research.

While the participants had varying levels of experience teaching the technology curriculum, they were all clearly committed to continue moving their teaching in this direction. All the participants were relatively experienced teachers, with years of teaching ranging from seven to more than twenty five. Their PK, CK and PCK were not a focus of this research.

Initially all but one of the teachers (Ashley) strongly believed that integrating WBRs would have a positive impact on their students' learning and engagement, and hoped that through their involvement in the research they would develop their knowledge and skills to use WBRs more effectively in their teaching. However, only one teacher (Ashley) had significant TK, developed through many years of extensive use of ICT and WBRs personally and in previous careers. Paradoxically, she was also the one who did not at that point see a value in incorporating WBRs.

All the participants had limited TCK and TPK because of their limited experience using WBRs in the classroom. Together with their limited TK, with the exception of Ashley, the participants' lack of knowledge in these three components was limiting their development of TPACK in technology education.

A key factor constraining the participants' development of these three components of TPACK, in particular in School A and B, was difficulty accessing computers and the Internet for their students. This limited access was a considerable barrier to them gaining experience using WBRs in the classroom and subsequently the opportunity to develop their TCK, TPK, and TPACK. Lack of computer skills, and time to develop these, were also constraining factors for six of the seven participants, and three of the participants identified the pressure of completing the practical component of their technology programmes as challenging their integration of WBRs in the classroom.

In the next chapter, analysis of findings from Phase two and three of the research are presented.

CHAPTER SIX

CASE STUDIES OF THREE SCHOOLS

6.0 Introduction

The focus of this chapter is the presentation of findings from phases two and three of the research (see Table 3.1). These phases explored the journey of the participants as they responded to, and moved towards, the goal of the intervention, which was to integrate WBRs effectively in the classroom to enhance teaching and learning.

The teachers' developing knowledge and skills are categorised and analysed using the TPACK framework. As discussed in the previous chapter, all the participants were experienced teachers and were considered to have a sound level of CK, PK and PCK at the outset. Hence, findings on the participants' development of TPACK are mainly confined to the components of TK, TPK, TCK and TPACK.

The findings show that the participants all had different start and end points and the pattern of change over time was different for each of them, as were the driving and constraining factors.

Although all the participants were committed to implementing the revised technology curriculum, the stage they were at in terms of making the shift from their traditional discipline to the new curriculum varied. While implementation of the 'new' curriculum was not the focus of this research it did create a context where teachers (and schools in general) were reviewing their programmes and the learning opportunities offered to students. This was likely to have been a contributing factor in the participants' willingness to be involved in the research project – they were on a change pathway and perhaps saw the project as providing some support for change.

In addition, schools' increasing focus on ICT development, and the Curriculum recommendation that schools should explore how ICT can supplement traditional ways of teaching and open up new and different ways of learning (Ministry of Education, 2007), were also contributing factors for many of them.

The chapter is divided into four main sections. Each section presents the findings of a different school as a separate case study and concludes with a chapter summary. Data in this chapter were drawn from Interview two (Iii), Interview three (Iiii), classroom observations, the workshops and field notes. More detail on the research design can be found in Section 3.3.

6.1 School A

School A had three participants: Alison (HOD), Agnes and Ashley (see Section 5.1). Of the three schools, this was the only one that involved more than two participants. In addition, these three participants comprised the entire technology department. This appeared to better enable collegiality, and there was evidence of particularly strong collegial support between them. The strong support appeared to contribute to the momentum that was sustained throughout the research from the three participants. Being an entire department also made it possible for the researcher to attend a department meeting part way through the research period. This provided an opportunity to discuss interim progress and schedule visits for observations and interviews in a face-to-face situation rather than via email. This was a considerable advantage as all seven research participants were slow in responding to email communication and committing to a time for a second interview.

Having three participants in this school entailed more visits overall as it proved difficult to schedule three interviews on the same day, and also classroom observations with Ashley and Agnes were conducted on separate days. Having extra visits was an advantage as it meant there was more incidental contact between the researcher and these participants, and more opportunities to build rapport than in the other two schools.

As outlined in Section 5.1.3, increasing classroom use of ICT was a priority in School A and regular whole staff professional development sessions focusing on ICT use had been scheduled throughout the year. Departments were also encouraged to allocate some of their department meeting time to up-skilling in ICT. Alison had implemented this in her department on a monthly rotation basis, utilising Ashley's ICT skills to help up-skill her and Agnes.

> [Ashley's] a member of the ICT group and so she'll often run a bit of ICT stuff with us but we're using working with you [the researcher] as our focus this year for our staff meeting PD so that's a time when we share any resources we've found, and talking about where to from here. (Alison, Ii)

The fact that this ICT-related PD was a school priority contributed to the Principal's support for the participants to take part in the research and also to the participants' willingness to be involved. Alison volunteered herself to be involved in the research in the first instance and then encouraged Agnes and Ashley to be involved. As such, she was a significant driving force for the other two participants.

Alison and Agnes were both using WBRs only occasionally in the classroom at the start of this research mainly due to their limited skills and confidence using WBRs personally, and limited access to ICT for their classes. However, they were positive about the value of WBRs for enhancing student engagement (see Section 5.1.4 and 5.1.5 respectively). Ashley, by contrast, had significant skill and confidence in using WBRs personally but openly admitted to believing that they would add no value to her classroom teaching. Consequently, she rarely used them in the classroom. Despite her beliefs, Ashley willingly joined the group and was committed to trialling WBRs and keeping an open mind about their impact on teaching and learning (see Section 5.1.6).

6.1.1 *The participants' post-workshop activity*

By the time the researcher attended a department meeting in School A in early August it was clear from the participants' conversations that there had been a lot of discussion about when and how they would use WBRs in their classes. When asked about their progress, all three participants mentioned that, having committed to the project, they were encouraged to not only look for opportunities to use WBRs but also to follow through with using them, where they might otherwise have given up when things got too hard.

The participants had discussed strategies for accessing WBRs and, as they all had limited access to ICT (see Table 5.1), they all decided to plan for using a school COW as their main source of WBRs for their classes. The two COWs were relatively new in the school but were in frequent use by other staff, so advance booking was essential.

The decision to try using a COW to meet their commitment to the project was a significant step forward for Alison and Agnes. They had already trialled using the COW (before the August meeting) in some of their classes. They commented that they had been pleased with how the lessons had gone and as a result were more confident and motivated to use the COW again. They found bringing the set of computers to their own rooms worked much better than taking their classes to a computer suite. As Agnes explained:

> Using the COW and therefore bringing the computers to your own classroom – your comfort zone – where students know the guidelines and boundaries, has also been much easier than expected. Previous experiences taking students to another room – an unfamiliar environment where you don’t have established routines for working with them, and where there may be other students and other distractions – have been much more difficult. (Agnes, Iii)

Alison, in particular, talked about a number of positive experiences she had had and it appeared that she had already made a significant shift in her thinking about the value of using WBRs, as indicated by this comment: “I no longer plan my lesson to fit the technology, I plan the technology to fit my lesson” (verbatim quote from Alison, in field notes). This reflected a shift from thinking about the technology (ICT) as the focus of the lesson when this was being used, to thinking about the learning objectives and integrating technology to support teaching and learning when she deemed it appropriate and valuable to do so.

6.1.2 *The participants' proposed units of work*

Alison and Agnes both taught food technology and worked collaboratively to plan and deliver the same units of work wherever they had the same level class. They decided to both focus their integration of WBRs on a unit of work with their Year 9 food technology classes. Ashley was the only textile technology teacher in the department and she planned to incorporate WBRs in a six period unit of work with her Year 10 class.

Alison and Agnes's Year 9 unit was based around a brief to develop a family recipe book of quality meals using different varieties of potatoes, including Māori potatoes. Alison appeared to take a lead role in the planning of the unit. This was likely to be partly because she was HOD and partly because she had initiated her department's involvement in the research and hence felt a responsibility to lead it. As such, Alison seemed to have more ownership of the unit and she also appeared to be more committed to broadening her use of WBRs than Agnes.

Alison and Agnes planned to use WBRs during the unit for two full periods of guided research using a pre-booked school COW. They pre-prepared supporting worksheets together to help scaffold student learning. They also planned to use Skype to communicate with the local primary school class that they had formed a relationship with to provide feedback on their students' product ideas. However, only Alison's class actually used Skype because Agnes was absent for some periods and so her students were not prepared for it.

Alison and Agnes's unit was interrupted by a school-wide focus on the Rugby World Cup during which teachers in all subject areas had to focus their teaching on that topic for several weeks. Although they had to suspend the potato unit, Alison and Agnes both took the opportunity to continue their commitment to integrating WBRs and incorporated web-based research into their World Cup unit as well. Once again they used a COW and prepared a supporting worksheet to guide students in their initial research into their allocated World Cup country.

Ashley's unit on fashion history spanned six periods and incorporated WBRs in each of the six periods using a COW. The students worked in pairs, each researching a different decade of fashion using WBRs, working towards presenting their findings to the class using Power Point. Ashley had taught this fashion history topic at Year 10 in previous years without using WBRs but reported having fairly limited learning outcomes.

Ashley generally found it challenging to draw her students' attention away from practical work sufficiently that they would engage in other tasks. Subsequently, choosing a relevant and engaging topic for trialling WBRs was critical: "We need to do something where they stop sewing for a little bit and so this unit works because they don't touch the sewing machines for a few weeks" (Ashley, Iii). This was more of a challenge for Ashley than it was for Alison and Agnes as the practical component in textiles is more sustained. Ashley needed to find a strategy to gain student interest from the outset. She planned to do this by showing a YouTube clip that provided a short and snappy overview of 100 years of fashion, and by designing a worksheet to introduce key words and help students focus on key ideas.

6.1.3 *Enacting their plan in the classroom*

Although Alison identified the Year 9 unit as her focus for this research, she had clearly started to think about opportunities for using WBRs from the start of the year knowing that she had committed to being involved in the research. As a result she began to use them more often in her classes early in the year. It was clear from her discussion during the August department meeting that she wasn't limiting her use to just one class. By comparison, Agnes and Ashley appeared to be only focusing on the unit they had pre-planned to integrate WBRs in for the purpose of the research.

As a result of her wider use of WBRs Alison had a lot more classroom experiences to critique and learn from than Agnes and Ashley, and she could build on each of these experiences. Alison developed more confidence each time she used WBRs, based on the positive outcomes she experienced and the positive responses from her students. She appeared to quickly reach a point where she no longer felt she had to master the ICT aspects in order to use WBRs in the classroom. She was able to confidently use them, knowing things were likely to go wrong but also knowing she was able to cope in those situations and that the benefits for learning made it worthwhile:

> I also think that it's because my confidence has grown and so I'm able to maybe deliver the lesson more assertively rather than tentative, and I hope these [computers] are going to work, and thinking of all the problems. (Alison, Iii)

Alison appeared to just naturally progress to integrating WBRs in all her classes as she learnt from her experiences, gained confidence and was able to see opportunities where they could enhance teaching and learning. The constraints she had reported initially affecting her use of WBRs no longer appeared to be an issue, particularly when compared with the benefits she identified. It appeared that the positive outcomes Alison continued to experience were driving her enthusiasm and empowering her to increase her use of WBRs. Alison's increasing use of WBRs and increasing enthusiasm were progressively more noticeable in the second and third interviews, as her opening comment in the third interview aptly illustrates:

> Ohh, it's been absolutely fabulous! Well, I think I've worked on a couple of units haven't I. … but the Potato one is the one that's been my focus that I've used mostly – continuously. And that has just been absolutely mind blowing! Skyping with those kids has just been absolutely unreal. And I had an appraisal with it and he [the appraiser] was just blown away. (Alison, Iiii)

In some situations Alison pre-booked the COW but she also supported this extensively with the flexible access she had to three computers in her classroom. For example, Alison reported taking opportunities to direct individual students to WBRs in response to their inquiries when she perceived there were learning advantages for the students, rather than just providing an answer as she may have done previously:

> One of them, when we did something just the other day [asked]: "How come sometimes when you get a bag of potatoes you get

> different colours?" And I said: "Why is that?" And she said: "because when we cut it this one is really yellow and yet the other day the one we cut was really white?" And I said: "Well what do you think?" And she said: "I don't know", and I said: "Well go over to the computer and have a look" and then she came back and said: "Oh no they're two completely different varieties – why would we have different varieties?" So that was good that they're noticing those things when they're working with them. (Alison, Iii)

There was a significant difference in learning and change of perceptions about the value of using WBRs between Alison and the other two participants – most likely because of the scope of Alison's classroom experiences. Alison was able to take advantage of opportunities like the one above because she had the computers in her classroom whereas Agnes had none. Agnes sometimes sent individual students into Alison's room to use a computer but this generally needed to be pre-arranged and was not always convenient. Consequently, Agnes did not have the same flexibility of access beyond her use of the COW.

It was clear from observing Agnes in the classroom with students using the COW and from interviewing her afterwards that she had developed more confidence using WBRs and identified more affordances for teaching and learning. However, because she was only using them with one class, mainly focused on one unit, she had far fewer experiences to reflect on and learn from than Alison and more limited opportunities to develop effective strategies for scaffolding learning using WBRs. Similarly, Ashley – who was competent using WBRs personally but not experienced using them in the classroom – focused on using them only in one unit of work.

While Agnes's and Ashley's views had clearly changed, they were not immediately applying their learning by trying to integrate WBRs more widely or frequently during the period of the research as Alison was. Rather, their reflections were focused on what they would do differently the following year to build on their experiences. For example, Ashley reflected on specific details she would change to enhance the Year 10 unit she focused on:

> [I] would teach Prezi first before we even did anything else. Teach Prezi maybe without even telling them what for. Just to maybe put a garment on and talk about the garment or something like that, and *then do* the project, but we [the students] already know how to use Prezi … so another four lessons maybe. … So that's for next year. (Ashley, Iiii)

Ashley's commitment to ongoing use of WBRs was also clearly evident in one of her final statements at the evaluation workshop: "It worked so well, why wouldn't I [continue using them]?"

The strong collegial relationship between Alison, Agnes and Ashley meant that they interacted a lot in both formal and informal situations. Their interactions provided a lot of opportunities for them to share experiences and ideas, and to learn from and encourage each other as they trialled using WBRs in the classroom. Their collegial relationship and their commitment to the group project appeared to be key factors helping to sustain their participation and motivation. This was evident in discussion at the August department meeting where they talked about the inspiration they had gained from other participants at the first workshop and the peer pressure they felt to achieve something worthwhile to share at the final evaluation workshop.

6.1.4 *Changing views about the value of using WBRs*

Over the course of the research all three participants in School A reported a considerable change in their thinking about the value of using WBRs, in particular for increasing student engagement and for enhancing learning. The change appeared to be more significant for Alison.

Alison and Agnes were both positive about the value of integrating WBRs from the start but they articulated a wider range of benefits after their more focused integration of WBRs. Ashley, on the other hand, didn't feel initially that there were any significant advantages for her students through integrating WBRs. Rather, she had openly expressed that it was not worth the effort involved, and that it would impede her students' ability to complete the practical component of the course and meet external assessment requirements. However, after trialling the integration of WBRs for the research Ashley's thinking significantly changed from her initial negative view to reporting a range of advantages for student engagement and student learning.

Student engagement

In the first interview both Alison and Agnes identified student engagement as a key affordance of WBRs. However, they talked about engagement in quite general terms referring to students' motivation and excitement to become involved in the lesson. After their focused integration of WBRs they both reiterated and expanded on the engagement value of using WBRs, providing more specific examples. In particular, they both reported that using WBRs enabled them to engage all students, including those who often chose not to participate in classroom activities. For example:

> Kids who may have just, well [student name], sat at the back of the room and looked at pretty pictures in a book and not done anything, whereas today she's writing it, she's feeling it, she's just enthused about it. (Alison, Iii)

> My student who was on report would normally refuse to work but she's happy to work using the COW. And students with limited attention spans are more engaged and learn better because they can control the pace of learning. (Agnes, Iii)

While it is possible that this increased engagement could be because using computers in food technology was still a novelty, and the novelty might wear off, the teachers indicated that they felt it was more than this as the change was more sustained.

Both Alison and Agnes were also surprised that they were able to maintain their students' interest throughout the entire unit, despite the considerable interruption of the whole school World Cup focus. They attributed this to the level of student engagement achieved through using WBRs. For example:

> Especially because, like, we did it and then we stopped and we did that World Rugby Cup thing … and I wasn't sure that we were going to be able to pick it up again. And so it was a certainly a tell-tale for me in that once you get them motivated [using WBRs], that learning, and so they've remembered that too. (Alison, Iiii)

Ashley reported initially thinking there would be no benefit for her students from using WBRs and that they were not relevant for her subject. However, she did mention noticing the positive response from students in other subject areas when WBRs were used. This indicated that she may have given some consideration to their value for engaging her students, as the following comment suggests:

> But I do think particularly for my Year 10s who get very fidgety that it would be beneficial if they had more of their kind of entertainment, therefore their learning would be better. (Ashley, Ii)

Nevertheless, Ashley was still emphatic at the start of the research that the benefit did not outweigh the effort involved in accessing WBRs and modifying her teaching programme to accommodate them. It is also interesting to note that her comment above refers to the entertainment value of WBRs as opposed to benefits for student learning, which reflects a limited view of the affordances of WBRs for teaching and learning.

As indicated earlier, Ashley believed it was particularly important to engage her students in the unit because she would be interrupting their practical work. She prepared for this by planning an introductory lesson using WBRs with the aim of capturing her students' interest and providing an effective transition to the new unit. Despite the expected initial reluctance of her students, Ashley found that they soon became much more engaged than she expected:

> They're asking interesting questions, finding interesting things out and they seem excited to get the computers out. They weren't the first day, they were very reluctant …. So I think it's made a huge difference. Today I felt they were 100% engaged and they really

> wanted to get this done and finished and do a good job of it. (Ashley, Iii)

Ashley also found that in the following periods her students were more self-directed as they worked through the research and presentation project.

Like Alison and Agnes, Ashley also noticed that using WBRs helped engage previously disengaged students:

> Especially like these two can just sit the whole class and do nothing on a very regular basis and not just my class and, but they're bouncing ideas off each other really quite well. (Ashley, Iii)

When she reflected on the outcome of the unit, comparing it with when she had taught the same topic previously without using WBRs, Ashley highlighted the increased engagement:

> It's much more fun and fun to me means they'll be learning because they're interested. The only other time I've done history [of fashion] it was hard. Well we did it with the Museum so it was interesting, but this time I saw evidence that they'd actually done the learning. (Ashley, Iiii)

Ashley found that using WBRs in this way allowed her students to follow their interests, which sustained their engagement and led to deeper learning.

Ashley and Alison also both talked about using WBRs being 'more fun' for the students than traditional teaching methods or resources. In addition, Alison reported feeling excited about her own learning and feeling more motivated as a teacher:

> It's fun! Fun for me, and fun for the kids. And it's *fun* to see them on task, and *really* wanting to know more about the topic and that sort of stuff. If I hadn't been asked to do this you tend to think: oh same old, same old, you know. (Alison, Iii)

Supporting student learning

While Alison and Agnes initially identified some benefits of using WBRs for student learning, their comments were not extensive (see section 5.1). This was likely because they had very few experiences using WBRs in the classroom to reflect on and mostly these involved individual student research using only one or several classroom computers. Ashley did not articulate any particular learning benefits initially, although she did have individual students use her computer on occasions for background research for their projects. After their focused integration of WBRs, however, all three participants reported noticing significant benefits for student learning.

Alison, Agnes and Ashley all commented on how using WBRs enabled them to enrich and extend student learning because of the greater depth and breadth of information their students could access. Comparing this to their traditional approach of drawing on their own knowledge as the teacher and whatever paper-based sources they could access, they identified significant benefits. They commented on the limitation of relying on their own knowledge not only in terms of breadth and depth but also accuracy. As Agnes noted:

> They [the students] could get more depth of information rather than just me sharing bits and pieces. Or, yeah, I think they probably get a better source of information and they can find information that is relevant to their level rather than me just pitching at one level. (Agnes, Iiii)

The participants also noted how much more efficient and convenient it was for them as teachers to prepare and make information accessible for students and how this contributed to them being able to extend student learning. For example:

> Previously [I] would have collected research books ahead of time and/or taken the class to the library. Students were never able to get as much information as they wanted and you relied on them being motivated enough to do much more in their own time. (Agnes, Iii)

Ashley also commented on the speed and convenience of using WBRs compared to print-based resources and how they appealed to the students: “I think the kids enjoy being able to access that stuff really quickly and easily, which I couldn’t have done in a print version” (Ashley, Iiii).

They all found that the breadth of information their students could access enabled students to branch out and follow their interests, creating opportunities for self-directed learning. This helped students to become more deeply engaged in the topic or project and subsequently to gain a deeper understanding:

> I think they’ve already [half way through the unit] gained more depth than they would have if they were reading a book because they follow what they’re interested in. Yeah, I think they’re getting a way deeper understanding. (Ashley, Iii)

> I think it gives variety to the kids’ learning and it opens up a wider learning field too for them and helps them to move onto that next level without realising they’re doing it in some respects. (Alison, Iiii)

Reflecting on the subject-specific value of WBRs for technology education, Alison and Agnes both reported on the advantages of being able to conveniently connect with industry experts and other stakeholders to learn about product development, new materials and manufacturing processes. The constraints imposed on taking groups of students out of school to make these connections, such as the organisation, administration, time and cost involved, can be a barrier to teachers making such visits and often there are not relevant links available locally. In addition, often industry cannot accommodate groups of students because of increasingly stringent health and safety regulations. Alison perceived that Skype would open up many possibilities for her to enrich her teaching by making these connections:

> Once I get confident with the Skyping then I can see the range of stuff that I can do with that in the future. […]. But anyway it would be great to be able to Skype that guy who’s doing the vanilla and

> talk about what he's doing and be able to see the self-pollination and all that stuff and him talk about it. Whereas when I talk about it it's not the same. (Alison, Iii)

Agnes could also see the opportunities for these connections using WBRs, especially as the department continually moved from home economics to technology at senior level and subsequently the industry connection became more relevant:

> Especially for the Level 2 because we'll be able to get into the processes, the development of products and because we can't get into the factories we'll be able to see it on the Net. (Agnes, Iiii)

Alison and Agnes also both commented on the currency of WBRs, making content more relevant, authentic and up-to-date for students and of particular value for learning about and doing technology. For example:

> I think possibly the resources have moved with the time. You know when we went to conference and there were no handouts, there were only cards with websites to go to. So when you go into the sites you see that they're developing. Whereas when they used to give you a brochure and you used that brochure until all the brochures had run out or when you had lost them or needed new ones for your class. So, much, much, much more up to date. (Alison, Iii)

In summary, all three participants changed their views to some degree on the value of WBRs for student engagement and student learning. Alison and Agnes appeared to develop a broader view of the engagement value of WBRs. They found that using WBRs better enabled them to sustain student interest for the duration of a unit of work, and also to engage all students – even those who often chose not to participate in classroom activities. Ashley's initial strongly-held views that WBRs had no value for teaching and learning in her classroom programmes were challenged when she found the outcomes of the unit of work were much more positive than she expected. Her positive experience resulted in her developing similar views about engagement to those expressed by Alison and Agnes.

All three participants also articulated similar ideas about the impact their use of WBRs had on student learning, which they had not initially identified. Primarily, they noted that the greater depth, breadth, currency and relevance of information contributed to deeper engagement, and deeper and more independent learning. Furthermore, they all perceived potential value for their technology programmes in using WBRs for connecting with industry, other experts and stakeholders in students' technological practice.

6.1.5 *Changes in pedagogy*

Alison and Agnes both reported finding that using WBRs in the classroom supported a change in pedagogy from a teacher-centred to a more student-centred approach. They found they were better able to step back from the 'sage on the stage' approach and take on more of a facilitator role in guiding student learning. They no longer felt the need to know all the content and provide the answers for students:

> [Before] I think they would have been bored out of their tree and it would have been short, sharp and more teacher-directed whereas this is much more student-directed. And *they're* asking the questions, *not me*. So they're finding the information, asking me questions and then we have a discussion and then they're able to go and build on that knowledge. (Alison, Iii)

In addition, they found they could more readily interact one-on-one with students, which enhanced teacher-student relationships. Alison and Agnes also both reported increased ability to differentiate learning for individual students when using WBRs. They found they were more able to work individually with students and provide support where and when it was needed:

> Using WBRs, there is much more individual teaching – it is less teacher-directed. Students share with you their skills and interesting findings. Students can be shown when they are ready to be taught

> rather than students having to keep up with the pace of a teacher-led lesson. There's more interaction with the students so it's better for relationship building because of the greater interaction and individual contact. (Agnes, Iii)

Alison and Agnes also found using WBRs in the classroom gave them more scope to structure tasks that supported students at all levels to achieve, and that students were taking more responsibility for their own learning. In particular, the more able students were striving for higher achievement:

> They bought into it much quicker and they certainly moved up the learning scale and the gifted and talented kids could really then excel, whereas the kids that struggled, they reached the end. Whereas when you do teacher-directed, you either lose one group or you've got to find something else for the other group to do while you spend time with them. (Alison, Iiii)

It appeared, from interview conversations with Ashley, that her usual teaching approach was generally more student-centred than Alison's and Agnes's. This was possibly because her programme was more closely aligned to the technology curriculum and her students were predominantly working on individual projects, which necessitates more teacher-student interactions and individual teaching. Hence, integrating WBRs *per se* did not have as noticeable an impact on Ashley's role in the classroom as it did for the other two, although she did comment on the greater interaction between students – mainly because they were working in pairs.

One of the challenges discussed at the initial group workshop was the need to develop scaffolding strategies to better support student learning when using WBRs. It was evident that all the participants in School A had thought about this and had planned strategies such as structured task sheets, planned interactions, probing questions and modelling using the data projector. These strategies contributed to the enhanced student learning and engagement that the participants reported. For example, as Alison highlighted, previously she would just leave the students to do a task or find information using WBRs with little support or direction:

> Whereas before I used to say, “Go onto the Web and see what you can find on [a topic] and then answer these questions.” Well, now I’m directing them more and helping them with their research, I suppose. I’ve learnt to have a look and give [the students] certain questions and certain sites that I find best for them so you haven’t got those kids that struggle. (Alison, Iiii)

Alison also believed that her increasing confidence, as a result of her more extensive use of WBRs and the positive student responses, helped enable the shift in her pedagogy:

> It’s developing the confidence in realising that sometimes you’ve got to let go that teacher position and enable the kids to do some of the teaching. And I think it really is a strong demonstration of cooperative learning because they can help each other and it doesn’t have to all come from me, and that’s been a huge learning curve for me with using these COWs. (Alison, Iii)

While Agnes worked together with Alison to develop worksheets for the Year 9 potato unit, the direction of the unit appeared to be largely driven by Alison. In addition, while Agnes implemented similar strategies to Alison, her lessons using WBRs were fewer and more isolated than Alison’s. One of the main reasons for this seemed to be because she had more limited access to computers. This restricted her ability to use WBRs in a more flexible and spontaneous way and meant that she had considerably fewer classroom experiences to reflect on and learn from. As a result she did not have as many opportunities to implement and critique any change in practice as Alison, and she acknowledged that she needed to do a lot more work to develop in this area. Furthermore, in the evaluation workshop Agnes acknowledged that her classroom experiences using WBRs were still very controlled and that she would like to use them more freely.

In contrast to Alison, it appeared that Agnes was still constrained by her own lack of knowledge and confidence:

> As I get more knowledge I think I can probably start using it differently – so not just use it for research, to get in there and use it for more presentation type things and making activities that they can use in different ways. (Agnes, Iiii)

Ashley implemented a number of strategies to scaffold student learning in her Year 10 fashion history unit, both in terms of their understanding of key ideas and also support with using the technology. Ashley was able to provide this ICT support more readily than the other two because of her considerable personal skill and confidence using ICT. She also appeared to have more ability to recognise students' need for support in this area. This was evident during the lesson that was observed, in the support she gave to individual students and groups as she interacted with them. For example, she asked probing questions to focus students and help them narrow their searches. She helped them to come up with alternative key words and also to recognise that not all information is trustworthy.

Reflecting on her teaching after the unit Ashley identified further scaffolding that was necessary that she hadn't anticipated. Her comments reflect her greater emphasis on scaffolding students' ICT skills than was evident in interviews with Alison and Agnes:

> I had to make sure they knew how to use the netbooks, the programs they were going to use, how to use power point, let alone I had to teach how to do the research. So there was some teaching about all those steps that I hadn't really thought about. Yeah, and of course thank god we had a teacher aide because those 3 [special needs] kids wouldn't have got there. … So, … I need to make sure I've allowed time for one on one just with the kids that need extra help. (Ashley, Iiii)

The most notable change in pedagogy that occurred during the integration of WBRs for these participants, was the shift, particularly in Alison's case, from a teacher-centred to a student-centred approach. Alison and Agnes both found that they no longer felt the need to know all the answers and could see the value in letting go some of their control and adopting more of a facilitation role in students' learning. This change in their role in the classroom also enabled more individual interaction with students and allowed them to more readily differentiate learning for individual students.

6.1.6 *Development of TPACK*

Developing Technological Knowledge

Alison and Agnes both reported initially having limited TK. They lacked confidence using WBRs both personally and in the classroom, and they used WBRs with their classes only occasionally. Agnes in particular, had very limited experience and opportunity to develop her skills and knowledge because of her more limited access to WBRs in the classroom and the fact that she had no computer access at home.

As described in the sections above, both Alison and Agnes's confidence and ability to manage WBRs in their classrooms and provide support for students, steadily increased as they implemented a unit of work in which WBR use was planned and structured to enhance student learning. They appeared to quite quickly reach a point where they no longer felt the need to master the technology before attempting to use it in the classroom, and became comfortable with developing their own knowledge alongside their students. Hence, as they began to use WBRs more frequently, their TK (and confidence) appeared to develop more rapidly. As their TK and confidence increased it helped them to reach a point where their focus shifted from management of the technology to a focus on student learning, where WBRs were just another (albeit very important) classroom resource to select from as and when appropriate for student learning.

Alison was so inspired by the positive outcomes of her lessons using WBRs early in the research that she quickly extended her use of them to all her classes. It was clear that she had made considerable progress and was feeling empowered to continue her own learning:

> My enthusiasm and my growth is the big surprise, and just my hunger for wanting to keep it going. Yeah, I think it's probably that I'm learning new stuff and it's good to get into your learning while

> the kids are learning and you're both travelling this road together. (Alison, Iiii)

Agnes's more restricted access and limited use of WBRs resulted in her development of TK being less significant than Alison's. However, her awareness of her own development needs and her commitment to using WBRs and taking control of her own ongoing learning were very clear:

> First of all I need up-skilling myself because I've found the students have taught me little bits and pieces and then I've gone "pching!" [a sound indicating she now understood something], I know how to do that now, and I will pass that on to other students or whatever. But I am developing in this area put it that way. As I get more knowledge I think I can probably start using it differently. (Agnes, Iiii)

Although Alison and Agnes were still in the early stages of developing TK, the data suggest that their experiences and development thus far have been sufficient to set them on a trajectory of ongoing self-development and increasing, strategic use of WBRs.

In contrast to Alison and Agnes, Ashley had a lot of experience using computers and the Internet from the outset so she had relatively well-developed TK and was very confident. Because of this, Ashley reported being relaxed using computers in the classroom and was confident that she could provide the support students needed and solve most problems that might arise.

Developing Technological Pedagogical Knowledge

All three of School A's participants had very limited TPK at the start of the research. In other words, they lacked understanding of the pedagogical affordances and constraints of WBRs and had not developed pedagogical strategies to maximise student learning when integrating WBRs in the classroom. With their limited experience using WBRs in the classroom they had not had much opportunity to develop this specialised knowledge. In addition, because of Alison and Agnes's limited TK, when they did use WBRs their focus tended to be on managing the technology with little attention given to pedagogical strategies to scaffold student learning.

As the participants planned, trialled and critically reflected on their experiences using WBRs in the classroom during the course of the research project, they all began developing TPK, but to varying degrees. As reported above, both during and at the conclusion of the research, all three of School A's participants identified a range of pedagogical affordances and constraints of WBRs that they hadn't previously considered. For example, WBRs were identified as enabling a more student-centred pedagogy, and offering increased potential to differentiate, enrich and extend student learning; as well as greater efficiency, convenience, currency and relevance to teaching and learning.

Planning a unit of work with an explicit focus on integrating WBRs required the participants to think about pedagogical strategies to support student learning using WBRs. This was a key topic at the first workshop (see Section 4.2.3). Hence they had already been introduced to key theoretical ideas and had the opportunity to think critically about their role in scaffolding student learning and the implications for using WBRs. Group discussion at the workshop had also initiated critical reflection on, and sharing of, existing strategies they had tried or that they might adapt.

As experienced teachers their existing PK undoubtedly contributed to their ability to develop appropriate strategies for their individual classroom contexts. Rather than starting 'from scratch', as a beginning teacher would, they were able to integrate their existing PK with their developing TK. By building on and adapting familiar and tested strategies and reflecting on their previous success using these, they were able to more readily develop pedagogical strategies for working with WBRs, as the following comment suggests:

> It really worked doing this watch it, watch it and think about it, watch it and do it. I don't know why. I must have learnt that somewhere in the last seven years because I knew it. As soon as I went to write it I knew they had to watch it three times. … And yeah, it worked beautifully. (Ashley, Iii)

Their previous teaching experience also better enabled them to apply strategies flexibly and responsively in the classroom, recognising when and how to adapt their pedagogy either during the course of a lesson or in preparation for a similar situation in future lessons.

Hence, all three participants devised and trialled pedagogical strategies to scaffold student learning and maximise the affordances of WBRs. For example, they all had success with creating structured worksheets to focus and guide students' research using WBRs. As mentioned before, Alison identified the importance of researching appropriate websites for this purpose first, whereas her previous approach was to just leave it up to the students to find appropriate information with no guidance. The worksheets were carefully planned to maximise student learning with WBRs and all three participants reported finding that the worksheets supported significant learning advantages that were sustained through the whole unit. For example:

> This [task sheet] was fantastic for showing them how to look for differences and "what is it you're even looking for?" And, "why do you say that's 70s?", and "so what just changed between then and then?" … And so they started to recognise those differences. (Ashley, Iiii).

Alison appeared to make the most progress in her development of TPK during the research, because of her more extensive range of experiences using WBRs and subsequent trialling and critiquing of strategies, as well as her flexible access to computers and the Internet in her classroom. Alison had reached a point where she was beginning to flexibly and spontaneously appropriate WBRs for pedagogical purposes as and when she recognised that they afforded learning advantages for her students. In this way she found she could better meet individual needs and maximise learning outcomes for all her students, as this comment suggests:

> It's like playing one of those video games when the kids were little and you got into the house and you had to find the key to open the treasure box and if you couldn't open the box you couldn't go to the next lane. And I suppose that's what it's like for me now with

> teaching and you've got all these little treasure boxes and you see it open so then I take them to the next lane so like in my food tech class, I took kids up different lanes but at the end of the day they still achieved the learning goal for the unit but some achieved that to excellence whereas others to just an achieved [no one failed to achieve]. (Alison, Iiii)

Agnes's experiences contributed to her recognising a wide range of affordances of WBRs compared to when she started. However, while she implemented pedagogical strategies to support student learning when using WBRs, because her access remained constrained, she had limited opportunity to develop and build on her experiences. In addition, while she contributed to developing the worksheets used, she did this alongside Alison who appeared to be driving the unit. Hence, while Agnes was clearly beginning to develop TPK, the extent of her development was more limited than Alison's. However, Agnes had clearly identified that she needed to develop in this area and highlighted her intentions to continue working on this in the future:

> Well I'll probably have to step up my game to develop more interesting activities rather than just using it for "Goodness, we've got this here, what can we do?" (Agnes, Iiii)

Agnes's close working relationship with Alison provided opportunities for her to observe strategies and outcomes from Alison's experiences as well, which likely further contributed to her learning and motivation.

While Ashley only integrated WBRs in one unit of work, as Agnes did, her reflections indicated more extensive development of TPK than Agnes. This was possibly influenced by the fact that Ashley planned the unit herself and therefore had more ownership. In addition, it appeared that Ashley's strong level of TK may have been an advantage. She appeared to intrinsically understand and identify potential gaps in students' TK that could be barriers to their subject learning. For example, Ashley reported:

> There's a lot of learning about the how to, not content but how to. Not just using the equipment but what words to put in Google, you know, there's so many things. (Ashley, Iiii)

In some cases she identified and prepared for this in her planning, in other cases she identified these gaps during a lesson and was able to intervene spontaneously to provide support, or she noted the need to address the issue at a later time. This explicit pedagogical focus on the students' lack of TK was much less noticeable with Alison and Agnes. Ashley's reflections at the end of the unit indicated that she would likely be better prepared to scaffold student learning and improve outcomes in the future. For example:

> I need to make sure that I have in my mind how to keep it wide open what they go looking for but how to put some boundaries on it as well – really hard because of course they spend a lot of time finding the wrong thing or websites that aren't trustworthy or whatever. … [Now] I've got a lot more idea where they went this time I can know "right, would those sites work?" Maybe put those as a set of: "here's your starter sites", and give them a document that they can click on the hotlinks. … Now that I've done it once I've got a better idea of the time frames and things as well. (Ashley, Iiii)

Developing Technological Content Knowledge

Alison's and Agnes's initial TCK was very limited. While they had become very aware of the potential to find valuable resources via the Web through colleagues and some of the professional development sessions they had attended, they had found very few WBRs themselves that were relevant for the content they were teaching. This appeared to be directly related to their lack of TK and the difficulty they reported finding relevant and appropriate resources quickly and easily.

In contrast, while Ashley had limited experience using WBRs in the classroom, her well-developed TK and extensive experience using WBRs personally gave her a considerable advantage in developing TCK. Although her initial mindset was that WBRs did not afford learning advantages for her students, and she had not given a lot of thought to specific WBRs that might enhance her teaching, nevertheless she had a broad knowledge base to draw on as a starting point for developing TCK. For example, she was very aware of the extent and nature of resources that related to her subject area, and also had the skills and knowledge to source particular WBRs quickly.

Implementing her unit in the classroom, Ashley soon noticed the affordances of these resources for enhancing student learning. For example, she reported broader and deeper learning by her students compared to using books or visiting a museum, and how they allowed students to take greater ownership of their learning. Also, reflecting on her use of the YouTube video clip in her introductory activity, she highlighted how effective it was representing this particular content in such a dynamic way that would have been difficult to achieve with traditional resources.

As Ashley reflected on her experience and identified affordances of WBRs, she made further connections with the wide range of relevant WBRs she was familiar with. She began to consider other opportunities with potential for enhancing learning. Her projections were also motivated by the knowledge that she was going to have greatly improved access the following year. She would not only have the use of the department’s mini COW that Alison had negotiated, but she was also being provided a data projector and screen and another computer for her classroom.

Through the course of the research Alison made considerable progress in her development of TCK. As she took opportunities to use WBRs in all her classes she gradually became aware of, and could more readily source, a more extensive range of WBRs with direct relevance to content she was teaching. She also increasingly recognised the affordances of WBRs for enhancing learning of content in particular ways. For example, Alison noticed how she could enrich students’ learning about how things are made using YouTube rather than text-based resources:

> A good example is when we were doing a bread unit and we wanted to make Bagels. So we [the teachers] went onto YouTube and looked at all the different ways to make it. And then we thought, this one's really good and we can understand it simply so instead of us teaching it we did it on YouTube with the kids. (Alison, Iiii)

Alison and Agnes both highlighted how WBRs would enable them to teach about manufacturing processes and product development that they would not otherwise be able to do in the classroom.

Agnes's more limited access to WBRs limited the extent of her development of TCK compared to Alison in the same way it did for the other components of TPACK. However, the data clearly showed that she had developed TCK to some extent. Her experiences clearly prompted her to think about how WBRs could influence her delivery of content and enhance student learning. Hence, she increased her understanding of the affordances of WBRs in terms of changing the way her students could access and interact with content. In particular, she highlighted the speed and ease of access to information they afforded; the depth, accuracy and relevance of the information; and the flexibility in terms of meeting a range of student needs at one time and students having more control of their own learning needs.

Agnes recognised the need to further develop her TCK by developing her knowledge of specific, relevant WBRs that linked to her programme and had potential to enhance students' learning. It was evident that Agnes was motivated to develop in this area and she fully expected that when she did get computer and Internet access at home she would make more progress.

Technological Pedagogical Content Knowledge:

The subsections above analyse the participants' varying degrees of progress in developing TK, TPK and TCK during the research. As a result of their experience and their subsequent increasing knowledge in those areas, the participants all began to develop TPACK – knowledge that emerges from the interaction and integration of all the individual components. Hence, they began to broaden the knowledge base they could draw on in the decisions they made about teaching and learning to include the use of WBRs if and when they deemed the affordances and constraints best met the needs of a particular learning situation.

Alison appeared to make more progress than the other two through her more extensive range of experiences during the research. Although Ashley and Agnes didn't demonstrate the same level of TPACK during the research, their development was clear in their reflections and their projections about potential future use. Ashley's existing TK appeared to be an advantage in her development of TPACK in contrast to Agnes, whose lack of TK and more limited ability to develop this component were limiting the pace of her development.

Alison's developing TPACK was evident in the ability she demonstrated to flexibly and spontaneously appropriate WBRs in particular learning situations in the classroom. It was clear that using WBRs had now become an integral part of her teaching repertoire to the extent that she felt empowered to make a case to her Principal for improved access for her department. Alison's experience during the research gave her the confidence and enabled her to provide evidence to support her case.

Alison resolved to review all her unit planning to take account of WBRs and was inspired by the increasing opportunities she would have the following year with the increased access she had achieved. As a result, it appeared likely that her TPACK would steadily continue to increase, as illustrated in this comment:

> If I'm doing something big I'll still get the COW up here so that each student has their own computer, but just being able to say to somebody "Oh you're struggling with that just go and have a look". … And, it'll also make me have to … like I'm thinking about it for the holidays, is looking at a unit and then I have to now as one of my resources write down the [web] sites, whereas before you would say, "Oh well, we're going to do research", and then the night before you might have a look and think, "Oh yeah, we're going to do this, this and this". Whereas now one of my learning

> intentions has to be in the overall unit planning that I have got to look at the resources on the Net that can link and connect through the whole unit. (Alison, Iiii)

Ashley's experience was much less extensive than Alison's, however, it clearly prompted a shift in her thinking about the affordances of WBRs for her teaching. This shift was pivotal in inspiring her to consider how she could potentially integrate WBRs more broadly in her classroom programme. Her development in the components of TPACK analysed in the above sections and subsequently her ability and motivation to integrate this knowledge in her planning and teaching are clearly evident. In particular, her projections about future use of WBRs, especially with increased access, were a clear indication that she considered them an integral resource in some teaching situations and suggested that her TPACK would continue to build, as the following comment exemplifies:

> I to date have only used more if you like searching the equivalent of encyclopaedias – the knowledge websites – but I can easily see us using more of the interactive stuff once we have availability. And I can teach using me projecting to start with, without booking the COW, and then we can use the COW. I think that could be really good. (Ashley, Iiii)

Agnes's less extensive use of WBRs and more restricted access meant that she had fewer opportunities to draw on her developing knowledge in an integrated way and hence, more limited opportunity to demonstrate TPACK in the classroom. However, her reflection on her experiences indicated that with increased access the following year, she would be in a better position to continue her development of TK, TPK and TCK and to draw on her developing knowledge in her teaching and hence demonstrate a level of TPACK.

6.1.7 Summary

As a result of their experiences using WBRs, all School A participants made a significant shift in their thinking about the value of using WBRs and were committed to continuing their own learning and increasing their use of WBRs in the classroom.

Alison showed the most significant change of the three participants. Her progress appeared to be driven initially by her commitment to the research project and her leadership role in the department, which included some responsibility for her department members' progress. The positive outcomes she experienced early in the research began to outweigh the barriers that had initially constrained her use of WBRs and success motivated her to use them more extensively. Her range of experiences quickly broadened the knowledge base she could draw on in her pedagogical reasoning. This allowed her to increasingly make strategic decisions about when, where and how to appropriate WBRs in the classroom to enhance student learning. Alison had reached a point where she viewed WBRs as integral classroom resources to be integrated with traditional resources as and when appropriate in any particular learning situation.

Agnes showed the least change of the three. Like Alison, she was initially motivated to trial WBRs by her commitment to the project. However, she became involved through the encouragement and leadership of Alison as her HOD rather than directly volunteering. Agnes experienced positive outcomes early on as Alison did. However, she did not extend her use of WBRs beyond what she had pre-planned. This appeared to be mainly due to her more limited access to ICTs both in her classroom and personally, which impacted on her ability to develop her skills and knowledge. Although her use of WBRs was much more limited than Alison's, her experiences were sufficient to broaden her views about the affordances of WBRs for learning and subsequently to influence her commitment to ongoing learning and increasing use of WBRs the following year.

Ashley did not increase her use of WBRs to the extent that Alison did either, but like the other two, the positive outcomes she experienced significantly changed her views about the affordances of WBRs for learning. Subsequently, her increasing appreciation of the value of using WBRs influenced her commitment to increase her use of them. Like Agnes, she was planning changes for the following year and increased access would make this easier. The key difference between

Ashley and the other two was the baseline skills, knowledge and confidence she already had using WBRs. Her extensive experience enabled her to more readily identify other opportunities for using WBRs to enhance her classroom programme, and therefore, was a considerable advantage for her development of TCK and TPK, and subsequently TPACK.

School A participants' development of TPACK is summarised in Table 6.1.

Table 6.1. School A participants' development of TPACK

Participants	Components of TPACK	Initial	After implementation
Alison	**TK**	Limited experience and knowledge using ICT and WBRs – gradually developing Lack of confidence in ability to solve ICT problems and manage student use in the classroom	Extensive increase in experience, skills and confidence Focus on student learning rather than managing the technology Using WBRs spontaneously in the classroom Motivated to continue own learning
	TPK	Teacher-directed and technocentric pedagogy used with WBRs Limited knowledge of ways teaching and learning can change when using WBRs Limited strategies for scaffolding learning using WBRs	Using more student-centred pedagogy Focus changed from managing the technology to supporting students' learning Developing strategies and confidence for scaffolding and differentiating learning using WBRs
	TCK	Limited knowledge of subject-related WBRs that can enhance learning of specific ideas and concepts	Increased knowledge of range of relevant WBRs and affordances for enhancing content learning Increased knowledge enabling flexible and spontaneous use Resolved to search for relevant WBRs for all topics as a routine part of annual planning
	TPACK	Undeveloped	WBRs became an integral classroom resource Developing the ability to reason and make spontaneous decisions about what, when and how WBRs could enhance learning of particular content for particular students and to employ them

			flexibly in the classroom – evidence of TPACK
Agnes	**TK**	Very limited experience using ICT and WBRs, impacted by limited access at home and school Subsequent lack of skills, knowledge and confidence to support classroom use	Some increase in experience Increased confidence to use WBRs in the classroom Acknowledged need and motivation to develop ICT skills/knowledge
	TPK	Very limited experience and subsequently limited knowledge of how WBRs could enhance teaching and learning	Increase in experience and confidence enabled change in focus from managing the technology to supporting learning Experience still limited but identified need to develop range of pedagogical strategies to enhance learning using WBRs
	TCK	Limited knowledge of WBRs that could support understanding of specific content in technology education Development impacted by lack of access and lack of TK	Increasing awareness of affordances of WBRs for enhancing learning of content in particular ways Recognised limited knowledge of relevant WBRs as a barrier and need to address this Committed to continue building TCK when access improves – expected the following year
	TPACK	Undeveloped	Identified areas of knowledge and skill she needed to develop Identified strategies to build on her limited experiences Committed to increasing her use of WBRs with increased personal and classroom access imminent

Ashley	**TK**	High level of skills, knowledge and confidence for personal ICT use Very limited experience or motivation to use in the classroom	Easily able to identify and meet students' need for TK support and learning integrated with content learning
	TPK	Negative views about value of WBRs for learning in technology education – subsequent limited classroom use No consideration given to ways WBRs may impact pedagogy	Developed positive view about value of WBRs for learning in technology education Easily developed strategies for scaffolding student learning using WBRs – existing PK (as an experienced teacher), TK and CK an advantage Identified additional pedagogical strategies to support student learning when she used WBRs in the future
	TCK	Existing knowledge of a wide range of WBRs but lack of acknowledgement of affordances of WBRs for enhancing teaching and learning in technology education	Acknowledged range of affordances of WBRs for enhancing student learning and engagement, as well as constraints Making links between existing knowledge of WBRs and opportunities for enhancing teaching and learning of particular content and extending her use in the classroom
	TPACK	Undeveloped	Experience and knowledge development sufficient to prompt reasoning about how, where and why she might use WBRs in her future programme Evidence of developing TPACK

6.2 School B

School B had two participants: Brenda, who was a Dean and taught textiles technology, and Brian, who taught structural technology (see Section 5.2).

Brenda and Brian worked largely independently of each other and their classrooms were situated in separate buildings at opposite ends of the school. They were leading their department in terms of implementing the technology curriculum, and the department generally lacked coherence in programme planning linked to the new technology curriculum.

At the time of the research, access to ICT facilities throughout the school was limited. Brenda had recently been provided with a computer, data projector and Internet access in her classroom. Brian had no computers in his classroom so didn't use them at all with his students in school. However, his senior students used them extensively to support their independent project work in their own time.

Although initially Brian didn't use WBRs at all in his classroom and Brenda had only recently begun to use them occasionally, they were both very positive about integrating WBRs and believed they had particular relevance for technology education. Brenda described herself as being at the 'entry level' in terms of her knowledge and skills for using WBRs but she appeared to be confident in her ability to develop these over time. Brian also reported having limited skills and knowledge using WBRs but he appeared to be much less confident in his ability to develop this knowledge than Brenda.

Both Brian and Brenda reported finding the time allocation of three hours per week for technology at all levels a significant constraint for them getting through the large practical component of their programmes. Consequently, they had limited time to add anything extra, and neither of them managed to schedule a time for a classroom observation visit.

6.2.1 The participants' post-workshop activity

Brenda and Brian both joined their school ICT professional development group at the beginning of the year, after committing to the research project. This became their professional learning focus for the year and they both found it to be a valuable support network. They both reported that the expertise of people in the group raised their awareness of relevant WBRs and gave them opportunities to try things out in a supportive environment.

Brian and Brenda both decided to focus their efforts on incorporating YouTube clips into their teaching. Brenda had already tried this using her newly acquired data projector and was pleased with the outcomes. She also felt she needed to make much more use of the equipment to justify having it in her room when other teachers were not so fortunate. Brian decided because of his limited access to ICT and his limited experience that he would focus mainly on searching for relevant YouTube clips that would support his Year 10 programme and look for opportunities to use these in his class. Brenda's main focus was on searching for relevant YouTube resources and planning how she could incorporate them into a Year 9 class programme where she prepared a workbook for the students.

After the first workshop Brian took steps to improve his access to make it easier for him to use WBRs. He had noticed that there was a data projector and screen in another room that wasn't being used and made a request to his HOD to have them moved to a classroom he used adjacent to his workshop. While his HOD supported his request, it appeared that it wasn't given priority at some level in the school management. Brian's frustration is clearly evident in this excerpt from an email to the researcher four months after the first workshop:

> Well that [request] was a few months ago now and still nothing at the time!! Caught up with the Principal as she was walking around the school, I told her my situation and the opportunity to save a bit of money by using already existing equipment and making more use of it, as you do!! This approach worked a treat and she agreed that instead of moving things over that the school will just put a new system in for me to do my work!!! FANTASTIC!!!!!

> WAHOOOOOO!!!! Someone has finally listened to my request. That request was made about 6 weeks ago and still nothing!! In fact, my HOD got a note from our principal asking if the projector and equipment could be a justifiable investment!!!!!!!
>
> After about 4 months of deliberation and convincing that this is a good idea to move a projector to the next room has resulted in…………wait for it!!!.............Nothing!!
>
> I was talking to the HOD of Social Sciences and he was all excited. "Why?" I hear you say!! "The new display screen is arriving for one of my teachers in a couple of days". "WOW, that's great" I said. "When did you order that?????" Only a couple of weeks ago!!!" he said. This is one of the rooms that I have been using and already has a projector screen in it!! Equity rocks!!!! (Brian, email communication, September 2011)

Brian had to actively follow up the request for two terms before the equipment was eventually provided at the beginning of the fourth school term. It appears from this series of events, that the need to provide ICT access for technology education was considered lower priority than for other subjects in this school. This sentiment was echoed by Brenda and Alison at the evaluation workshop.

6.2.2 The participants' planned units of work

Brian didn't plan a unit of work, as such, because of his lack of access to WBRs at the start of the research. Rather, he planned a number of lessons incorporating YouTube clips, initially focusing on his Year 10 class.

Brenda, on the other hand, planned to integrate WBRs into her Year 9 programme in a more holistic way. She planned to use YouTube clips to look at technology failures and analyse factors that contribute to good and bad design. Her plan was to show some examples in class and have students analyse them interactively. Students would follow this up with a homework activity that would require them to look at a different YouTube clip and complete a similar activity independently. She linked this with the students' design development for a sweatshirt. She also linked it through to her students' peer assessment of their practical outcomes at the end of the unit.

6.2.3 Enacting the plan in the classroom

Brian got started by arranging to use other classrooms that were available when he needed them. This was time consuming, because it involved multiple classrooms and he often had technical difficulties because the equipment worked differently in each room. However, he was very encouraged by the positive outcomes he experienced:

> When things went right, it was awesome to use this as a tool to support the work that I am doing at the time and I can see the huge benefits that this method will bring to my teaching. (Brian, email communication, September, 2014)

Brian found his students related to the YouTube clips particularly well because they could see that they involved real people in authentic situations and they could understand the relevance to their learning. He found that it reinforced his explanations and students recalled the information better because of the visual nature of the resources:

> This has been fantastic as the students see what is being explained to them from a *real* point of view and see relevance to it. I also discovered that if we do review work, the students refer to what they have seen rather than what was discussed in the class. (Brian, email communication, September, 2014)

The success of Brian's initial experiences using WBRs in his Year 10 class inspired him to use them in other classes as well. Similar to Alison in School A, it appeared that Brian became more confident each time he used them, encouraged by the positive response from his students and the benefits he could see for their learning. It appeared that the benefits he perceived outweighed the considerable time and effort involved for him in accessing WBRs.

Also, like Alison, Brian began to make spontaneous use of WBRs in his classes. Having researched and saved a ‘library’ of YouTube clips he was able to make flexible and spontaneous use of these when he recognised an opportunity to broaden students’ learning. While he may have saved a YouTube clip with a particular class or lesson in mind, he was able to draw on it in other situations where he perceived it to be relevant:

> Like before we were talking about [a particular] clock and I would say, “Well this carcass construction here would be veneer” [and students asked] “What’s veneer?” [and Brian said] “What is veneer? Let’s have a look.” And I’ve got this backed-up little clip about how veneer is made. (Brian, Iii)

In contrast to Brian, Brenda confined her trialling of WBRs to the one class she had pre-planned for. In this respect, as for Ashley and Agnes in School A, Brenda had fewer experiences to reflect on than Alison and Brian. Subsequently, she had more limited opportunities to apply her learning in different situations and hence broaden her pedagogical repertoire for using WBRs and her perceptions of the affordances of WBRs.

While Brenda’s views had clearly changed, her reflections were projected to opportunities and strategies she perceived for using WBRs the following year, as was the case for Ashley and Agnes:

> Well, now that I’ve had a taster I know that over the holidays … I’ll be searching for more YouTube kind of clips. … Whereas in the past it was a bit haphazard, if I found something then I’d show it but otherwise I probably wouldn’t bother because there’s such a short period of time but now I’m building it into my programme to make sure we actually do it and the kids get something from it because I think it’s very worthwhile. (Brenda, Iiii)

Although Brenda and Brian had less opportunity to work collegially than was the case in School A, they both appeared to gain knowledge and support from the school ICT group that they joined. It was evident that this support contributed to their learning during the course of the research. They appeared to gain both direct support with their planning and implementation, as well as broadening their knowledge of the range of WBRs with potential to enhance teaching and learning in their subject.

6.2.4 Changing views about the value of using WBRs

Brenda and Brian both had positive attitudes towards using WBRs at the start of the research project and they identified a range of affordances related to their limited experiences. However, both significantly broadened their views based on their experiences using WBRs during the course of the research. Similar to the participants in School A they identified a range of benefits for student engagement and student learning.

Student engagement

Brenda and Brian both expressed surprise at how well their students engaged with the activities that incorporated WBRs. They reported more than a superficial enjoyment of the resources by the students. Rather, they found that the students engaged at a deeper level with the content and it helped promote discussion:

> I could see that kids are actually listening and actually interacting with what was being presented to them as well. (Brian, Iii)

> I'm surprised at how much the students have enjoyed seeing what's on there and so that's motivated me to think I need to do that a lot more…. So that's good because I thought they'd be like "ho-hum, we can do this at home what's the big deal?" But the fact that we were able to generate a discussion about what things we find makes them enjoy it a lot more. (Brenda, Iiii)

They both highlighted the value of being able to readily access real-life examples of products and processes and how this added relevance and contributed to student buy-in to a topic or activity. In addition, both Brian and Brenda commented on how students connected with the visual and dynamic nature of the resources and how much more effective this was than using static images in paper form.

Supporting student learning

In addition to increased student engagement, Brenda and Brian both noted how using WBRs enabled them to enrich and extend student learning, building on and reinforcing their own knowledge at the same time:

> There's a sense of, this is the information I am providing you – my experiences with this particular product or process or whatever, let's have a look at how people in industry can utilise it as well. And then they can see … technologists, professionals using it. It's made me more confident with the material I'm using because I can back it up. (Brian, Iii)

Further, as with Agnes and Alison, both Brenda and Brian identified the affordance of being able to conveniently connect with industry to access a wide range of relevant and up-to-date knowledge about materials, products and processes: "You can get a technologist into your classroom at the click of a button" (Brian, Iiii). Both Brenda and Brian noted the value of students learning directly from experts and being able to complement and extend their own knowledge. For example:

> I know that [student name] – he used a new material, new to him – in regard to an aluminium skin with a plastic interior … and he's been onto the manufacturer's website to see how to manipulate it and things like that – it's fantastic! (Brian, Iii)

In addition, Brenda and Brian highlighted the efficiency and convenience of using WBRs, similar to School A participants. In particular, they both reported how this enabled them to more efficiently support and extend students' learning in the workshop. As Brian said, "I suppose it's that third person in the workshop" (Brian, Iii), indicating that WBRs (in particular, YouTube clips) provided an additional source of expert instruction, other than the teacher.

Brenda also highlighted how it enabled her to illustrate a process or a concept that would otherwise not be possible in the classroom:

> I think with the new curriculum there's a lot more emphasis on research and on planning and looking at existing solutions and practices and … if there's something you can download and show, and show a short clip that lasts for 2 or 3 minutes and that's one way of illustrating something that you can't always show in class because you don't have the resources. (Brenda, Iii)

As indicated above, Brian valued how the visual nature of WBRs better enabled his students to recall and apply knowledge in other situations. The following example demonstrated this further:

> Especially when it comes to assessment for unit standard work … they make reference to the video rather than what they read or what I'd read in the class. … And I'll even make some reference to it as well. We were recently doing some work with epoxy resins etc., etc., and some of them, one of the lads says "well what is this? What does it do?" and I said "well look, remember that video we showed you with that guy with a chainsaw hacking through that plastic boat and he glued it together and did all those testings with it?" He said: "That's right! So it's quite a strong glue then, that's right, it's waterproof". And they give us these attributes of these specific products and that's what I'm after. (Brian, Iiii)

6.2.5 Changes in pedagogy

Brian and Brenda's classroom use of WBRs during the research mainly involved the projection of YouTube clips to the whole class because they perceived this to be the most achievable with the access they had to WBRs at the time. While they didn't report a significant change in their role in the classroom as such, they both found that they could make their lessons more relevant for the students and this stimulated a lot more discussion:

> It’s showing that technology doesn’t just happen in this classroom like it’s really important for them to see that it happens in real life. And to be able to bring that outside in to the classroom certainly helps raise awareness and starts generate discussion as well, and starts getting them thinking. (Brenda, Iiii)

Brenda did report however, that while her usual style of teaching was generally quite interactive, her limited ICT skills sometimes presented opportunities for students to become the teacher and share their knowledge, which enhanced teacher-student relationships:

> Because there might be stuff that they know more about and so that would give them a chance …. And so, there’s a lot more sharing I guess of that and where I become the student and they’re the teacher, which is, that would probably be where the change is. (Brenda, Iiii)

Once Brian had saved a ‘library’ of YouTube clips and had these at his fingertips, he found he was able to be more flexible and responsive in the classroom. Hence, he was able to make lessons more dynamic and provide a richer learning experience by generating more discussion and interaction. Similar to the participants in School A, Brian also found that he could more readily differentiate lesson content because of the diversity of WBRs. For example:

> I had mixed boys and girls, so the presentation was catered to both genders. So, we were doing epoxy resins so we looked at how in industry they form a resin bucket seat for a sports car and they were really, really into that, even some of the girls. But then we had another where it was like a kayak where they got a chainsaw and ripped it in half and then epoxied it all up and then they did all this testing. … And some of the girls were actually keen, into their water sports, and then we looked at another product that was suitable for surfboards and repairing them and they really hooked into that. (Brian, Iii)

Like the participants in School A, as Brenda and Brian planned to use WBRs for the research, they considered appropriate strategies for scaffolding student learning. In her Year 9 class, Brenda incorporated activities using WBRs into a student workbook. In this way she scaffolded student learning throughout the whole unit, strategically integrating WBRs with a range of other resources to support student learning. In addition, because her students had to do a homework activity using WBRs, she planned to model the activity with her students first. In this way students could benefit from the wider discussion and teacher guidance, as well as having an example to support them. The following comment from Brenda, similar to an earlier one from Alison, suggests that previously she would not have provided any structured support:

> Well, normally I'd just set a homework activity and say, "Good luck, go and do it", sort of thing (laugh). This way I've been able to model – because I've actually had some examples, I've been able to model it first and then give them some strategies. Like, showing them how you get on the website, showing them, saying: "What are we gaining from this?" You know, I'm not just doing this as an activity. I'm actually saying: "What are you going to learn from this?" (Brenda, Iii)

Brian reported using a range of strategies to encourage students to engage more deeply with content, stimulate discussion and enhance student understanding. For example, he used questioning to get students to focus on particular aspects of a product or process in a video clip, and probed for more information to encourage deeper thinking and discussion. In a senior class, he was able to model how to find resources and support material for an assessment task students were to complete for homework. In some situations he prepared a structured worksheet. Sometimes he turned off the audio in a video clip and prompted students to explain what was happening.

Brenda also highlighted that the new curriculum had recently impacted on what she was teaching and this had supported a change in her pedagogy:

> In the past we never really did a lot of, I don't believe we did a lot of "let's look at what's already been made" and "let's look at it and decide whether it was a good make or not". And I really enjoy the fact that kids are able now to look at things and look at how they've been made and look at whether it's a quality product or not and how to make it a better product. (Brenda, Iiii)

It appears that Brenda found using WBRs supported her teaching of some aspects of the new curriculum particularly well. In that respect the timing of her involvement in the research aligned particularly well with the curriculum changes. WBRs supported the implementation of curriculum changes and vice versa. Consequently, it appears likely that both these elements of change and their alignment contributed to the successful outcomes Brenda observed, as she explains:

> It's probably both. The curriculum has put an emphasis on things that have been there but not really been focused on before. But by doing it [analysing existing products] it's actually made the teaching a lot easier because the students have learnt information and so they've been able to inform their practice because of it. So normally I wouldn't have used the computer so straight away that's changed because I've got the resources to be able to do that now. So by doing that it's forced me to actually look at what's out there to see what I can bring to the classroom from outside. (Brenda, Iii)

6.2.6 Development of TPACK

Developing Technological Knowledge

Brian and Brenda initially reported having limited experience using WBRs and hence limited knowledge and skills to use them successfully in the classroom. In other words, like Agnes and Alison in School A, they lacked TK.

Brian was particularly impressed by the skills his senior students demonstrated in their independent portfolio work. This appeared to intensify his perceptions of his lack of skill and contributed to his lack of confidence to use WBRs in the classroom. Brenda, on the other hand, was more pragmatic about her lack of skills and assumed that as she gradually increased her use of WBRs her skills and her confidence would develop.

As the data suggest, Brian and Brenda's TK developed as they focused on using WBRs in a more strategic way in the classroom, similar to Alison and Agnes. They were still in the early stages of developing TK, as this comment from Brian about his skill development suggests: "Absolute novice to about the second rung on a 10 rung ladder" (Brian, Iiii). However, their positive experiences early on helped them to quickly become more confident about using WBRs in the classroom and developing their skills alongside their students.

Hence, it appeared from the commitment they were both showing to increasing their use of WBRs, that, like School A's participants, they too were on a trajectory of ongoing self-development, which would likely result in a steady increase in their TK.

Developing Technological Pedagogical Knowledge

Having little or no initial experience using WBRs in the classroom, both Brian and Brenda had limited TPK. On the occasions when they used WBRs in the classroom or encouraged students to use them for their course work or project work, it appeared that they did not employ any particular strategies to support students' learning.

Similar to School A's participants, as Brian and Brenda focused on using WBRs in the classroom in a more structured way, they began to develop TPK. As they reflected on their experiences they developed knowledge of pedagogical affordances of WBRs. In particular, as already mentioned in Section 6.2.4, they both highlighted the currency and relevance WBRs could bring to their teaching and the interactions using WBRs could inspire in the classroom. Brian also reported how WBRs enabled him to be more flexible and responsive to students' needs in the classroom and to encourage student inquiry.

They both developed and trialled pedagogical strategies to support student learning using WBRs. For example, as mentioned in Section 6.2.5, they modelled how to access particular resources to support students with completing independent tasks at home. Brenda integrated structured tasks into a student workbook and modelled the activity first in a group-work situation in class.

Brian used WBRs more extensively than Brenda during the research and hence trialled a broader range of strategies. Like Alison in School A, his wider range of experiences appeared to contribute to his ability to be more flexible and spontaneous when he identified opportunities to enhance learning in the classroom.

As with School A, it was evident that Brian and Brenda's existing pedagogical knowledge as experienced teachers was an advantage and contributed to their ability to develop appropriate strategies to support student learning. Their previous teaching experience also appeared to better enable them to recognise pedagogical affordances and constraints of using WBRs. Subsequently, as they reflected on their experiences they could make critical comparisons with traditional teaching approaches and more readily identify other opportunities in their programme where using WBRs could enhance teaching and learning.

Developing Technological Content Knowledge

Brian and Brenda's initial TCK was limited, in a similar way to their TPK, by their lack of experience using WBRs both personally and in a strategic and focused way in the classroom. Similar to Alison and Agnes, they were inherently aware of the potential of WBRs to enrich their programmes. However, at the start of the research they could identify very few specific examples of WBRs that were relevant to their programme, or particular ways these resources could transform content to enhance understanding of specific ideas and concepts.

As they trialled and reflected on their use of WBRs during the research project, both participants became more aware of specific WBRs and reported particular ways that they enhanced teaching and learning of particular content. They found they could represent content (in particular, contemporary products), in a more dynamic way that better enabled concepts to be unpacked, and encouraged deeper discussion in the classroom.

Brenda and Brian's experiences also enabled them to reflect in a more general way about using WBRs throughout their programmes. As they perceived affordances for teaching and learning particular types of content, they were able to identify multiple opportunities for using WBRs in their teaching and they were inspired to use them more widely. For example, Brian acted spontaneously on a number of opportunities he identified during the research project (see Section 6.2.3), and both Brenda and Brian expressed ideas they planned to follow up beyond the research project.

Like School A's participants, they both expressed intentions to specifically look for opportunities to integrate WBRs in their programme planning for the following year.

Developing Technological Pedagogical Content Knowledge

The subsections above describe Brian and Brenda's developing TK, TPK and TCK during the research period. The data suggest they were still in the early stages of developing their knowledge in these areas at the conclusion of the research project. However, their reflective comments, and in some cases their actions in the classroom, provide evidence that they were developing TPACK. They were integrating new knowledge, gained from reflecting on their teaching experiences, with their existing knowledge as experienced teachers to make informed decisions about where, when and how they could integrate WBRs in their classroom teaching programmes.

Brian, like Alison in School A, showed more evidence of his developing TPACK than Brenda during the research, most likely because he used WBRs more widely and therefore had more experiences to reflect on and contribute to his knowledge. For example, he demonstrated TPACK in his spontaneous decision-making in the classroom when he took opportunities to use WBRs in particular situations where he deemed it more appropriate and effective for learning than traditional resources or approaches.

Brenda's development of TPACK was evident in reflective comments she made connecting particular affordances of WBRs with aspects of the curriculum. For example, she highlighted how online links to industry provided authentic opportunities to explore functional modelling and critically analyse existing solutions, and how this was relevant for her students at all year levels.

Brenda and Brian both expressed commitment to reviewing their programmes and considering when, where and how to incorporate WBRs as an integral part of their planning for the following year. In addition, they were both inspired to continue to increase their skills and knowledge.

6.2.7 Summary

Both Brenda and Brian's access to WBRs for their whole class was very difficult. For this reason they integrated WBRs into activities based around the teacher accessing and projecting WBRs in the classroom – direct student use was confined to follow-up homework activities. In this respect, their classroom use during the research was necessarily more teacher-directed than the approach used by School A's participants.

Despite more restricted ICT access and using a different approach to School A, Brian and Brenda's experiences were similarly positive and appeared to surpass their expectations. Their successful experiences significantly broadened their views about the affordances of WBRs for learning in technology education, and their changing views about the benefits of WBRs appeared to outweigh the barriers that had previously inhibited their use.

Brian used WBRs more extensively than Brenda during the research and as a result, showed a greater degree, and rate, of change. Like Alison in School A, he used WBRs more widely than he initially planned and also identified and acted on opportunities to integrate WBRs spontaneously into his classroom teaching when he perceived learning benefits, and when he had the access required.

Brian appeared to be driven from the very early stages of committing to the research project, when he took a proactive stance in obtaining better access to ICT equipment for his classes. His resolve increased when his first trials were successful, both in terms of his ability to manage technically and his students' engagement and learning. The positive outcomes and sense of achievement he experienced in overcoming significant access difficulties and expanding his own knowledge and confidence were empowering. This empowerment appears to have been a key factor in driving him to continue his own learning and broaden his use of WBRs during the research and to show commitment to continue this the following year. Brian was also very motivated throughout the research by the prospect of sharing experiences with the other participants in the final workshop.

Brenda's positive experience prompted her to identify multiple opportunities in her teaching programme where she perceived WBRs could enhance student learning. In particular, she highlighted affordances of WBRs for supporting particular components of the new Technology Curriculum. While Brenda did not extend her use of WBRs beyond the planned unit during the research, she appeared to be committed to extending her use of them the following year. Like Brian, she came to view WBRs as integral classroom resources to incorporate where appropriate throughout her programme and was committed to reviewing her programme with this intent for the following year. Hence, like School A's participants, it appeared that the positive outcomes were empowering and became enablers driving them to increase their use of WBRs.

Brenda and Brian's development of TPACK is summarised in Table 6.2.

Table 6.2. School B participants' development of TPACK

Participants	Components of TPACK	Initial	After implementation
Brenda	TK	Beginning to develop ICT knowledge, skill and confidence	Some increase in ICT skills and considerable increase in confidence using WBRs in the classroom
	TPK	Limited strategies for scaffolding learning using WBRs Limited knowledge of ways teaching and learning can change when using WBRs	Trialled scaffolding strategies and recognised benefits for student learning Identified modifications to pedagogy to further enhance outcomes Increased knowledge of pedagogical affordances of WBRs
	TCK	Limited knowledge of subject related WBRs with potential to transform content and enhance understanding of specific ideas and concepts	Increased knowledge of affordances of WBRs to represent particular content in new ways Increased awareness of WBRs with specific relevance to curriculum and classroom programme at various levels
	TPACK	Undeveloped	Recognised multiple opportunities in her classroom programme to integrate WBRs Experience and increased knowledge enabled reasoning about how, where and why she might use WBRs in her future programme Committed to ongoing development of knowledge and skills in above components of TPACK and integrating WBRs into annual programme planning
Brian	TK	Limited skills, knowledge and confidence using ICT and WBRs Very limited experience using either in the classroom	Increased confidence to use WBRs in the classroom Recognised need to further develop ICT skills Motivated and committed to continue building his skills

	TPK	Strong belief in the value of WBRs for learning in technology education but very limited access preventing classroom use and subsequent development of TPK	Experienced success using a range of strategies to integrate WBRs in the classroom Building a repertoire of strategies that work in particular situations with particular content to enhance learning Increased knowledge of affordances of WBRs for enhancing pedagogy
	TCK	Limited knowledge of WBRs that can transform content in ways that enhance understanding of specific ideas and concepts	Increased knowledge of affordances of WBRs for transforming content to enhance teaching and learning Increased knowledge of WBRs with specific links to his programme
	TPACK	Undeveloped	Identified potential for more extensive use of WBRs in his teaching programme and the need to locate and link to relevant WBRs when planning for the following year Developing the ability to identify situations where using WBRs would likely enhance teaching and learning for individual students or the whole class, and to make spontaneous decisions about their use

6.3 School C

School C had two participants: Carla, who was HOD, and Cheryl who was an assistant teacher. Both taught food and fabrics technology – Carla taught all senior classes and Cheryl mostly junior classes (see Section 5.3).

There were some key differences between School C and the other two schools. It was higher decile, Catholic, urban and perhaps most significantly, it was relatively new. As a newer school, it had more modern buildings and a more modern layout than the other two schools. All technology areas were housed in one block with a large shared office space. The physical layout appeared to enable and encourage collaboration between teachers across all technology areas, which didn't occur in the other two schools. As described in Section 5.3.1, the department was doing some collaborative planning in their junior programmes to ensure generic technology concepts were taught consistently across all areas, and they were progressively sharing more resources on a department shared drive. There also appeared to be a more coherent and united approach to the new technology curriculum across the department in this school.

School C had a significant advantage over the other two schools in terms of their access to ICT because they had a small computer suite in their block exclusively for their department. This provided whole class access to computers for their classes without having to compete with other departments. It also enabled some flexible access for individual and groups of students. However, while Carla's classes were timetabled into the department computer suite for the majority of their lessons, Cheryl's classes were not timetabled into the suite at all. In addition, computer access in individual classrooms in School C was limited. The classrooms had not been designed with provision for multiple computers and they were all quite small so there was limited space to accommodate computers. Both Carla and Cheryl had teacher laptops, which they could use with data projectors in their various classrooms.

Despite the greater access to computers in this school, there appeared to be less infrastructure to support teachers to upskill in the use of ICT for teaching than there was in the other two schools. Apart from some occasional generic school PD sessions, the participants reported mostly working things out for themselves and learning from colleagues within their department.

Cheryl initially reported having very limited skills in using WBRs and rarely used them, either personally or in the classroom. Her fear of things going wrong when using WBRs in the classroom and not being able to cope was considerable, and it appeared that for Cheryl the risks outweighed the benefits. She appeared to be one of the least confident of all the participants and probably had the least skills and experience. She also found having to carry her computer around and set it up in different rooms a burden, and consequently tended to avoid it: “It’s just so much easier to say forget it” (Cheryl, Iii).

Carla had a lot more experience than Cheryl and her students used WBRs extensively in her classes, although mostly for independent research. She reported being dependent on WBRs for supporting her senior programmes. Carla was fairly confident in her ability to use WBRs personally and was relaxed about asking for help when she needed it. This included asking for help from her students, whom she considered generally had more ICT skills than she did. However, Carla appeared to feel out of her depth managing students’ use of WBRs in the classroom, and was frustrated that she was unable to give them the guidance she felt they needed in searching for and selecting relevant and appropriate resources.

Carla and Cheryl both found lack of time was a barrier to developing their skills and knowledge. In particular, they found searching for and locating relevant resources was time-consuming, as did all the participants except Ashley.

6.3.1 The participants’ post workshop activity

Cheryl was developing some generic units for Years 7-9 to develop students’ understanding of the characteristics of technology. She decided to focus on incorporating WBRs into one of these units to trial with her Year 8 class. She planned to incorporate a number of web-based video clips into the introductory lesson and she invited the researcher to observe the lesson. Linking to a number of video clips in one lesson in front of the class was quite a big step for Cheryl based on the level of experience and confidence that she reported initially, and it was clear that that she had sought help from others and put considerable time and effort into preparing for the lesson. The following comment from Cheryl illustrates that what she planned to do was well outside her comfort zone:

> I'm still very computer phobic and I get frustrated when things don't work and so for me to engage with the computer and the screen, I can't remember how many times in the lesson, is a huge step up for me. (Cheryl, Iii)

Carla, on the other hand, didn't appear to have a particular focus for enhancing her use of WBRs for the research project. Accordingly she didn't commit to an interview part way through the research – her second interview was her final interview, conducted at the end of the research project. For this reason it was unclear what specific preparation Carla did.

As reported earlier, Carla's students were already using WBRs extensively in her classes but she lacked strategies for providing effective support. Because she was teaching only senior classes all her students were working on independent client-focused projects. Having convenient access to computers for her classes, WBRs provided the main source of information and communication to support and inform students' product development projects.

Based on Carla's final interview and her contribution to the evaluation workshop, it appeared that she may have tried to use more scaffolding strategies to support students with research and that she had continued to search for relevant WBRs to use with her classes during the year. However, because Carla did not identify a particular focus, it was unclear whether the work she did with WBRs was in response to the research project or simply natural progression of her ongoing learning and striving to better meet the needs of her students, who were heavily reliant on WBRs.

6.3.2 The participants' planned units of work

The aim of Cheryl's unit was to broaden students' understanding of the Nature of Technology by exploring the origin and development of particular innovative technologies. Cheryl planned to incorporate a number of video clips into an introductory lesson and access them directly through Google and YouTube using her teacher's laptop and a data projector. The lesson, which was observed by the researcher, was the first lesson of a two-term course of food technology for the Year 8 students.

Cheryl initially sought help with searching for appropriate video clips. She spent considerable time locating a wide range of video clips that she felt would interest the students in this year level. She particularly wanted to include examples that would interest the boys, to be certain of sustaining their engagement in the lesson.

As mentioned earlier, it was unclear what specific planning Carla did for the purposes of the research.

6.3.3 Enacting the plan in the classroom

Cheryl delivered her introductory lesson in a practical foods room, which was her allocated room for this class. The Year 8 programme was designed to be predominantly practical skills-based, utilising the facilities in this room. Cheryl set up all the resources including the laptop during the lunch hour prior to the start of the class and practised linking to the clips so that she was certain they would work successfully.

The key ideas of the unit built on concepts introduced to students the previous year, so Cheryl began the lesson with a quick recap of students' prior learning. The lesson included some group discussion and sharing of ideas with the whole class before and after some video clips, and Cheryl used a lot of questioning to encourage thinking and maintain student engagement. However, overall the lesson was very teacher-directed, partially necessitated by the facilities available in this classroom.

Cheryl was clearly well-prepared for the lesson. There was a logical progression of ideas and she kept the lesson moving at a relatively fast pace with smooth transitions between activities, which kept the students engaged. The students were instructed not to get out any books at the start of the lesson and they did not record any notes.

Cheryl set the students a related homework task using WBRs. Although it seemed likely at the time that the task would be followed up in a subsequent lesson, when asked about the outcome in the final interview, she reported that she did not follow this up. It is unclear from the data why Cheryl did not go on to explore and clarify the students' developing ideas in another lesson, as the unit outline identified it as a two-lesson unit.

Cheryl made no further attempt to integrate WBRs. She may have decided at some point after the classroom observation that she would not plan for any further trialling of WBRs in that year or she may have simply not got around to it. It is possible that the considerable effort she put into preparing for the one lesson, given her limited skills and confidence, outweighed the benefits she observed and discouraged her further use.

As a result of not following up with a second lesson there was limited opportunity for Cheryl to reflect on student learning and consider how she might build on the experience of using WBRs. In the second interview, immediately after the lesson, she had no thoughts about how she might change it if she was to do it again. In the final interview it appeared that she still didn't have any specific ideas about this: "There hasn't really been any formal development, it's still evolving" (Iiii). Although the following comment, later in the interview suggests that she had given it some thought, and ready access to computers in the classroom may have made a difference:

> I think I need to develop the second stage of that [lesson] and it would be great to have the COW or the computer and get them straight on to doing something earlier, but then that brings in the concept of the machinery and getting access. (Cheryl, Iiii)

However, while Cheryl appeared to have done very little reflection on her own lesson using WBRs, she appeared to have reflected considerably on, and been inspired by, the work of a student teacher assigned to some of her classes later in the year. She reported on the significant use of WBRs by the student teacher and was clearly impressed:

> I had a student teacher who was a food technologist who then has gone into Teachers' College, but she absolutely adores computers and research and everything. … So she would come into my classroom and we might have been doing bread or I don't know, whatever, and she would have the mini library on her computer. So I didn't actually access it but I can see the value. So if you're talking about separating eggs or whisking da, de, da, she would just say "Just a minute", and there it would be and then we would all do it and talk about it. (Agnes, Iiii)

Like Cheryl, Carla also appeared to make limited progress. At the final interview, she reported still struggling with the same issues related to WBRs that she mentioned in the first interview. That is, the challenge of guiding and managing the diversity of students' research when they were working on client-focused projects:

> Well I use WBRs every day with the students because we're in there every day through necessity, … we don't have a lot of text books so we tend to use WBRs unless it's a worksheet that I've made up for the students I suppose. Um, but the hardest part has been making sure the students don't go off on a tangent and waste time. (Carla, Iiii)

It also appeared that Carla was particularly busy that year. She had taken on several new challenges, such as, teaching senior food technology for the first time and entering her students into a national product development competition as well as the CREST Awards, in addition to her involvement in this research. The following comment suggests that she may have been overwhelmed by the number of new initiatives she was involved in:

> There just seem to be so many new things all at once and you don't have enough **time** to process and go through and learn how to use these things before you start on the next one. And I think we were just too keen to try and use all these things so nothing worked very well at all. You just need to slow down a bit and make sure you can

> manage one thing and master it and really use it well before going on to the next thing. (Carla, Iiii)

6.3.4 Changing views about the value of using WBRs

Cheryl initially expressed the view that WBRs could help engage students in a new topic and stimulate discussion. However, her views were based on very limited use of WBRs and she had limited insight into affordances for enhancing student learning. While Cheryl's use of WBRs was limited during the research period, her views appeared to change significantly after working alongside a student teacher using WBRs. By contrast, Carla considered WBRs to be an essential resource for supporting her students' learning and she maintained this view – while recognising the need to develop appropriate pedagogies to support students' independent research processes.

Student engagement

When Cheryl reflected on her lesson using WBRs, she identified how well her students engaged with ideas compared to how she approached a similar topic previously:

> Well it's got to be more effective – the kids are such visual learners, you know, with the films and movies and everything, they key into that so much. (Cheryl, Iiii)

Cheryl did not build on her experience using WBRs, but she was inspired by the student teacher's practice using WBRs with her class. Cheryl's comments suggest that the student teacher used WBRs as an integral classroom resource during her placement in the school. This gave Cheryl a variety of vicarious experiences to reflect on and appeared to be pivotal in influencing her thinking about the value of WBRs for engaging students, as this comment suggests:

> Oh, [the students were] totally switched on. Yeah. She was um, I was dead and she was alive! The comparison between me and the presentation of my lesson compared with hers – there's no

> comparison. The kids are so much more engaged with it. (Cheryl, Iiii)

Despite having clearly changed her views about the value of WBRs after her experience with the teacher trainee it is unclear to what extent Cheryl's change of attitude may drive her use of them in the near future. Unlike the participants in Schools A and B, it appeared that Cheryl's lack of confidence may continue to constrain her use of WBRs, as the following comment suggests:

> I can see that the kids benefit tremendously, so I need to move… But again it's having the computer that will switch on quickly, always work in the classroom, and we're just making minute steps towards that. (Cheryl, Iiii)

Supporting student learning

Cheryl's experiences with the student teacher appeared to help increase her awareness of the breadth of relevant WBRs, and strategies for using them in the classroom. The data suggest that as she observed and reflected on the student teacher's work she began to identify benefits not only for engaging students but also for enhancing student learning. The experience appeared to have opened Cheryl's eyes to possibilities that she would not have conceived previously.

As she discussed examples of how the student teacher used WBRs, Cheryl identified a range of affordances of WBRs for supporting student learning which were similar to those identified by the participants in Schools A and B, for example, being able to show processes and real examples of technologies:

> [WBRs] allows you to bring other situations into the classroom, show processes and examples and definitions. [Students] can see in real life something you're trying to explain. Showing actual examples makes it more real. (Cheryl, Iiii)

As already stated, Carla reported initially being dependent on the Internet for her students to access the breadth of information they needed to inform their product development projects. Her comments in her final interview about affordances of

WBRs for supporting student learning appear to reiterate her initial thinking and align closely with the participants in Schools A and B. For example, she commented on the breadth and currency of resources and the ability to connect with industry and stakeholders to support students' learning. She also highlighted how the nature of technology education necessitates access to the diversity and currency that is characteristic of WBRs and beyond the realms of traditional classroom resources:

> Well in technology you've just got access to so many resources and because we don't have a lot of Kiwi or New Zealand based text books, you know, we're not a text book based subject. … And because technology and everything is changing so quickly the Web is a perfect place to find things like that. (Carla, Iiii)

6.3.5 Changes in pedagogy

There appeared to be no significant changes in the pedagogy of Carla or Cheryl during the research project. In Carla's case the reason for this appears to be twofold. First, from the outset, Carla had ready access to a computer suite for the majority of her lessons, which allowed her students individual access to WBRs most of the time. As such, she did not increase her use of WBRs in the way that Schools A and B's participants did. This may have meant changes were more subtle, and may have also contributed to the difficulty Carla had identifying a specific focus for the research. Second, it was evident that Carla was using a predominantly student-centred pedagogy at the start of the research. Hence, she did not report any change in her role in the classroom as Alison and Agnes had. Carla was teaching only senior classes and all of them were doing a technology programme that required students to work on self-directed projects. As was the case in Brian's senior technology classes and in most of Ashley's classes, this type of programme demanded a student-centred pedagogy. For both Carla and Brian this approach was well-established, the key difference being that Carla's students could use WBRs during class. Consequently, there had been more opportunity for Carla to experience using WBRs in the classroom and hence more scope for her to identify difficulties and begin to develop some skills and knowledge to support her students’ use of them.

Carla initially reported that she sometimes developed structured worksheets to scaffold student learning using WBRs when there was a common focus. However, she reported having no particular strategies for supporting students’ independent research. This was similar to both Alison and Brenda’s initial approach to using WBRs reported earlier. Carla found this aspect of her teaching difficult and it appears that she may have continued to work on this during the year as in the final interview she described several helpful strategies she had tried, for example:

> Giving them some lead questions or a particular set of websites and me doing some pre research and saying, “Ok, you could find out this sort of information here on this site or this sort of information here”. So, you sort of almost directed them into finding information – that worked. (Carla, Iiii)

Carla was also thinking ahead to the following year and considering further strategies she could employ to enhance this aspect of her teaching:

> What I’d change for next year is, … I’d quite like to set up a folder on the student shared drive … so then they’re more self-directed and they can manage themselves a bit better. (Carla, Iiii)

In contrast to Carla, Cheryl appeared to be using a more teacher-centred approach in the classroom, and this was the case in the lesson that was observed with her using WBRs. In this lesson, while she used a variety of video clips, which appeared to make the lesson more dynamic and engaging, her pedagogy seemed similar to her usual approach in which she used paper-based images to stimulate thinking and discussion.

However, because Cheryl did not follow up the lesson or make any further use of WBRs there was limited scope for her to try out any other strategies or reflect on how using WBRs in this lesson may have enhanced student learning. It appeared that this one isolated lesson was insufficient to build her skills and confidence or to help her recognise affordances for learning that may have encouraged her to further her use of WBRs. Cheryl remained constrained by her own lack of knowledge and confidence.

6.3.6 Development of TPACK

Developing Technological Knowledge

Cheryl's initial TK was very limited – it appeared to be more limited than any of the other participants. Carla, on the other hand, was reasonably confident in using ICT and appeared confident that her skills and knowledge would continue to develop as she tried things out, which was similar to the attitude expressed by Brenda in School B. Carla was much less skilled and confident than Ashley but had considerably more experience using WBRs in the classroom than any of the other participants.

Cheryl only tried using WBRs in one lesson. While she clearly extended her knowledge and skills in her preparation for and teaching of this one lesson, this experience alone was insufficient to increase her confidence. Without any further use of WBRs there was limited opportunity for Cheryl to make further progress in her development of TK or to increase her confidence. Cheryl's lack of confidence clearly remained a key factor constraining her further use of WBRs in the classroom, and subsequent development of TK. Despite being more inspired about the value of using WBRs by the student teacher and showing some commitment to ongoing use, it was clear that Cheryl was not on the same trajectory of ongoing self-development as Alison and Agnes in School A and Brian and Brenda in School B.

In Carla's case, because she did not identify a clear focus for the research, it was more difficult to determine her development of TK. Her students were already heavily reliant on WBRs for their individual project work and used them extensively in her classes. Her students were mostly self-directed and she was the 'guide on the side', although her guidance was more subject-related than ICT-related. She reported that she often asked her students for ICT help and learnt from them.

Carla had clearly already been developing TK as a result of her extensive and ongoing use of WBRs in the classroom as she strived to better meet the needs of her students. In her words: “You learn as you go along and every day you try and learn something or you pick up other bits and pieces” (Carla, Ii). Therefore, it seems likely that Carla continued to develop her TK to some extent throughout the research, and also that her TK will continue to develop as a result of her attitude and commitment to change:

> It’s [ICT] constantly changing and updating but the hardest part is being able to keep up with it yourself. But that is just part of our lifestyle, or our lives and it’s just something we’re going to have to learn to live with. (Carla, Iiii)

Developing Technological Pedagogical Knowledge

Cheryl rarely used WBRs in the classroom so, like Schools A and B’s participants, she had had little opportunity to develop TPK. In addition, her initial TK was more limited than any of the others, and subsequently her lack of confidence was a significant barrier affecting her motivation to increase her use of WBRs.

Cheryl’s limited trialling of WBRs during the research provided little opportunity to build her TPK. However, when she had a student teacher in her class who used WBRs extensively, it clearly inspired her to reflect critically on her own practice. This experience appeared to be a turning point in Cheryl’s thinking about the value of using WBRs and the need for her to integrate them more in her classroom practice. As a result of her experience with the student teacher, she developed a greater awareness of affordances of WBRs and pedagogical strategies to support student learning using WBRs. Hence, although she did not demonstrate increased TPK in the classroom during the research, her reflections showed that she had begun to develop a level of TPK.

In contrast to Cheryl and all the other participants, Carla was using WBRs frequently in the classroom from the outset. However, her classroom experience did not automatically translate into TPK. She clearly recognised the affordance of

WBRs to make accessible the scope of information needed to support the diverse and individual learning needs of her students. However, she struggled to manage and support her students' use of WBRs effectively. This suggests that Carla's TPK was not well developed.

Although Carla reported sometimes using scaffolding strategies, such as structured worksheets when the whole class was working on the same task, she appeared to have no pre-planned approach when the students were using WBRs for individual project work. Rather, it appears that Carla relied on her students' ability to use WBRs effectively. Her approach appeared to be to provide what help she could when a problem or need arose in the classroom, rather than identifying potential difficulties and planning scaffolding strategies in advance to support the students. For example, Carla acknowledged that the sheer scope of information was a difficulty even for her, and she had not developed strategies to help students develop skills to manage this more efficiently.

Carla's approach was similar to the initial approach used by Alison and Agnes in School A and Brian and Brenda in School B; that is, sending the students off to complete a task using WBRs without providing any guidance. Despite her more frequent use of WBRs Carla's TPK was clearly under-developed. It appears that her level of TK in using WBRs may have been a limiting factor in her development of TPK. Unlike Ashley, whose extensive TK and confidence using WBRs enabled her to more readily identify the sorts of problems her students were likely to encounter in a particular situation. Consequently, Ashley was better able to pre-plan strategies to scaffold student learning and to diagnose problems and spontaneously provide support in the classroom than Carla.

Carla's development of TPK during the research was more difficult to determine than for the others because she did not clearly define a focus or the parameters of what she did. However, she did report trying some strategies that helped, such as providing focus questions, key words and suggested websites. However, it appears that a lot of the time much was still left to chance: "most of the time I was just individually checking and seeing what they were doing" (Carla, Iii).

Carla was also clearly finding it challenging teaching senior food technology classes for the first time, especially with the added pressure of a national competition and external stakeholders. In addition, the sheer diversity of contexts her students were working in generated wide-ranging demands that made the task of scaffolding more complex. Despite lack of clarity around her progress, it was evident that Carla reflected on ways to better scaffold her students' learning. Some of her ideas may have been 'banked' for implementing the following year, as was the case for Agnes, Ashley and Brenda. For example, Carla was planning to set up a shared folder and begin to build a 'library' of resources and audited links to relevant websites, YouTube clips and blogs to help students to be more self-managing. Hence, it appeared that Carla was making some progress in developing TPK.

Developing Technological Content Knowledge

Cheryl's initial TCK, like her TK and TPK, was very limited because she rarely used WBRs. Her limited trialling of WBRs gave her little opportunity to build her knowledge in these areas. However, her experience with the student teacher did raise her awareness of affordances of WBRs to more effectively represent particular types of content, such as technological processes and authentic product examples. While she did not appear to develop her ability to locate these resources herself during the research period, her changing views about the affordances of WBRs for learning appeared to have inspired her to want to increase her use of WBRs in the future, which would enable her to further develop her TCK. In addition, the provision of a COW for the department at the end of that year, may remove one of the barriers that Cheryl reported as constraining her use of WBRs.

From the outset, Carla had a reasonable level of TCK developed through her extensive classroom use of WBRs over the previous few years. Similar to her TK, it is likely that she continued to increase her TCK incrementally as she strived to better support student learning, as the comment below exemplifies:

> I was just surfing round on the Web trying to find a technologist that the students could research or focus on and I then found that blog for that woman, … and she had some really, really good

> pictures and step by step instructions for making particular garments and then she turned out to be a [local] person and she came in and talked to the students. So that was quite useful but it took, I don't know, I was mucking about for about an hour and a half before I found her. So you can waste a lot of time. But once you've got it, and we've used it a lot and all the students have accessed that site, so it's been really useful. (Carla, Iiii)

Carla's plan to set up a shared drive for students to access audited links for the following year is testament to the point she had reached in her development of TCK. It reflects the considerable range of WBRs she had already accessed with her students and her recognition of the value of establishing a platform, which students and teachers alike can share and contribute to. She perceived this to be an effective way to better support students in their independent study.

As a result of Carla's access to and reliance on WBRs in the classroom over a number of years, it seems likely that her TCK relating to technology education was more developed than the other participants. By contrast, Cheryl appeared to be just on the starting line with a glimpse of what using WBRs can offer in the classroom and some motivation to start using them. Hence, Cheryl did not make the same progress in developing her TCK as the other participants during the research.

Developing Technological Pedagogical Content Knowledge

The analysis above indicates the progress Carla and Cheryl made in developing TK, TPK and TCK during the research. It was evident that Cheryl's level of knowledge in each of these areas was very limited at the start of the research. As a result of only using WBRs in one lesson during the year, she also had limited opportunity to begin to build a knowledge base that she could draw on in subsequent planning and teaching, which would indicate progress in developing a level of TPACK.

Carla clearly had more experience using WBRs than Cheryl from the start, and much greater knowledge in each of the three components, which she was integrating in decisions she made in her planning and teaching on a daily basis. Hence, it appeared that Carla was already developing TPACK.

Carla had a considerable advantage over all the other participants for gaining experience and developing her knowledge in the components of TPACK, due to her level of classroom access. She also appeared to have a greater level of TK than all the participants except Ashley from the start, and it was likely that her level of TCK was more advanced than all of them. However, her TPK was less developed than the other two components and appeared to be the area that was causing her the most difficulty in the classroom. While she likely made some progress in this area during the research, it was more difficult to identify and define than for the other participants.

While there was no evidence of Cheryl demonstrating TPACK during the research, it was clear that she became more aware of affordances of WBRs as a result of observing the student teacher, and data suggest that this may have been pivotal in changing her views about the value of WBRs for enhancing teaching and learning. As a result, she appeared to be better able to visualise possibilities for integrating WBRs and more motivated to do so. This is similar to the change in thinking that was evident with Schools A and B's participants except that it did not occur as a result of reflecting on her own practice. However, it is possible that it may influence her decision-making in planning for the following year.

6.3.7 Summary

The outcomes of the research for Carla and Cheryl were significantly different from each other and they showed the least change in their classroom use of WBRs (from the beginning of the project) of all the participants. For both Carla and Cheryl, the initial constraints they identified appeared to remain throughout the research and it is clear that neither of them experienced the significant driving forces that helped the participants in Schools A and B to overcome the constraints that initially hindered their use of WBRs.

School C had considerably better access to ICT available for classes than Schools A and B, in their technology department computer suite. However, while Carla accessed this facility most periods with her classes, Cheryl appeared not to use it at all. Hence, Carla initially had considerably more experience using WBRs in the classroom than Cheryl, and all the other participants.

Carla’s frequent classroom use of WBRs over previous years had likely contributed to some development of TPACK knowledge. However, her self-reported difficulty scaffolding student learning using WBRs suggested that her level of TK and TPK in particular were not well developed. Given Carla’s ongoing frequent use of WBRs it is possible that she continued to build on her knowledge in the components of TPACK during the research. However, because she was not explicit about changes she made, her progress was difficult to define.

Cheryl appeared to have the least initial personal experience and confidence using ICT of all the participants. Her lack of skills and confidence were a significant constraint inhibiting her initial use of WBRs. However, in contrast to the other participants, Cheryl’s lack of confidence appeared to remain a significant constraint and she only trialled WBRs in one lesson. This limited experience appeared to be insufficient to increase her confidence or motivation to use WBRs further during the research period. While Cheryl was inspired by a student teacher’s use of WBRs in her class and this appeared to change her views about the affordances of WBRs for learning in technology, her development of TPACK knowledge was limited.

Carla and Cheryl’s development of TPACK is summarised in Table 6.3:

Table 6.3. School C participants' development of TPACK

Participants	Components of TPACK	Initial	After implementation
Carla	**TK**	Reasonable level of skill and confidence using ICT and WBRs	Development of skills is ongoing Overwhelmed by trying too many new things in one year Resolved to focus on and master fewer things at a time
	TPK	Extensive classroom use of WBRs to support independent student research Recognised affordances of WBRs for supporting independent student research Recognised limited pedagogical strategies to manage the affordances and constraints of WBRs to scaffold student learning	Gradual development of strategies for scaffolding individual student learning in widely varying contexts, but this still remains a challenge Planned to establish a 'library' of appropriate WBR links collegially for students at a range of levels for the following year
	TCK	Ongoing development of knowledge of WBRs that represent technology curriculum content in new ways	Continuing to build knowledge of WBRs that represent specific content in new and interesting ways
	TPACK	Developing	Development is ongoing – further development of TPK in particular is needed to better enable her to make spontaneous and reasoned decisions about how to scaffold individual student learning using WBRs

Cheryl	**TK**	Very limited experience using ICT and WBRs No personal use of ICT Lack of skills, knowledge and confidence to support classroom use	Insufficient trialling of WBRs to build TK and confidence
	TPK	Very limited experience and confidence using ICT and subsequently limited knowledge of how WBRs could enhance teaching approaches and student learning	Beginning to identify some affordances of WBRs for enhancing pedagogy, through observation of the student teacher's use
	TCK	Limited knowledge of subject-related WBRs and affordances for transforming content Development impacted by lack of access and lack of TK	Increased awareness of subject-related WBRs and ways they can transform content, mainly through observation of the student teacher's use Lack of access and skills still perceived as significant barriers to increasing use of WBRs
	TPACK	Undeveloped	Undeveloped

6.4 Chapter summary

This chapter has reported the changes that occurred in the practice and beliefs of each of the seven teachers as they focused on increasing and enhancing their integration of WBRs. The findings have been presented as separate case studies of the three schools so that each teacher's progress can be viewed together with the relevant contextual factors that impacted on their practice.

All the participants showed some change in their views about the affordances of WBRs for teaching and learning and/or change in their integration of WBRs in the classroom. However, there was considerable variation among the participants in the extent of change and the rate at which change occurred, with similarities between some participants and significant differences between others. Various driving and constraining forces affected integration of WBRs at different stages during the research. The main constraints initially affecting participants were lack of ICT experience, skills and confidence, which affected all but one participant (Ashley); limited access to ICT, which affected six of the seven participants (not Carla); and limited views of the affordances of WBRs for teaching and learning, which affected all participants to some degree.

Schools A and B were older schools in rural areas and both had very limited access to ICT in classrooms compared to School C. On the other hand, in Schools A and B there appeared to be a greater level of collegial support in working towards the goal of the research than was evident in School C.

In School A, collegial support between the participants was particularly strong and appeared to be a significant driving force in initiating and sustaining their commitment to the research. There was also more evidence that increasing ICT use in classrooms was a priority in this school. Regular ICT professional development was provided and staff members were encouraged to further their own development in departments. The Principal was very supportive of these participants' involvement in the research.

In School B collegiality also appeared to be an enabling factor. Although Brenda and Brian did not work together as closely as School A participants, they were united in their curriculum leadership in their department and also appeared to be united in their commitment to meeting the goal of the research. They gained further collegial support from the school ICT group, which they both joined early in the year after volunteering to be part of the research project.

By contrast, collegial support between Carla and Cheryl in School C in terms of meeting their commitment to the research appeared to be lacking. There also appeared to be limited infrastructure in the school to support staff in using ICT in the classroom. Stronger collegial support may have helped these two participants achieve greater change in their use of WBRs.

The teachers in School A and B, who all initially used WBRs only rarely or occasionally, showed the most change, both in their integration of WBRs and their views about the affordances for teaching and learning. When these teachers integrated WBRs in a planned and strategic way, they experienced positive outcomes, which surpassed their expectations with regard to student engagement and student learning. The positive outcomes began to change their views about the affordances of WBRs for teaching and learning. In addition, for all but Ashley, whose ICT skills were already well developed, their success boosted their confidence in using WBRs in the classroom. They quickly reached a point where they no longer felt the need to master the technology before using it in the classroom and the focus of their use shifted from managing the technology to using the technology to support student learning. For all these teachers, their positive experiences outweighed the constraints that initially inhibited their use, and motivated them to integrate WBRs more widely. The key drivers appeared to be motivation, changing views about the affordances of WBRs for teaching and learning, and their commitment to the research group.

Alison and Brian showed the most significant change in practice. They started implementing changes more quickly and extended their use of WBRs beyond one unit of work with one class, which was the basic expectation for the research. Their greater increase in classroom use of WBRs gave them more experiences to reflect on and therefore more opportunity to build confidence, adjust their views and develop their knowledge. Together, these factors appeared to increase their motivation and the momentum of change. They appeared to be empowered to integrate WBRs more widely and began to make strategic and spontaneous decisions to use WBRs in the classroom in response to needs and situations where they perceived advantages for student learning. This was evidence of their developing TPACK.

All School A and B participants reached the conclusion that successful integration required a planned approach. They committed to making this change the following year by making links to WBRs where appropriate in all programmes as part of their annual planning. They all considered the impact of WBRs on teaching and learning too valuable to leave to chance. Alison and Brian were also empowered to put a case for improved access to ICT for their classes and were successful in achieving this.

School C participants showed the least change in their practice. Cheryl, who initially appeared to have the least ICT experience, skills and confidence of all the participants, made the least progress of all. It appears that her limited trialling of WBRs during the research was insufficient to build her confidence, or motivate her to increase her use of them. Her lack of confidence remained a significant barrier. However, her experience later in the year with a student teacher who used WBRs extensively in her class appeared to be pivotal in influencing her views about the benefits of using WBRs, prompting her to more seriously consider integrating them more in her teaching.

Carla also appeared to make less progress in her use of WBRs than School A and B participants. However, she was initially in a different position to all the others: she had good access to ICT for all her classes and she was already using WBRs extensively. While Carla initially identified specific problems with using WBRs she appeared to take a more *ad hoc* approach to implementing changes than the other participants. It was difficult to identify what specific changes she made and her progress was more difficult to define. This was made more difficult by not having an interview with her mid-way through the research.

The findings suggest that the design and support of the professional development programme provided the initial impetus for participants to change their use of

WBRs. Participants who experienced additional collegial support and encouragement in their individual schools appeared to reach a breakthrough point in their thinking where WBRs became ubiquitous classroom resources, integral to supporting student learning of particular content in particular situations. Barriers were no longer significant impediments and a shift from technocentric to learner-focused pedagogies was evident. These participants appeared to gain sufficient momentum that they were empowered to continue their own ongoing learning and increase their use of WBRs. With a planned and strategic approach to implementing WBRs, sustained use and reflective practice, participants began to develop TPACK. Their level of development of TPACK appeared to be closely aligned to the extent of their use of WBRs.

In the next chapter the research findings are discussed in relation to relevant literature. The chapter goes on to present the conclusions, implications and suggestions for further research.

CHAPTER SEVEN

DISCUSSION

7.0 Introduction

The purpose of this research was to answer the overarching research question: *How can secondary technology teachers be effectively supported to enhance their classroom integration of WBRs?*

The previous two chapters presented an analysis of the findings from the three phases of the research. This chapter begins with a discussion of these findings in relation to relevant literature. Following the introduction the discussion is organised in three sections. These three sections address the research sub questions and in this way contribute the detail required to answer the key research question. The first section discusses the participants' initial context and use of WBRs. This is followed by discussion of the design of the intervention and then insights into the nature of change for individual teachers are discussed. The final section provides a chapter summary.

7.1 Teachers' initial use of WBRs in technology education

This section addresses research sub-questions: *What is the nature and extent of secondary technology teachers' existing use of WBRs in the classroom? What are teachers' existing perceptions of using WBRs in technology education and what barriers are impacting on integration?*

At the outset of this study, the technology teachers' classroom use of WBRs was generally very limited, with the exception of Carla in School C. Computer access for their classes was also difficult for all except Carla. The participants' occasional uses of WBRs in the classroom were mainly technocentric and teacher-directed. Due to their lack of skills, knowledge and confidence, their focus when using WBRs in the classroom was on managing the technology and students' use of it rather than on student learning. Student activities reflected teacher-directed approaches, such as students researching particular websites for predetermined information or watching a video clip shown with the purpose of transmitting information.

This finding is consistent with recent national and international research, which indicates that despite significant increases in funding for ICT, in general there has been limited change in teaching and learning. Apart from pockets of transformative use, didactic teaching approaches and low-level uses of ICT are still dominant in classrooms (2020 Communications Trust, 2011, 2014; Ertmer & Ottenbreit-Leftwich, 2010; Lai, 2008; Lai & Pratt, 2007; Mishra & Koehler, 2009), as discussed in Sections 2.3.3 and 2.3.4.

Comparing the initial context for each of the participants revealed that although there were some distinct differences, there were also a number of common factors that were constraining their integration of WBRs to varying degrees. These common constraining factors included both first order and second order barriers (Ertmer, 1999). First order barriers included limited access to ICT and the Internet, inadequate professional development and lack of time. Second order barriers included limited skills and confidence using WBRs and limited perceptions of the value of WBRs for teaching and learning in technology education.

It is also worth noting that there were a range of levels of implementation of technology education among the participants. Some had recently shifted from more traditional skills-focused programmes to the 2007 technology curriculum, while others had been working to align their programmes with the revised curriculum for some time. Although this was not explored in any depth in this research, it is possible that this may have had some influence on participants' perceptions, and change in perceptions, of the value of WBRs.

7.1.1 First order barriers

Access to computers and the Internet

One of the key reasons for the teachers' limited use of WBRs at the beginning of this study was clearly their limited access to computers and the Internet in their classrooms, as reported in Chapter 5. Alison, in School A, was the only participant with more than one classroom computer and Carla, in School C, was the only teacher who had frequent and easy access to a computer lab. School A had a wireless Internet connection in classrooms but it was unreliable. Schools B and C did not have wireless connections in their classrooms.

The limited Internet connectivity in the participants' schools in the year of data collection is understandable, in light of the findings of the *ICT in Schools* survey (2020 Communications Trust, 2011), which indicated that data caps were constraining Internet use in the majority of secondary schools at that time (UFB was in the very early stages of availability in schools), and Internet resources generally had low levels of use by students. This differs significantly from the U.S. where a 2009 national survey found that nearly every classroom computer had Internet access (L. Gray, Thomas, & Lewis, 2010).

The limited access the participants in this study had to computers, however, was somewhat surprising. Increasing computer numbers in schools had been a major focus of early Government strategies to enhance integration. Large-scale surveys in various countries, including New Zealand, provide evidence that significant increases in student to computer ratios had been achieved (e.g., 2020 Communications Trust, 2011; L. Gray et al., 2010). For example, in New Zealand the ratio dropped steadily from 10:1 in 1995 down to 3:1 in 2007 – discounting computers for teachers' or administrators' use. Interestingly this ratio has remained unchanged since 2007. The low level of access the participants in this study faced in 2011 therefore differed significantly from the national survey results. The New Zealand survey data, however, were not extrapolated to identify where in the school computers were available for student access and this may explain the apparent discrepancy.

In each of the schools in this research, the participating teachers' main computer access for classes was in computer suites or pods. For the participants in School A and B these facilities were difficult to access and their preference was to have access in their own classrooms, as mentioned in Section 5.1. This situation resonates both with research that distinguishes between access and easy access in relation to accessing computers housed in labs (e.g., Selwyn, 1999; Zhao et al., 2002), and with Becker and Ravitz's (1999) finding that having four or five computers in a teacher's classroom led to more frequent use than lab access alone. Even in School C where the Technology department had its own computer suite, because it had to be timetabled at the beginning of the year, flexible and irregular use for a whole class was still very difficult. Hence, while Carla had frequent access timetabled for her classes because they were senior classes, Cheryl's junior classes were not timetabled. As a result, Cheryl was restricted to using her teacher laptop as her only means of classroom access.

The significant barrier that limited access imposed on the participants in this study also corroborates findings of Hew and Brush's (2007) extensive review of empirical research findings on ICT integration between 1995 and 2006. They identified limited resources as the most significant barrier to ICT integration, although their definition of resources included not only computer hardware and software, but also time and technical support.

The possibility that misconceptions about technology education based on a narrow view of the subject (as woodwork, metalwork, sewing etc.) may still have existed in some of these schools and impacted on their computer access, also cannot be discounted. If this were the case it could have led to assumptions by some staff that WBRs had less relevance for technology education than for some other subjects and subsequently impacted on provision of resources. This would help explain the difficulty Brian faced trying to improve his classroom access to WBRs during the research project compared to the Science department (see Sections 5.2.2 and 6.2.1), and concurs with Selwyn's (1999) research, which indicated that some subject areas were more constrained in this regard than others.

No New Zealand survey data have been found relating to numbers of computers located in classrooms compared with numbers provided in computer suites or pods. Neither have data comparing access for technology classes as opposed to other subjects in New Zealand schools been found. Consequently, it cannot be assumed that this situation was typical of other schools in New Zealand, although there is significant anecdotal evidence of this. However, it differs significantly from the U.S. where nearly all teachers had one or more computers in their classrooms and more than half could bring more computers in when needed (for example, laptops and tablets). This transposed to a U.S. ratio of 5.3 students to one computer in each classroom every day (L. Gray et al., 2010).

ICT professional development

All the participants clearly regarded the ICT professional development that had been provided in their schools as inadequate. However, when discussing professional development they only referred to examples of whole staff sessions or workshops provided by the school. From a sociocultural perspective, teachers' learning occurs through many different experiences, both formal and informal (Bransford et al., 2000). In this respect, all the teachers had been exposed to various forms of professional learning in relation to using ICT and WBRs in addition to the more formal opportunities they identified, which were provided by their schools.

School A participants appeared to have had more regular formal professional development opportunities with an ongoing programme of whole staff ICT professional development sessions – although at one compulsory and one optional session per term it was not very frequent. On the surface, it appeared that these participants had an advantage over the participants in the other two schools, who only identified training sessions in using the school management system. However, the whole staff sessions in School A were often generic and skills-based, for example focusing on using particular hardware and software. Although the foci of the sessions were wide ranging and included different staff members sharing their experiences, it appeared that any specific pedagogical or content applications in specific subject areas were incidental and it was left to individual teachers to make these connections. Although one session had focused on using *Te Kete Ipurangi* (TKI) (the New Zealand Ministry of Education web-based portal providing comprehensive curriculum and resource support for all learning areas) to access WBRs, the emphasis was on how to use the website rather than how particular resources could be used in different subject areas to enhance learning. It was up to teachers to explore the website independently to find resources relevant to their subject and make decisions about if and how they might integrate these in their teaching. In this respect, while it is very likely that School A teachers increased their skills and knowledge of ICT applications and how to use them, it seemed that the sessions did not contribute significantly to their skills and knowledge about WBRs in general, or specific content and pedagogical affordances of WBRs for teaching and learning in technology in particular. This finding is reflective of research literature that promotes the importance of addressing the variable needs and uses of ICT in specific subject domains and classroom contexts over skills-based approaches (e.g., Cuban, 2001; Lai, 2001; Wallace, 2004), as well as the importance of pedagogy and constructivist theories of learning in effective integration of ICT.

In addition to the more formal learning opportunities, the participants all had various informal avenues to develop their knowledge and skills. One of the most significant informal opportunities was likely the provision of teacher laptops under the Government-supported TELA Laptops Scheme. All the participants except Ashley had a teacher laptop under this scheme, and, although their level of use of the laptop was not a focus in this study, findings of the TELA evaluation (Cowie et al., 2007) and ICT PD evaluation (Billowes & Alexander, 2010) suggest that teacher laptops have led to increased use and knowledge of ICT. Importantly, the laptops allow the teachers flexibility in where and when they use ICT, providing much greater opportunity to use a computer and to learn informally through their own trial and error. This also aligns with research by Somekh (2008) and Zhao and Frank (2003), who argue that providing opportunities for teachers to explore the affordances of ICT through play may be the most effective way to develop their pedagogy, and their beliefs about the value of ICT (see Section 2.3.5).

Although Ashley did not have a teacher laptop, she had very good access to ICT and the Internet at home and this had been the case for many years. She had also used ICT extensively in a previous career and used it extensively in her personal life. Her considerable experience had clearly contributed to her knowledge and skills.

Most of the participants had used the services of their school ICT support person to help them with computer problems. It was clear that they valued this support and that it contributed to their professional learning about ICT. For example, Alison had her school support person help her set up Skype to use with her class. She valued the fact that the support person explained how to do things rather than just doing it for her and that he used plain language rather than technical jargon so that she could more readily understand how to do something. Another illustrative example is from Carla, whose school support person provided support with establishing an electronic planning template for her students to use. Carla had found this so effective that she had shared it department-wide.

The findings also indicate that all the participants gained valuable support from various collegial networks. In School A in particular, there was strong evidence that collegial networks were actively encouraged to support ICT professional development. All departments were encouraged to build on the whole school sessions by devoting some of their department meetings to developing ICT capability. As HOD, Alison had already identified meeting times for this purpose and planned to utilise Ashley's ICT skills to help her and Agnes upskill. Again it appeared that the focus, at least initially, was to address technical ICT skills.

In addition to department meetings, the three colleagues from School A interacted regularly on an informal basis, which provided further opportunities to seek support and learn from each other. In addition, Alison and Agnes had adjacent classrooms and shared office space and consequently had very regular contact. Furthermore, there appeared to be a school-wide culture of sharing and support with regard to ICT in this school. This is exemplified by Alison's intentional identification of a number of staff in other departments who were willing and able to help her develop her ICT skills. In particular, with this research project in mind, she had already arranged for support to help improve her Internet searching skills. This evidence of a collaborative culture emerging in School A aligns with several recommendations for school leaders proposed in the TELA evaluation (e.g., foster a collaborative culture around ICT use; provide opportunities for professional learning, particularly in the areas of teaching and learning with ICT; and provide suitable support for ICT use) (Cowie et al., 2007), and also with the vision of the

ICT PD programme (Billowes & Alexander, 2010). The importance of teachers working collaboratively is also widely advocated in contemporary literature on effective teacher professional development, as discussed in Section 2.4.

In School B, a collaborative culture was much less evident. Rather, it appeared that it was up to individual teachers to seek out help when it was needed. The older style buildings in this school were also less conducive to a collaborative culture, with classrooms in the traditional technical disciplines being located in separate areas of the school and with no shared teacher office space for technology education.

In School C, an overall collaborative culture in terms of integrating ICT was also less evident, although an open plan department office space enabled frequent interactions among teachers. While the ICT expertise of several department members was well known and there was clearly a willingness to support others when help was sought (Cheryl depended on this support when she used ICT in the classroom), generally the teachers were more independently focused.

Some of the participants had also created opportunities to learn from their students. In particular, Agnes, Brenda and Carla reported asking students to help them with ICT in the classroom. Similar to the (sometimes controversial) rhetoric around the current generation of students being identified as *digital natives* (Prensky, 2001) or the *Net generation* (Tapscott, 1999), the teachers were very aware that some students in their classes were more competent than they were in some aspects of ICT use. Hence, they had, on various occasions asked students to help solve a problem or to demonstrate how to do something. A strategy Agnes used was to ask a competent student to show another student how to do something and she would watch so that she could learn at the same time. This would enable her to then support other students in the same way. Brenda also found that her own children were able to show her how to do things.

However, whilst they considered that many of their students were tech savvy, the participants were also aware that not all students had the ubiquitous access that the ‘digital natives’ rhetoric implied. This was particularly the case in School A where they had recently determined via a survey that most of the students either did not have Internet access at home, or that they were not allowed to access it because they were on 'dial-up'. The teachers were also realistic about the limits of their students' ICT abilities and aware that their use of ICT was not necessarily education focused. This concurs with Wright (2010) who posits that despite digital technologies being everyday tools for many young people, students are still likely to be novices when it comes to educational uses.

Teachers also learn from their own teaching experiences by reflecting on and adjusting their practice over time (Bransford et al., 2000), and this appeared to be how Carla in School C had developed her knowledge thus far. That is, through a trial and error approach in working with students in her department's computer suite. Equally, through her reflective practice she had recognised the need for more professional support to develop her pedagogy to better support her students' use of WBRs.

7.1.2 Second order barriers

Knowledge, skills and confidence using WBRs

The initial level of the participants' ICT knowledge and skills largely reflected the learning opportunities that had been available to them and the extent of their participation in these. For example, Ashley had developed extensive knowledge and skills through many years of personal experience and home use of ICT and WBRs. However, lack of knowledge and skills, and subsequently lack of confidence, were clearly key factors hindering all the other participants' classroom use of WBRs to varying degrees.

All the participants had developed some level of computer skills influenced by factors such as the increasing computerisation of school administration tasks, the TELA scheme, as well as education policy, such as e-learning and pedagogy recommendations in the New Zealand Curriculum (Ministry of Education, 2007), and school, student and community expectations. However, in most cases their technical skills were still not well developed and they were dependent on a technical support person when problems occurred. Their limited skills and lack of ability to solve problems independently appeared to lead to a lack of confidence.

For Alison, Agnes and Cheryl in particular, lack of confidence was impeding their attempts to use WBRs in the classroom. Consequently, they only used WBRs occasionally in the classroom and when they did the focus of their lessons appeared to be mainly on managing students' use of the technology rather than on student learning outcomes. Brian also expressed a considerable lack of confidence in his ability to facilitate student learning using WBRs. His lack of confidence appeared to be heightened by the apparent high level of ICT skills his senior students demonstrated in their technology projects, which they worked on independently out of class time. Although lack of access was clearly a major barrier inhibiting Brian's classroom use of WBRs, his perception of his students' superior skills also appeared to be a significant contributing factor.

Finding that the participants' lack of knowledge and skills was a significant barrier affecting their integration of WBRs was not unexpected and aligns with findings of a significant body of research investigating barriers to ICT integration, as discussed in Section 2.3.5 (e.g., Ertmer, 1999; Hew & Brush, 2007; Jones, 2004; Somekh, 2008). Despite a key focus of early interventions being on the development of knowledge and skills (alongside increasing computer access), literature suggests these factors continue to be a significant barrier for teachers. Indeed, Hew and Brush's research found that lack of knowledge and skills were the second most frequently identified barriers for teachers behind lack of access.

The participants' lack of knowledge and skills also resonates with Billowes and Alexander's (2010) finding in their evaluation of the New Zealand ICT PD programme, that although teachers' skill levels had increased over the decade that the programme had been in operation, 50 percent of teachers still identified skills development as their main goal. Billowes and Alexander attribute this apparent anomaly to the rapid development of technology and its increasing level of use by students, parents and in the media. They suggest that this rapid development may be challenging teachers' expectations of the nature and extent of ICT or WBR use they should be making in the classroom, and leading to a feeling of inadequacy. This is similar to Ertmer and Ottenbreit's (2010) analogy of developing technology knowledge and skills being like aiming at a moving target, such that even experienced teachers can feel like novices as they strive to integrate ICT effectively. This feeling of not being able to keep up with the rapid and ongoing change was reflected by all the participants in this study, with the exception of Ashley.

That participants' lack of confidence appeared to be closely linked to their lack of knowledge and skills is consistent with literature that identifies self-efficacy as a significant influence on classroom use of ICT (Ertmer & Ottenbreit-Leftwich, 2010). Research literature also suggests an interrelationship between teachers' confidence to integrate ICT, their ICT knowledge and skills, and their ICT attitudes and beliefs (Christensen & Knezek, 2008; Ertmer et al., 2012; Ertmer & Ottenbreit-Leftwich, 2010). However, whilst Ertmer and Ottenbreit-Leftwich posit that teachers' confidence may be more important than skills and knowledge in their decisions about using ICT in the classroom, Christensen and Knezek argue that teachers' confidence increases with experience.

Viewing the teachers' initial level of knowledge and skills through a TPACK lens (Mishra & Koehler, 2006) offers insights into why this barrier may have remained significant. It was clear that the participants had developed some level of technological knowledge (TK) through various professional learning opportunities, and their increasing use of computers. On the other hand, the participants' technological pedagogical knowledge (TPK) and their technological content knowledge (TCK) had not been sufficiently developed to enable them to integrate WBRs effectively in the classroom. This is exemplified by the limited range of subject-specific WBRs accessed by the participants for classroom use, reflecting their limited TCK, and their mainly teacher-directed pedagogical approaches, suggesting limited TPK (see Table 5.2). An illustrative example is Cheryl's classroom use, which was limited to showing an occasional web-based video clip of a process as an alternative to demonstrating, and showing excerpts from documentaries to introduce a topic or context as an alternative to providing text-based information (see Section 5.3.4). Her pedagogy was teacher-directed – she was the provider of information. She was using web-based video clips as a replacement for another method of providing the same information and to amplify or enhance the presentation of her lessons (Hughes, 2005). Even Carla's more extensive classroom use of WBRs reflected replacement and amplification uses.

Although the nature of the technology education curriculum and her ready access to computers provided the potential for Carla to transform her teaching, the difficulties she described suggested that lack of TPK and TCK were limiting her ability to adequately scaffold her students' learning using WBRs (see Section 5.3.4).

The participants' level of TK appeared to correlate with their level of experience using ICT and WBRs. For example, in Ashley's case, years of intensive personal and professional use (in other careers) of ICT and WBRs had contributed to her significant level of TK. At the other end of the spectrum, Agnes and Cheryl, who appeared to have the lowest level of skills and confidence using ICT and WBRs, initially made the least use of them, including outside of school. In spite of having a teacher laptop, Cheryl only did what she had to do to meet school and department administrative expectations. She was firmly of the opinion that neither the computer nor the Internet was relevant in her life beyond school. Agnes, on the other hand, was constrained in her ability to practise using WBRs at home because she did not have Internet access. This helps explain the lower skill level of these two participants compared to the others. It also aligns with findings of the TELA evaluation (Cowie et al., 2007) and with research by Christensen and Knezek (2008) that home access is key to high competency in using ICT for both teachers and students. On the other hand, Ashley's significant ICT skills and knowledge but her lack of integration of WBRs in the classroom concurs with research that emphasises that knowing how to use technology is not enough to enable teachers to integrate it effectively in the classroom – beliefs are also important (Ertmer & Ottenbreit-Leftwich, 2010).

Perceived value of using WBRs in technology education

Initial findings indicated that the participants generally perceived WBRs to have value for supporting student learning in technology education, with the exception of Ashley (see Section 5.1.6). However, findings also showed that their perceptions about the value of WBRs mainly focused on student engagement, alignment with students' interests and usefulness for finding information. Participants' limited and low-level uses of WBRs in the classroom, together with their limited computer and Internet skills, suggested that they may not have perceived the transformative potential of WBRs for teaching and learning in their classes. As discussed in Section 2.3.5, teachers' beliefs about the value and relevance of ICT for teaching in their subject have significant influence on their decisions about integrating ICT in the classroom (Baggott La Velle et al., 2003; Christensen & Knezek, 2008; Ertmer et al., 2012; Hew & Brush, 2007; Somekh, 2008). Similar to the initial situation of most participants in this study, literature also identifies a close relationship between teachers' beliefs and attitudes towards using technology in the classroom, their level of ICT competence and experience (Ertmer et al., 2012), and their confidence (Christensen & Knezek, 2008).

An unexpected finding in this study was the decidedly negative attitude towards integrating WBRs initially shown by Ashley. Her perception that WBRs had no relevance to her teaching and added no value to her students' learning very clearly influenced her decision not to integrate WBRs. This aligns with research that stresses the considerable influence teachers' perceptions about the value of WBRs for teaching and learning in their subject have on their decisions about integrating ICT in the classroom, as discussed in Section 2.3.5. However, her negative attitude to integrating WBRs despite her significant level of ICT knowledge and skills contrasts with the other participants in this study and also contrasts with literature that identifies a relationship between these two factors (e.g., Christensen & Knezek, 2008; Ertmer et al., 2012).

7.1.3 Summary

This section has discussed the initial barriers the participating teachers faced in their respective schools and how these impacted on whether or not, and in what ways they chose to integrate WBRs in their classrooms prior to their participation in this research. The barriers were classified as first order and second order barriers. However, as discussed in Section 2.3.5, there are complex interrelationships both within and between various internal and external barriers (Ertmer, 2005; Hew & Brush, 2007; Jones, 2004; Zhao & Frank, 2003). The following section offers insights into how the components of the intervention supported and enabled participants to overcome various barriers, and to progress to varying degrees in their integration of WBRs and development of TPACK.

7.2 A guiding framework to support and enhance teachers' integration of WBRs

This section addresses research questions 2 and 3: *What are key components of an intervention to support technology teachers to enhance their integration of WBRS*? *What is the impact of the intervention on teachers' integration of WBRs?*

The principles guiding the design of the research intervention to support technology teachers to enhance their use of WBRs in the classroom encompassed sociocultural theories of learning and principles of effective teacher professional development (see Section 4.1). Teacher professional learning involves a complex range of interacting variables (see Section 2.4) – as does integrating WBRs, as discussed in Sections 2.3 and 7.1. Therefore, no single approach to professional development will be equally effective for all teachers in all situations. Rather, teacher learning can be better understood by viewing it as a complex system because of the different dynamics that interact and combine in different ways in each individual teacher's unique context at any particular time (Opfer & Pedder, 2011).

It is helpful to use a framework to discuss this complexity. In this study, Bell and Gilbert's (1996) model of teacher professional development (see Section 2.4.2) is used as a framework to analyse the multiple interacting variables and how they impacted on the participants' individual learning journeys. The multiple overlapping and interdependent dimensions and stages of Bell and Gilbert's model support the representation of the complex nature of the teachers' learning.

This section aligns the phases and components of the intervention with the three stages of the teachers' personal, professional and social development (B. Bell & Gilbert, 1996), and discusses how the participants' progression in each of the three dimensions was integral to their success or otherwise in integrating WBRs and therefore to the overall success of the intervention. As Bell and Gilbert's model emphasises, the three dimensions of teachers' development are interdependent – development in one aspect cannot proceed without development in the other aspects. Therefore, while the following section discusses the dimensions separately, their interdependence is acknowledged. In addition, as Bell and Gilbert emphasise, although their model describes progression in the three dimensions in three stages, their intention is to indicate a loose sequence of change rather than to promote the notion of clearly defined stages of teacher development.

7.2.1 Personal development

The participants' initial commitment to joining the research group was a significant first step in motivating them to spend the extra time and effort that involvement in the project required. Although reasons for agreeing to participate varied, commitment to the group was nevertheless a significant factor in their engagement in the project (see Chapter 5).

The participants were all cognisant of expectations from school, curriculum and students that they increase their use of ICT. Many of them reported that they needed to increase their skills and knowledge in order to meet this expectation. Despite the apparent pressures to integrate ICT, the varying challenges the participants faced, particularly lack of classroom computer and Internet access and lack of ICT knowledge and skills, presented substantial barriers to address before progress could be made. For some participants the barriers initially appeared to be insurmountable given the limited time available in their busy daily routines, their cognisance of rapid and ongoing advances in ICT and the Internet, and the apparent lack of targeted support within their schools. Therefore the research project aligned with a real dilemma that they faced in their work, and in most cases they viewed the opportunity to be involved as a way to receive support to address a current and growing need to embed ICT in their teaching and learning programmes. This aligns with findings of Timperley et al.'s (2008) Best Evidence Synthesis of teacher professional learning and development, which identified alignment with wider trends in policy and research as a key element that contributes to an effective context for teacher learning.

The importance of teachers having personally identified a need or a problem in their teaching as a catalyst to engage with professional learning is recognised in literature as a significant first step in successful teacher professional development (B. Bell & Gilbert, 1994; Evans, 2002; Kwakman, 2003; Timperley et al., 2008). In Bell and Gilbert's model, teachers' self-initiated acceptance of a professional dissatisfaction or need indicates that the initial stage of personal development has occurred and is essential for any further progress to be made in teachers' learning. This is also consistent with constructivist perspectives of learning, which emphasise the importance of learner-centred principles and building on the prior knowledge, needs and interests of learners in constructing new knowledge (Dede, 2008; Schunk, 2008).

It is possible that the initial stage of personal development had occurred for all participants at a similar time by virtue of their agreement to participate. However, various factors could have influenced their decisions to volunteer, and in reality the timing of initial personal development varied for each of them. Influential factors may have included: the encouragement of the Principal in School A, peer pressure from the initial contact and volunteer in each of the schools, the wider educational context described above, or perceived support for implementing the two new technology curriculum strands (see Section 2.1.5). However, Ashley, for example, who did not volunteer initially because she did not see the relevance of using WBRs in her classes, did not begin to accept a need to change until she undertook the workshop preparation task (see Section 4.2.2), which began to influence her views about the benefits of integrating WBRs. In Cheryl's case, initial personal development may not have occurred until much later in the year when her observation of a teacher trainee's integration of WBRs began to influence her perceptions of the benefits of WBRs for her students' learning. These observations resonate with Bell and Gilbert's (1994) research, which showed that personal development may not necessarily occur before the programme commences (despite voluntary involvement), and exemplify the loose and flexible sequence of the dimensions and stages of teacher development.

The initial group workshop activities supported participants to socially construct knowledge about effective integration of WBRs in technology education (see

Section 4.2.3). Back in their schools after the workshop each participant ideally had to personally evaluate, and consider where and how they would apply their new understandings to integrating WBRs in their classroom programmes. This included responding to the realities of their individual school and classroom contexts and beginning to address concerns and barriers that had previously constrained their use of WBRs. The process of dealing with these constraints in order to integrate their new ideas and successfully implement their unit of work represented the second phase of the participants' personal development ("Dealing with restraints") (B. Bell & Gilbert, 1994). This was a significant step, given the range of barriers and the degree of challenge they posed for each of the participants, such as Brian having no classroom data projector or computer access for students, and participants' perceptions of their ICT skills as being inadequate and the anxiety this caused them when planning and using WBRs in the classroom. However, they could not progress in their professional learning until they took positive steps and made some headway in addressing these challenges. Key factors enabling the participants to progress at this stage seemed to include:

- securing more convenient classroom computer and Internet access;
- considering what was personally manageable for them, that is, challenging but still within their capability and classroom and programme constraints;
- accessing and selecting WBRs that afforded new or enhanced representations of key concepts; and,
- planning and using effective pedagogical strategies to scaffold student learning using the selected WBRs.

When the participants took these steps, their integration of WBRs was more effective and they were spurred on by the successful outcomes. They described successful outcomes as increased student engagement, enhanced student learning (deeper and/or broader understanding, and greater retention), and having fewer classroom management issues. In most cases their lessons using WBRs were more interactive and enabled them to be less teacher-directed than their usual approach, assuming a more facilitative role in the classroom and supporting students to take more responsibility for their own learning. This reflected a more constructivist approach to teaching, which they inherently understood to be more effective pedagogically and better aligned with contemporary educational theory. In addition, the personal and professional satisfaction the participants gained when they experienced these positive outcomes made them feel better about themselves as teachers (B. Bell & Gilbert, 1994). They became more confident about using WBRs in the classroom and their early successes and increased confidence motivated them to use WBRs more. For example, Alison and Brian both expanded their integration of WBRs beyond what they initially planned to do quite early in the research project, and Agnes, Ashley and Brenda had specific plans for expanding their integration of WBRs in the following year. These participants had personally dealt with the restraints in their individual contexts and moved beyond the second stage of personal development.

When the participants integrated WBRs in a way that changed their role in the classroom they also found that they were able to learn alongside their students. Not only were they developing their knowledge and skills in using WBRs and ICTs (both from and with their students), they were also validating and expanding their subject content knowledge. They also found that when students perceived them as learners, and they interacted more with students individually, their relationships with their students improved. The participants valued feeling that they were no longer expected to know all the answers and provide all the information. Some found their learning made them more enthusiastic about their teaching and they were inspired to more actively pursue their own learning.

Once the participants had personally dealt with the restraints in their individual context and experienced successful classroom outcomes where they perceived their teaching was more effective and student learning was enhanced, they were empowered to take responsibility for their own ongoing personal and professional development. Feeling empowered indicated that the third stage of personal development had occurred. Participants' empowerment was exemplified by their enthusiasm to share their experiences and their learning with the other participants at the evaluation workshop, their commitment to ongoing planned and strategic use of WBRs, and in Alison's and Brian's cases, their proactive stance in securing improved classroom access to WBRs. Reaching this stage of personal development was dependent on development in each of the other dimensions and it occurred more quickly for some participants than others. Some participants (Carla and Cheryl) did not reach this stage during the research project.

7.2.2 Professional development

The first workshop was a critical component of the intervention for introducing new theoretical ideas to the participants as a group, and facilitating their learning through collaborative activities – Bell and Gilbert’s (1994) first stage of professional development. Introducing new theoretical ideas is acknowledged in research literature as an essential component of effective teacher professional development (Clark, 1992; Evans, 2002; Kwakman, 2003; Timperley et al., 2008).

The TPACK framework (Mishra & Koehler, 2006) was used as a tool to help communicate new ideas and facilitate participants’ learning about effective technology integration. Collaborative activities using the framework were a key component of the professional development programme. The TPACK framework also assisted teachers to link new ideas with their existing knowledge and expertise as experienced teachers’ (PCK), which helped to engage them in theory and effectively scaffold their professional learning (Bransford et al., 2000; Timperley et al., 2008). Correspondingly, TPACK validated the participants’ existing PCK and helped them put into perspective the new knowledge required for effective integration of ICT, thus assisting them to view the problem of integrating WBRs as only an aspect of their practice rather than seeing their teaching overall as problematic. This was important for ensuring that they perceived their participation in the intervention as learning rather than remedial, which was also an important part of the first stage of their professional development (B. Bell & Gilbert, 1994).

While introducing new theoretical ideas was important, opportunities for participants to change classroom practice was equally important for their professional development. Therefore gaining ideas for new teaching strategies was another essential part of the first stage of their professional development, also addressed initially in the first workshop. Sharing examples of their classroom practice provided an opportunity for the participants to gain insights into how other teachers were using WBRs to support learning of particular technological concepts. TPACK provided a framework to assist the participants to analyse their classroom experiences and to work collaboratively to consider how they might adapt their classroom practice using WBRs to better support student learning. Teaching strategies were also discussed in the context of managing affordances and constraints of WBRs. These activities were designed to help shift participants' thinking beyond technocentric classroom approaches and scaffold their subsequent planning of their own unit of work. Using TPACK provided a means of validating the participants' existing CK, PK and PCK allowing them to identify their own professional development needs. This gave the participants more sense of agency to take control of their own learning, which was important for learning and change to be sustained beyond the workshop and beyond the research project (B. Bell & Gilbert, 1994).

The second phase of the intervention was based in the participants' schools and was the longest phase, spanning almost three school terms (see Section 4.3). This phase involved the participants continuing to develop their ideas and beliefs about effective integration of WBRs as they planned and implemented new classroom activities – developing their classroom practice. This phase aligns with Bell and Gilbert's second stage of professional development ("Development of ideas and classroom practice"), and also resonates with Koehler and Mishra's (2008) emphasis on providing opportunities for teachers to practise curriculum design and teaching in meaningful contexts in order to develop their TPACK.

The progress of the individual participants in this second phase of the intervention, and second stage of professional development, varied considerably. Their varying progress illustrated the interaction and interdependence of the personal, professional and social dimensions and different stages of the participants' professional learning. Some participants started trying out ideas in the classroom more quickly than others. For example, Alison had already considered (prior to the workshop) in which class and where in her programme she would integrate WBRs, and the three School A participants had collaboratively decided to use the school COWs to improve their access. Having made this decision, both Alison and Agnes found opportunities soon after the workshop to try out new activities using the COW in their classrooms while continuing to plan their pre-selected unit of work for later in the year. On the other hand, Ashley didn't need to practise using the equipment and, while she decided quickly on a unit of work in which she would integrate WBRs, the timing needed careful consideration to fit comfortably into her programme where she felt confident that her students would be more receptive to the change.

When the participants started trying out and reflecting on new classroom activities earlier in the project (provided these were successful) they were able to trial more activities in a range of classroom contexts. Their reflection during and after new activities, and feedback from colleagues, assisted them to improve their classroom practice and generate new teaching ideas. With each classroom episode they were expanding their knowledge of WBRs that enhance student learning of particular concepts in different situations, as well as effective pedagogical strategies for scaffolding learning (TPACK). At the same time they were developing their beliefs about the value of using WBRs in technology education. Expanding their repertoire in this way had a self-perpetuating effect. This was particularly evident in Alison's and Brian's cases where they identified and acted on (often spontaneously) many more opportunities to integrate WBRs in a broader range of classroom contexts during the research project than they had planned.

It was evident that the participants who showed competency in the classroom using WBRs and therefore progressed in the professional dimension, had first developed in the personal and social dimensions. On a personal level they had addressed what they considered to be their main constraints to integration, been inspired by the outcomes and taken ownership of their development. With respect to the social dimension, they had established collegial networks within their schools, and valued the sharing, support and feedback that was possible through these networks. For example, Brian identified a range of classrooms with access to WBRs that he could use for his class, identified that showing YouTube clips to enhance students' learning about materials and processes was appropriate and manageable within his constraints, and joined and gained support from his school ICT group. By contrast, Cheryl, who had more limited skills and confidence than the other participants, rather than consider an activity she could manage relatively easily, pushed herself well beyond her comfort zone in the first lesson in which she integrated WBRs (see Section 6.3.3). As a result of the considerable effort it took to prepare and deliver the lesson and her relative lack of satisfaction with the outcome, Cheryl subsequently did not attempt to integrate WBRs any further. This finding resonates with Zhao et al.'s (2002) research into conditions for classroom technology innovations, which concluded that the more distant innovations are from teachers' existing practices the less likely they are to be successful. It also supports Koehler and Mishra's (2008) view that TPACK develops slowly in a spiral-like fashion so it is good to start with more basic and familiar technologies.

The teachers who achieved successful classroom outcomes were motivated to sustain and expand their use of WBRs, and became empowered to continue their own professional learning. They began to perceive WBRs as integral classroom resources for learning in technology. This was particularly evident in the case of Alison and Brian who made the most extensive use of WBRs during the research and showed the greatest change in practice. Their empowerment led them to advocate for, and achieve, improved access to WBRs for their classes and in Alison's case for her whole department (see Sections 6.1 and 6.2).

7.2.3 Social development

Data from this study showed that the participants valued working with teachers from other schools in a subject-specific group. Despite only meeting face-to-face on two days (one of which was at the end of the research), the participants' perceptions of belonging to a professional learning community with a clearly defined focus were evident throughout the project. The value they gained from belonging to a professional learning community was a significant motivating factor in sustaining the participants' drive to achieve successful classroom outcomes that they could share with other group members. Although the levels of motivation and extent of integration of WBRs varied among the participants, all were sufficiently motivated and committed that they sustained some level of participation for the duration of the project – as evidenced by their contribution to the final evaluation workshop. This resonates with Bell and Gilbert's (1994) model, which identifies teachers' social development as integral to the process of their professional learning. However, in contrast to Bell and Gilbert's research, which included weekly face-to-face meetings with participants over two terms, this project had only two days with all participants meeting together. Having only a one-day meeting at the start of the intervention was likely a limitation of this research.

The group workshop was crucial to enculturate participants into a professional learning community in which they could interact to socially construct their understanding of new ideas. The participation and contributions of the wider group, including the researcher, enabled by the interactive workshop activities were important for knowledge construction. The activities, as well as the more informal collaborations that transpired during break times, helped participants to feel more comfortable about contributing, and to value working collaboratively with colleagues. In this way, the workshop helped to foster positive sustainable relationships, and was significant in supporting the participants' initial social (and personal and professional) development prior to returning to the relative isolation of their individual schools.

Having more than one participant in each school was also an important feature of the intervention, and contributed significantly to participants' ongoing social development (as well as their personal and professional development) and to sustaining their motivation and commitment throughout the research project. Prior to the workshop the participants all expressed some apprehension about moving out of their familiar classroom context and working with participants from other schools. However, they clearly perceived a benefit from seeing what other teachers in their subject domain were doing and getting new ideas that might contribute to improving their own practice. Committing to the project with another colleague and knowing they would have ongoing support from the colleague throughout the project was important in helping to allay their initial apprehensions about being involved and provided ongoing opportunities for sharing, support, feedback and encouragement – all essential elements for supporting teachers' professional learning, as pointed out in Sections 4.2.1 and 4.2.2.

In this way, support for all stages of the participants' personal, social and professional development (B. Bell & Gilbert, 1994) continued beyond the workshop and was a significant factor in the success of the intervention. This was exemplified by the substantial collaboration, support and encouragement among the three School A participants compared to School C where there appeared to be more limited collaboration between the two participants. School A participants all acknowledged advantages of working together as a department, and they gained and sustained a much higher level of motivation throughout the project as a result of working collaboratively. It was clear that they had progressed to the second stage of social development ("Valuing collaborative ways of working"), and they each made greater progress in enhancing their integration of WBRs than the School C participants.

Similarly, School B participants showed that they recognised the benefits of working collaboratively by taking the initiative to join their school ICT PD group anticipating additional collegial support, as well as opportunities to contribute as a result of their learning. They both gained considerable support and new ideas from colleagues in the group. Taking this initiative suggested that they had moved towards the third stage of social development ("Initiating collaborative ways of working").

7.2.4 Summary

This section discussed the complex range of variables affecting individual participants' progress in their integration of WBRs and development of TPACK as they participated in the intervention. It illustrates how Bell and Gilbert's (1994) model of teacher professional development underpinned the design of the intervention and how the different outcomes for the participants' related to their development in each of the three dimensions (personal, professional and social).

The participants who showed evidence of empowerment (ownership of, and commitment to their own ongoing development) had clearly progressed beyond stage two in all three dimensions of development. Evidence of empowerment was obvious very early on in the research in Alison and Brian’s cases, and was also apparent in the later stages in Ashley and Brenda’s cases. In contrast, the School C participants, who made the least progress integrating WBRs, showed limited evidence of progression towards stage two in any of the dimensions.

7.3 Insights into variable rates of change in teachers’ practice

The previous sections have described a complex range of factors impacting on the participants’ integration of WBRs. Consistent with literature, these two sections illustrate the complexity of the process of teacher professional development to support and enhance integration of WBRs, and the multiple interacting factors that influence how individual teachers respond to professional development and translate their learning into change in classroom practice. This section will answer research question 4: *What is the nature of change in teachers’ classroom use of WBRs and what are the key influential factors?* To do this, the degree, and rate, of change in the participants’ integration of WBRs, and various combinations of factors that influenced the nature and process of change will be considered using velocity as an analogy.

Velocity can be defined as the rate of change of the position of an object relative to its starting point. Velocity is determined by both the speed and the direction in which the object is moving (speed describes only how fast the object is moving). Change in speed, direction, or both, indicates a change in velocity and the object is described as accelerating or decelerating. Change in velocity, or acceleration, is caused by an imbalance between the forces acting on the object, and the constraints or obstacles that cause friction and subsequently slow the pace, or change the direction, of the object.

When using a velocity analogy to explain variable patterns of change in the participants’ integration of WBRs during this study, *speed* relates to how far and how quickly each participant moved away from the position in which they started. *Direction* relates to the participants’ sense of the goal of the research (effective integration of WBRs through enhanced TPACK) at any point in time. In other words, how closely their perceptions aligned (or became aligned) with the parameters of this goal, which were presented at the first workshop. Change in the participants' velocity was caused by a range of forces pushing and pulling them in different directions at different times and to varying degrees throughout the research. The course that each person took was not linear and varied according to the particular combination of forces that were acting on them in their unique context. Participants also began at different starting points.

7.3.1 Rate of change

As a result of their participation in the first workshop, all the participants had some sense of direction when they started, and there was some initial movement in the direction of the project goals by all of them as they planned and trialled their first new activity using WBRs. However, the rate, and direction, of change varied considerably for each participant. Their rates of change were closely related to how soon they started to try out new ideas in the classroom (this also linked to how quickly they addressed individual constraints), and whether they perceived their initial trial to be successful (perceptions of success are described in Section 7.2.1). The sooner they started, the more time they had to change their practice, which enabled them to move further from their starting point. Early successes increased their motivation and inspired more frequent use of WBRs in a range of contexts. More frequent use led to more rapid change. This can be illustrated by comparing Alison's case, where the most rapid change was evident, with Cheryl's case, which was at the other extreme.

Alison started trialling new classroom activities using WBRs very soon after the workshop and experienced early successes, which increased her motivation. As a result, she soon extended her use of WBRs to all her classes (see Section 6.1.3). The more she increased her use of WBRs the more she identified further opportunities for using them, which increased her rate of change dramatically. Motivation was a powerful driving force, which increased with classroom success causing greater speed. By contrast, Cheryl took a long time to begin planning a new activity using WBRs (one term after the workshop), and when she trialled it in the classroom she was dissatisfied with the outcome and found it very stressful (see Section 6.3.3). Subsequently, she was not confident or motivated enough by her first experience to try out any more activities. Lack of classroom success reduced her motivation (reduced the driving force). Stress increased the ‘friction’ and a combination of reduced driving force and increased friction made movement very difficult.

As a comparison, while Ashley was even slower than Cheryl in starting to trial her new activities (although she had planned the unit of work much earlier), she perceived the outcomes to be very successful. As a result, there was evidence of a sudden change of pace at this point, as she showed increased motivation (increased driving force) and a clear intent to expand her use of WBRs the following year (see Section 6.1.6).

7.3.2 Change of direction

Initially, all participants were committed to making changes in their use of WBRs in the classroom. However, their vision of what effective integration of WBRs might look like was limited, in most cases, due to lack of classroom experience using WBRs and lack of ICT knowledge and skills (see Table 5.2 for a summary of participants’ initial TPACK). This meant they did not have a clear sense of direction for the changes they might make. In addition, their starting points differed with respect to their levels of classroom experience using WBRs, their ICT knowledge and skills and their perceptions of the educational benefits of WBRs.

All participants moved towards the goal of the research to some degree as they started to integrate WBRs and reflect on their experiences. Their movement in this direction was evidenced by change in one or more of three aspects: their perceptions of the value of WBRs for teaching and learning in technology education; their development of TPACK evident in planning and enactment of new classroom activities, including using more student-centred teaching approaches; and their commitment to ongoing self-development and improvement in classroom integration of WBRs. All the participants except Carla and Cheryl showed evidence of change in all three of these aspects, albeit at different times, but for some participants the directional change was more significant, and appeared to exceed their expectations.

Alison showed the greatest change of direction of all the participants. This was evidenced by the significant shift in her thinking about the value of WBRs for teaching and learning in technology education and the change in her pedagogy from technocentric to learner-centred, the extent of her development of TPACK through her reflection on the broad range of activities she trialled using WBRs, and her empowerment to take control of her own ongoing development and assume a leadership role in improving access to WBRs for her department (see Section 6.1.6 and Table 6.1). Alison was clearly moving towards the goal of the research. WBRs had become ubiquitous in her curriculum planning and her classroom practice, and her repertoire of what, where, when and how to use WBRs to enhance individual student learning (TPACK) was expanding. She demonstrated this in her ability to flexibly and spontaneously appropriate WBRs for pedagogical purposes as and when she recognised that they afforded learning advantages for students. Alison's development illustrated movement through three stages of Hooper and Rieber's (1995) *Model of adoption of technologies in education*, from the *Utilisation* stage to indication of reaching the *Evolution* stage (see Section 2.2.2).

Brian also showed significant change in direction. While the frequency and breadth of his use of WBRs was less extensive than Alison's, he started from a more distant position – having no classroom experience using WBRs. Brian's initial classroom experiences significantly influenced his perceptions about the value of WBRs for student learning in technology leading to more extensive use and development of TPACK (See Section 6.2.6). Brian also showed evidence of empowerment in his considerable resolve to continue his own development and improve his classroom access very early in the project, despite the considerable challenges (see Section 6.2). Brian's development suggested he had also moved through three stages of Hooper and Rieber's (1995) model, from *Familiarisation* to *Reorientation*.

Cheryl showed the least change in direction overall. While she did appear to change her thinking about the value of WBRs to some degree later in the project, the one lesson in which she trialled using WBRs was technocentric and teacher-directed and indicated little change in her usual classroom practice (see Section 6.3.5). While she clearly recognised some affordances of the WBRs she selected to engage and stimulate her students' thinking, at this point there was little evidence that she had changed her thinking about effective pedagogy using WBRs. Cheryl's lack of further change after her classroom trial indicated that her sense of direction possibly became less clear at that point, as her confidence waned. Consequently, the degree of change in her practice and her development of TPACK overall was minimal and likely fragile. Cheryl's development suggests that she moved only one stage in Hooper and Rieber's (1995) model, from *Familiarisation* to *Utilisation*, and only partially.

7.3.3 Change in velocity

The change of velocity for each participant in this study was influenced by various forces pushing and pulling them in different directions at different times, changing the balance of forces and affecting their movement. This section discusses the key forces that were identified, and the various ways they combined and interacted causing a change in velocity for different participants at different times. In this way it provides insights into the varying nature of change in integration of WBRs for the different participants and the key influential factors. While a number of forces impacting the participants' velocity are discussed, it is also acknowledged that a myriad of interacting factors, many of which were not observed or articulated, also likely affected participants at any one time.

Prior to the intervention, all participants started with some level of force pushing them, albeit slowly, towards integrating ICT into their teaching. In particular, they were all aware of expectations from their school and the curriculum that teachers needed to increase their classroom use of ICT (see Section 7.2.1). They were also conscious of the rapid and ongoing development of ICTs and WBRs, and of their increasing importance in students' lives outside of school, and generally they accepted the need to upskill and strive to keep up with change. Their starting positions were all different in terms of the frequency and nature of their integration of WBRs, as were their trajectories (velocities) based on the unique combination of forces impacting each individual (see Section 7.1).

There appeared to be a stronger school-based push for teachers from School A to integrate ICT than the other two schools, as evidenced by their regular ICT professional development, general support for teachers using ICT, and support for the participants to be involved in this research. For Alison, this support, together with having some classroom computer access, was sufficient to keep her moving – striving to improve her skills and occasionally trying out ICT in the classroom. However, her lack of ICT skills, knowledge and confidence and lack of full classroom access to ICT, were constraining her movement. For Ashley, the school support was insufficient to outweigh the obstacles that held her back (limited classroom access to ICT and her firmly-held belief that WBRs added no value for students' learning) and therefore her classroom practice remained unchanged prior to her participation in the research project, despite her ongoing personal ICT development.

In School B, Brian had less school support and encouragement than School A's participants, and significant constraints (lack of classroom access, and lack of skills and confidence), and therefore felt unable to integrate WBRs at the point where the research started. On the other hand, Brenda had gained some impetus from having recently been provided with classroom Internet access and a data projector, which was a sufficient push to start her trying to use WBRs in the classroom, to the extent that her level of access allowed. Therefore, there was evidence of some movement towards integrating WBRs.

If the balance of forces remained the same for each participant it could be anticipated that their trajectory in terms of integrating WBRs would remain the same and therefore there would be minimal change in velocity. The initial balance of forces impacting each participant likely had some influence on their decision to join the research group as described in Section 7.2.1. However, once they committed to the group, the intervention provided an external force, which disturbed the balance of forces for each of them and provided an impetus to change their velocity.

The change in the balance of forces initiated by the intervention is exemplified by the changes that occurred for both School A and School B's participants. These participants' commitment to the project inspired them to look for opportunities to use WBRs in their programmes and to take positive steps to address constraints to enable them to implement their plan (see Section 7.2.1). In part, their sense of accountability to the group pushed them to persevere with using WBRs in spite of difficulties, when they may otherwise have given up (see Section 7.2.3). Their commitment to the group became a significant force, which changed the balance of forces and gave them impetus to overcome the constraints that had previously prevented or inhibited their integration of WBRs. In addition, the collegial support they gained from the other participants in their school, and other school support networks (such as, the ICT PD group in School B), increased the force pushing them in the direction of the research goal.

When the participants subsequently enacted changes in their classroom practice that reflected some level of TPACK development, they experienced positive outcomes. Positive experiences increased both their confidence and their motivation, as well as positively influencing their perceptions about the value of WBRs, which created a further imbalance of forces and increasingly pushed them to make further changes. As discussed in Sections 7.3.1 and 7.3.2, the more frequent and the more diverse their successful experiences were, the more significant was their change in velocity – accounting for the differences in outcomes among School A and B participants.

In comparison to School A and B participants, School C participants' change in velocity during the project was much less (see Sections 7.3.1 and 7.3.2). Although their participation in the first workshop indicated motivation to change their practice, as it did for the other participants, once they were back in their school and isolated from the wider group, their level of motivation was not sustained to the same degree. Therefore, in their case, membership of the professional learning community alone did not change the balance of forces sufficiently to cause the significant change in velocity that was evident for the other participants. The key difference in School C that appeared to explain this difference was the more limited collegial support within their school in working towards the goal of the intervention. This is exemplified by the one-off lesson taught by Cheryl, which appeared to be planned and delivered in complete isolation from Carla, and devoid of any follow up reflection, feedback or support, which may have encouraged further attempts to integrate WBRs had they occurred. It is also possible that the significant difference between Carla and Cheryl's personal experience and classroom integration of WBRs at the start of the intervention may have contributed to the more independent approach that these two participants took.

7.3.4 Summary

This section discussed the key forces acting upon each participant, their various interactions, and how these accounted for the differences in the rate, and direction, of change (change in velocity) that occurred in their integration of WBRs. For all participants, commitment to the group was a significant initial force, which pushed them to begin to address constraints and to plan a more focused and strategic approach to integrating WBRs in the classroom.

For School A and B participants, commitment to the research group remained a significant force helping to sustain their motivation and ongoing change in practice. However, also critical in the progress of these participants was their membership of a school-based community of practice focused on integrating ICT, which provided ongoing opportunities to share ideas and to provide and receive support and feedback. Together, these two forces enabled the teachers to implement strategies using WBRs that better supported student learning and resulted in positive outcomes from their initial classroom trials. As a result of the successful outcomes, the participants' motivation and confidence to use WBRs in the classroom increased. This led to more extensive use of WBRs during the research in the case of Alison and Brian, and to commitment by the others to broaden their use of WBRs the following year. With increasing and more strategic use of WBRs the participants' began to refine their developing TPACK and continued to develop their perceptions about the educational benefits of using WBRs. These participants became empowered to continue their own ongoing development and now perceived WBRs as integral classroom resources to consider when planning for teaching and learning in technology.

For School C participants, support from a school-based community of practice was lacking and therefore they did not receive the extra push that this might have provided to help them plan and achieve a more positive outcome in their initial trialling of new ideas using WBRs. Without the targeted collegial support, the balance of forces for these participants appeared to revert to the position they were in prior to the intervention and consequently there was more limited change evident in their classroom practice.

7.4 Chapter summary

This chapter has presented a discussion of the research findings. In order to answer the key research question the discussion is organised in three sections with each section addressing different sub questions.

The first section discussed the teachers' initial use of WBRs, which was mostly infrequent and mainly technocentric and teacher-directed in approach. Both first order barriers (limited classroom access to computers and the Internet, and limited ICT professional development) and second order barriers (the limited knowledge, skills and confidence of the participants in using WBRs in the classroom, and their limited perceptions of the value of using WBRs in technology education) were impacting in various ways on whether or not, and how, each teacher was using WBRs. The complex range of interacting variables impacting on participants in their individual contexts is highlighted.

The intervention design and how it impacted on the learning journeys of the participants in a variety of ways is discussed using B. Bell and Gilbert's (1996) model of teacher professional development as an analytical framework. In particular, the importance of supporting all three dimensions of the teachers' development: personal, professional and social is emphasised. Furthermore, the findings suggest that teachers need to progress to stage three in each dimension in order to become empowered and for development to be sustained beyond the intervention.

Finally, the nature of change in the teachers' classroom use of WBRs is explored using velocity as an analogy. This section provides further insights into the key factors that contributed to significant and sustainable change in some of the teachers' practice, and attitudes towards, using WBRs in the classroom. An overview of the key elements and how they combined to support sustainable change in teachers' practice is provided below in Figure 7.1.

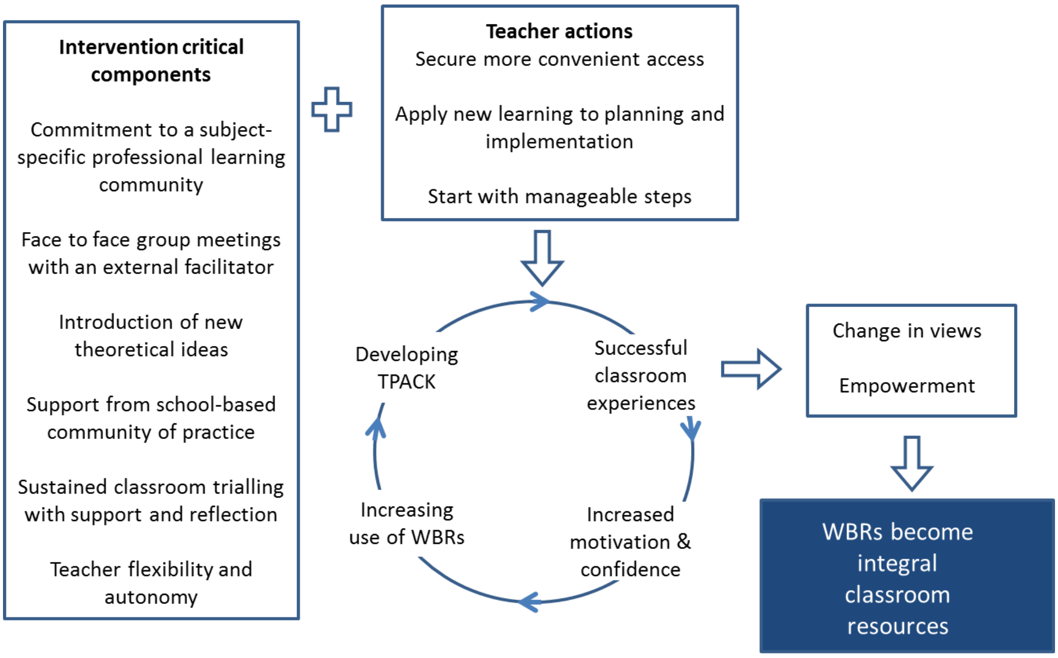

Figure 7.1. Research outcomes

CHAPTER EIGHT

CONCLUSION AND IMPLICATIONS

8.0 Introduction

The previous chapter discussed the key findings of the research in light of relevant literature in order to answer the research question: *How can secondary technology teachers be effectively supported to enhance their classroom integration of WBRs?*

This final chapter begins by presenting the conclusions arising from the discussion in the previous chapter, thereby answering the research question. It goes on to discuss some implications of the research. The chapter also outlines some limitations of the research and then provides suggestions for further research. This is followed by a section which situates the research findings within the bigger picture of the potential impact of WBRs in education. The chapter concludes with some closing remarks.

8.1 Conclusion

Although ICT integration is a priority in New Zealand schools, research shows that, while examples of transformative use exist, despite government funding for ICT initiatives and increasing use of ICT in education, generally the impact of ICT in education remains limited. The conclusions of this study are therefore particularly relevant, and may have implications for teacher ICT professional development in secondary schools. This was a small research project, limited in scope to seven teachers supported in their endeavours to integrate WBRs in technology education. While the results are therefore not generalisable, it is possible that, where contextual elements are similar, the key principles of the intervention may be more broadly applied to ICT professional development in general, and to other subject areas.

As indicated in Figure 7.1, this research concludes that with particular components included in a professional development programme, teachers can be supported to enhance their classroom use of WBRs and become empowered to continue their own ongoing development even when they have limited ICT skills and knowledge and face significant constraints. These critical components include:

- developing a subject-specific professional learning community that includes teachers from different schools and an external facilitator/mediator, and to which participants develop a sense of commitment;
- both face-to-face group meetings, including the introduction of new ideas and opportunities for teachers to share ideas; and a sustained period of time for teachers to try out new ideas and approaches in their classrooms, combined with support and encouragement for critical reflection;
- additional support and encouragement through membership of a school-based community of practice focused on similar goals with regard to integrating WBRs in ways that enhance classroom practice; and,
- autonomy for teachers to decide where, when, how and to what extent they integrate WBRs in their classrooms allowing teachers to build on individual levels of prior knowledge and experience, and to work within, or manage the unique set of constraints that confront them in their individual school and classroom contexts.

These critical elements of the intervention were all drawn from research literature and therefore individually were not new but, the particular combination of components was unique. When all these elements combined for individual teachers, the intervention proved effective in supporting them to overcome substantial constraints and enhance their classroom integration of WBRs. The TPACK framework was included and deemed effective by the researcher as a tool for facilitating communication of new theoretical ideas about effective integration of WBRs, and for analysis of teachers' developing knowledge and changing classroom practice This study offers insights into how the various elements of the intervention combined to influence and support this particular group of technology teachers to work towards and experience successful classroom outcomes using WBRs.

Successful classroom experiences encompassed more student-centred teaching approaches, increased teacher motivation and confidence, and commitment to using WBRs. This in turn influenced the teachers' perceptions of the affordances of WBRs for teaching and learning in technology, culminating in the view that WBRs are integral resources to consider in planning and teaching technology. Increased confidence led teachers to no longer feel the need to master the technology before trying it out in the classroom. With an expanding repertoire of successful experiences using WBRs, they were empowered to make more flexible use of WBRs in the classroom in response to needs and situations where they perceived learning advantages, and to take responsibility for their own ongoing development. Through this process the teachers were building and refining their TPACK.

Importantly, the study draws attention to the complex range of variables that can influence individual teachers as they progress in their integration of WBRs and development of TPACK. Insights into this complexity were gained using B. Bell and Gilbert's (1994) model of teacher professional development as a framework to analyse the variables and their interactions. In addition, using velocity as an analogy provides insights into various combinations of factors and how they impacted on the degree, and rate, of change exhibited by the teachers towards effective integration of WBRs into their teaching practice.

8.2 Implications

8.2.1 Implications for ICT professional development

Findings concur with literature on the importance of teachers having personally acknowledged a need for development in an aspect of their teaching in order to fully engage in professional development. Indications are that in the current educational environment, with the 2007 curriculum changes in technology education, and with ICT becoming increasingly pervasive in society and in the lives of teachers and students, technology teachers may be more likely to identify a professional need to increase their ICT knowledge and skills. This has significant implications for schools and ICT professional development and suggests that, in the current environment, secondary technology teachers are likely to be more receptive to professional development opportunities in this area.

Further implications for school ICT professional development are the insights offered into components of the intervention, including the use of TPACK to communicate the complex knowledge requirements of effective integration, and the importance of supporting teachers' personal, professional and social development. The insights gained into the intervention design, and the contexts and variable outcomes for the individual teachers, may assist schools to design and structure ICT professional development programmes in ways that better support teachers in similar contexts to enhance their ICT integration.

Findings from this research provide evidence that a programme that includes the key components listed in the previous section may support teachers to move beyond the dominant technocentric and teacher-directed approaches to using ICT towards more student-centred approaches. Further, such a programme offers potential to develop more positive perceptions of the affordances and benefits of ICT for teaching and learning in their subject, and to take more responsibility for their ongoing development.

8.2.2 Implications for teachers

For teachers, the findings provide insights into how various barriers influenced the participants' efforts to integrate WBRs and how and why different teachers overcame or managed various constraints in their particular context. These insights may assist teachers to develop strategies to manage and enhance their use of ICT within the resource limitations of their particular school and classroom context. In particular, the evidence points to the importance of trialling the use of ICT, supported by effective pedagogy, and also of starting with ICT that is not too unfamiliar; in order to experience positive outcomes, which are likely to increase motivation and confidence to make further use of WBRs.

Furthermore, the teaching examples in the case studies may assist teachers to better understand the relevance and value of using WBRs in technology education, in particular to support their teaching of aspects of the revised curriculum, and may inspire them to try out new ideas and approaches to enhance their teaching.

8.3 Limitations of this study

Despite the ubiquity of ICT in people's lives and significant increases in resourcing of ICT infrastructure and capability in New Zealand schools, in the year of data collection (2011) some teachers were still facing significant constraints that were inhibiting or preventing their classroom integration of WBRs. While this is consistent with recent literature at that time, and the 2020 Communications Trust (2014) data indicates that many schools are still under-resourced, it is acknowledged that this was a small study and these contextual elements may not be representative of other schools around the country, or in other countries. In addition, with the rapid and ongoing development in ICT and WBRs and their increasing pervasiveness in our lives, the resourcing and capability of similar groups of teachers today may have changed. In particular, *Bring your own device* (BYOD) policies, while still in their infancy in New Zealand schools, have the potential to address access issues. However, despite the likely increasing access, as literature shows, technology in and of itself does not automatically lead to change in practice. Therefore, it is likely that some of the challenges facing the teachers at the start of this study still apply for other technology teachers in New Zealand schools.

The research findings indicate that bringing the same-subject teachers together from different schools to form a professional learning community was a key element contributing to the success of the intervention. Critical to establishing and sustaining the professional learning community were the group workshops. This research was limited in scope to including only two workshops – one at the beginning and one at the end. While this proved sufficient for most of the participants, findings suggest that another face-to-face meeting of all the participants early in the intervention would have likely provided the extra support needed by some of the participants to increase the degree, and rate, of change in their classroom practice. Or alternatively, participation in some kind of online forum, which was trialled unsuccessfully in this research (see Section 4.3.2) and also proved unsuccessful in the New Zealand ICT PD Clusters programme (Billowes & Alexander, 2010). In particular, in School C where ongoing support for the participants within the school appeared to be lacking, the additional collegial support of the whole group may have assisted their progress. The addition of one, or both, of the above alternatives would likely have enhanced the intervention design, and provided necessary extra support for teachers who face greater constraints and/or lack sufficient access to critical and supportive collegial networks within their school.

8.4 Suggestions for further research

The purpose of this research was to investigate how teachers can be supported to enhance their classroom use of WBRs in secondary school technology education. The design, implementation and evaluation of the intervention which ensued, generated ideas for further research, which could strengthen and build on the findings of this study:

- Teacher professional development is a complex process involving multiple interacting variables, and programmes are most effective when they run for extended periods of time. ICT integration adds to this complexity, particularly in cases where teachers are starting with limited ICT knowledge, skills and confidence. Although the duration of the intervention in this study of three school terms proved effective for most of the participants, further research over a longer time period would be worthwhile. This would enable ongoing commitment and support, and monitoring of whether or not, and to what extent, change is sustained. The longer duration would also enable stronger collegial networks to be established, allow time for teachers to trial integration more extensively, develop their skills and knowledge to a greater extent, and to apply their learning from one year's programme to similar topics in the following year. In addition, the extended timeframe would better support teachers who may take longer to develop in the personal dimension, which is essential to fully engage in professional learning and to commit to making change in classroom practice.

- The scope of this study was confined to teachers. Further research could include collection of student data to represent student perspectives of the affordances and benefits of WBRs for learning in technology, as well as to provide empirical evidence of the impact of using particular WBRs on learning of particular concepts or topics for particular groups of students. Research evidence of the impact of ICT on student learning is an area that is lacking.
- Although this study was confined to teachers in the discipline of technology education, the key element of this grouping was that it was a subject-specific group of teachers. The same approach could likely be applied in other disciplines in secondary education, with the potential to achieve similar results.
- Further research could also be carried out with a focus on specific WBRs and associated pedagogy used by technology teachers, and ways that they impact on teaching and learning of particular concepts and topics in technology education. Such a study could contribute to the development of a quality assured database of curriculum linked WBRs for technology education, including analysis of pedagogy and learning outcomes. This would have immediate relevance and value for both practising and pre-service technology teachers in New Zealand, and particularly for teachers with limited ICT experience and confidence who are finding it hard to start using WBRs in the classroom.

8.5 Moving beyond web-based resources

The use of WBRs by the participants in this study was limited – the participants were relative novices to embedding ICT in their classroom programmes, and also faced significant access barriers in their schools. The teachers demonstrated a number of ways to enhance learning using WBRs, largely to make closer connections with the real world of technology. This broadened students' experiences and, added relevance and interest to their learning. In addition, teachers learned alongside students rather than feeling responsible for providing all the knowledge. In this way the use of WBRs supported a more student-centred pedagogy.

The teachers' successful experiences provided an important first step in developing their knowledge and supporting positive perceptions of the value of using WBRs. Potentially these early experiences will provide a stepping stone to some of the higher-level uses that are necessary in order to develop students' knowledge-building, problem-solving, and lifelong learning capability – essential skills for learners in this millennium. The types of ICT use described in the TEL report (Noss et al., 2012) and mentioned in Section 2.3.3 reflect the transformative uses that are possible and desirable. Although these uses represent a significant step up from the endeavours of the participants in this study, the increased confidence, change in attitude and empowerment of the individuals, alongside the increasing pervasiveness of ICT in our lives; provide potential to support such a change trajectory.

8.6 Closing remarks

Undertaking this research project has been both challenging and rewarding.

From the outset I felt a huge responsibility towards the teachers involved. Coming from a technology teaching background I know how busy teachers are and I was very aware that asking them to be involved in the study would add to their workload. Therefore positive outcomes for all were imperative, not only for the contribution to this thesis, but also to ensure it was worth the effort for the teachers.

After the first round of interviews it became clear that the undertaking would be a considerable challenge. The limited access to ICT and limited skills and confidence of most of the participants was unexpected. It appeared that it would be a daunting task for some of them to overcome the significant barriers they faced. The extent and diversity of their professional development needs presented a significant challenge in terms of designing an intervention that would cater for their individual needs, and at the same time appear relevant and manageable, and sustain their willing participation.

I was surprised and impressed by the willingness and enthusiasm of the participants to take the risk to be involved in the research despite the considerable limitations of their individual contexts. I was equally impressed by the considerable progress made by most of them. The intervention did make a difference for these teachers and also, by their accounts, for their students. Most showed significant shifts in their perceptions, pedagogy and confidence in using WBRs. More importantly, they were empowered to continue their own ongoing development, and committed to incorporating WBRs into their programmes in the future. They were clearly on a trajectory of ongoing self-development and increasing, strategic integration of WBRs. This was the most significant outcome because it indicates that the intervention really did make a difference and that the impact will be ongoing, as these quotes indicate:

> The only thing I would change is me doing more of it. What worked well? Everything that I've done so far has worked well. (Brian, Iiii)

> I have to say a big thank you for this, this year, because as a result I've just bought 6 or maybe 7 computers for our department and setting up our own COW for next year. I wrote in my STAR funding this year that I felt that what I'd learnt in this project and the students enjoyed the research using the computers and there was so much stuff out there so what I was saving in resources I'd like to spend on COWs. (Alison, Iiii)

The teachers were grateful for the support, proud of their achievements and impressed by the difference it made for their teaching and for student learning. I feel incredibly rewarded and humbled by the entire journey.

REFERENCES

2020 Communications Trust. (2011). *ICT in schools survey - 2011*. Retrieved from http://2020.org.nz/blog/ict-in-schools-reports-2011

2020 Communications Trust. (2014). *Digital technologies in New Zealand schools*. Retrieved from http://2020.org.nz/wp-content/uploads/2014/07/Digital-Technologies-in-School-2014-FINAL.pdf

Abbitt, J. T. (2011). Measuring Technological Pedagogical Content Knowledge in preservice teacher education: A review of current methods and instruments. *Journal of Research on Technology in Education*, *43*(4), 281–300. http://doi.org/10.1080/15391523.2011.10782573

Albion, P., & Ertmer, P. (2002). Beyond the foundations: The role of vision and beliefs in teachers' preparation for integration of technology. *TechTrends*, *46*(5), 34–38. http://doi.org/10.1007/BF02818306

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in Technological Pedagogical Content Knowledge (TPCK). *Computers & Education*, *52*(1), 154–168. http://doi.org/10.1016/j.compedu.2008.07.006

Avalos, B. (2011). Teacher professional development in teaching and teacher education over ten years. *Teaching and Teacher Education*, *27*(1), 10–20. http://doi.org/10.1016/j.tate.2010.08.007

Baggott La Velle, L., McFarlane, A., & Brawn, R. (2003). Knowledge transformation through ICT in science education: A case study in teacher-driven curriculum development – Case study 1. *British Journal of Educational Technology*, *34*(2), 183–199. http://doi.org/10.1111/1467-8535.00319

Becker, H. (1999). *Internet use by teachers: Conditions of professional use and teacher-directed student use* (Vol. 1). Center for Research on Information Technology and Organizations, the University of California, Irvine and the University of Minnesota. Retrieved from http://www.cyberbullyingprevention.com/teachers/internet-used-by-teachers.pdf

Becker, H. (2000). How exemplary computer-using teachers differ from other teachers: Implications for realizing the potential of computers in schools.

Contemporary Issues in Technology and Teacher Education, *1*(2), 274–293.

Becker, H., & Ravitz, J. (1999). The influence of computer and internet use on teachers' pedagogical practices and perceptions. *Journal of Research on Computing in Education*, *31*(4), 356–384. http://doi.org/10.1080/08886504.1999.10782260

Becker, H., & Ravitz, J. (2001). Computer use by teachers: Are Cuban's predictions correct. In *Annual meeting of the American Educational Research Association, Seattle*. Retrieved from http://94.23.146.173/ficheros/74cda1f539bc765fc1b4e440a3625195.pdf

Bell, B., & Gilbert, J. (1994). Teacher development as professional, personal and social development. *Teaching and Teacher Education*, *10*, 483–497. http://doi.org/10.1016/0742-051X(94)90002-7

Bell, B., & Gilbert, J. (1996). *Teacher development*. London, United Kingdom: Falmer.

Bell, J. (2005). *Doing your research project*. Berkshire, United Kingdom: Open University.

Billowes, N., & Alexander, R. (2010). ICT professional development (ICTPD) programme: Bridging the gap. In *e-Learnings: Implementing a national strategy for ICT in education, 1998-2010* (pp. 46–57). Christchurch, New Zealand: CORE Education.

Bogdan, R., & Biklen, S. (2007). *Qualitative research for education: An introduction to theories and methods* (5th ed.). Boston, MA: Pearson.

Bolstad, R., & Buntting, C. (2013). *Digital technologies and future-oriented science education: A discussion document for schools*. Wellington, New Zealand: NZCER.

Bolstad, R., Gilbert, J., McDowall, S., Bull, A., Boyd, S., & Hipkins, R. (2012). *Supporting future-oriented learning & teaching: A New Zealand perspective*. Wellington, New Zealand: Ministry of Education. Retrieved from http://westernsprings.school.nz/New%20School/becoming_a_new_school/Resources/Bolstad_Gilbert_FutureOriented.pdf

Bower, M. (2008). Affordance analysis – matching learning tasks with learning technologies. *Educational Media International*, *45*(1), 3–15. http://doi.org/10.1080/09523980701847115

Bransford, J., Brown, A., & Cocking, R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school*. Washington D.C.: National Academy.

Brown, J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32–42. http://doi.org/10.3102/0013189X018001032

Brown, T. (2006). Beyond constructivism: Navigationism in the knowledge era. *On the Horizon*, *14*(3), 108–120. http://doi.org/10.1108/10748120610690681

Bryman, A. (2004). *Social research methods* (2nd ed.). Oxford, NY: Oxford University.

Buntting, C., & Jones, A. (2012). Expanding the capacity for connection. In B. France & V. Compton (Eds.), *Bringing communities together* (pp. 101–112). Rotterdam, Netherlands: Sense.

Buntting, C., Williams, J., & Jones, A. (2015). The more things change, the more (some) things stay the same. In J. Williams, A. Jones, & C. Buntting (Eds.), *The future of technology education*. Singapore: Springer.

Burns, R. (1994). *Introduction to research methods*. Melbourne, Australia: Longman.

Candy, P. (1991). *Self-direction for lifelong learning*. San Fransisco, CA: Jossey-Bass Inc.

Christensen, R., & Knezek, G. (2008). Self-report measures and findings for information technology attitudes and competencies. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 349–365). Retrieved from http://link.springer.com/chapter/10.1007/978-0-387-73315-9_21

Clark, C. (1992). Self-directed professional development. In *Understanding teacher development* (pp. 75–84). New York, NY: Teachers' College.

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, *18*(8), 947–967. http://doi.org/10.1016/S0742-051X(02)00053-7

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education* (6th ed.). New York, NY: Routledge.

Cole, M., & Engestrom, Y. (1997). A cultural-historical approach to distributed cognition. In *Distributed cognitions. Psychological and educational* *considerations* (pp. 1–47). Cambridge, United Kingdom: Cambridge University.

Collins, A. (2006). Cognitive apprenticeship. In K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 47–60). New York, NY: Cambridge University.

Compton, V. (1997). The implementation of technology in New Zealand schools. In J. Burns (Ed.), *Technology in the New Zealand curriculum: Perspectives on practice* (pp. 60–78). Palmerston North, New Zealand: Dunmore.

Compton, V., & Bell, B. (2012). Working with technologists on technology curriculum development and implementation. In *Bringing communities together: Connecting learners with scientists or technologists* (pp. 73–88). Rotterdam, Netherlands: Sense.

Compton, V., & Compton, A. (2009). Technological knowledge and nature of technology: Establishing the nature of progression. Presented at the Pupils' Attitudes Towards Technology (PATT) International design & technology education conference: Strengthening technology education in the school curriculum. Retrieved from http://64.40.123.124/Conference/PATT/PATT22/Compton.pdf

Compton, V., & France, B. (2007). Redefining technological literacy in New Zealand: From concepts to curriculum constructs. Presented at the Pupils' Attitudes Towards Technology (PATT) International conference on design and technology education research: Teaching and learning technological literacy in the classroom. Retrieved from http://www.iteea.org/Conference/PATT/PATT18/fullprog-21a[1].pdf

Compton, V., & Jones, A. (1998). Reflecting on teacher development in technology education: Implications for future programmes. *International Journal of Technology and Design Education*, *8*(2), 151–166.

Compton, V., & Jones, A. (2004). *The nature of technology: Briefing paper prepared for the New Zealand Ministry of Education curriculum project*. Retrieved from http://nzcurriculum.tki.org.nz/content/download/854/6044/file/nature-techn.doc

Cowie, B., Jones, A., Harlow, A., McGee, C., Cooper, B., Forret, M., … Gardiner, B. (2007). *TELA: Laptops for teachers evaluation final report year 9-13*. Hamilton, New Zealand: University of Waikato.

Cox, M., & Marshall, G. (2007). Effects of ICT: Do we know what we should know? *Education and Information Technologies*, *12*(2), 59–70. http://doi.org/10.1007/s10639-007-9032-x

Cox, S., & Graham, C. R. (2009). Diagramming TPACK in practice: Using an elaborated model of the TPACK framework to analyze and depict teacher knowledge. *TechTrends, 53*(5), 60–69. http://doi.org/10.1007/s11528-009-0327-1

Creswell, J. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Thousand Oaks, CA: Sage.

Cuban, L. (2001). *Oversold and underused: Computers in the classroom*. Cambridge, MA: Harvard University.

Cuban, L., Kirkpatrick, H., & Peck, C. (2001). High access and low use of technologies in high school classrooms: Explaining an apparent paradox. *American Educational Research Journal*, *38*(4), 813–834. http://doi.org/10.3102/00028312038004813

Dede, C. (2008). Theoretical perspectives influencing the use of information technology in teaching and learning. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 43–62). doi: 10.1007/978-0-387-73315-9_3.

Denzin, N., & Lincoln, Y. (Eds.). (2008). The discipline and practice of qualitative research. In *Collecting and interpreting qualitative materials* (3rd ed., pp. 1–43). Thousand Oaks, CA: Sage.

Denzin, N., & Lincoln, Y. (Eds.). (2011). *The Sage handbook of qualitative research* (4th ed.). Thousand Oaks, CA: Sage.

De Vries, M., & Tamir, A. (1997). Shaping concepts of technology: What concepts and how to shape them. *International Journal of Technology and Design Education*, *7*, 3–10. http://doi.org/10.1023/A:1008869205370

Doering, A., Scharber, C., Miller, C., & Veletsianos, G. (2009). GeoThentic: Designing and assessing with Technological Pedagogical Content Knowledge. *Contemporary Issues in Technology and Teacher Education*, *9*(3), 316–336.

Drew, C., Hardman, M., & Hosp, J. (2008). *Designing and conducting research in education*. Thousand Oaks, CA: Sage Publications.

Ertmer, P. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development*, *47*(4), 47–61. http://doi.org/10.1007/BF02299597

Ertmer, P. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research and Development*, *53*(4), 25–39. http://doi.org/10.1007/BF02504683

Ertmer, P., Ottenbreit-Leftwich, A., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education*, *59*(2), 423–435. http://doi.org/10.1016/j.compedu.2012.02.001

Ertmer, P., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education*, *42*(3), 255–284. http://doi.org/10.1080/15391523.2010.10782551

Evans, L. (2002). What is teacher development? *Oxford Review of Education*, *28*(1), 123–137. http://doi.org/10.1080/03054980120113670

Falloon, G. (1999). Developing exemplary practice: Why are some teachers better at IT than others? *Computers in New Zealand Schools*, *11*(3), 19–23.

Ferguson, D. (n.d.). *Development of technology education in New Zealand schools 1985-2008*. Wellington, New Zealand: Ministry of Education.

Fisher, T. (2006). Educational transformation: Is it, like “beauty”, in the eye of the beholder, or will we know it when we see it? *Education and Information Technologies*, *11*(3-4), 293–303. http://doi.org/10.1007/s10639-006-9009-1

Fishman, B., & Davis, E. (2006). Teacher learning research and the learning sciences. In K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 535–550). New York, NY: Cambridge University.

Flyvbjerg, B. (2011). Case study. In N. Denzin & Y. Lincoln (Eds.), *The Sage handbook of qualitative research* (4th ed.). Thousand Oaks, CA: Sage.

Gall, M., Gall, J., & Borg, W. (2007). *Educational research: An introduction* (8th ed.). Boston: MA: Pearson Education, Inc.

Garrick, J. (1999). Doubting the philosophical assumptions of interpretive research. *International Journal of Qualitative Studies in Education*, *12*(2), 147–156. http://doi.org/10.1080/095183999236222

Gilbert, J. (2013). Catching the knowledge wave?: The knowledge society and the future of public education in New Zealand. *Journal Article*, *2013*(2). Retrieved from http://www.nzcer.org.nz/research/publications/catching-knowledge-wave-knowledge-society-and-future-public-education-new-zeal?cPath=130_152&products_id=1558&print_preview=

Good, T., L., & Brophy, J., E. (1990). *Educational psychology: A realistic approach* (4th ed.). New York, NY: Longman.

Graham, C. R. (2011). Theoretical considerations for understanding Technological Pedagogical Content Knowledge (TPACK). *Computers & Education*, *57*(3), 1953–1960. http://doi.org/10.1016/j.compedu.2011.04.010

Gray, D. (2014). *Doing research in the real world* (3rd ed.). London, United Kingdom: SAGE.

Gray, L., Thomas, N., & Lewis, L. (2010). Teachers' use of educational technology in US public schools: 2009. First look. NCES 2010-040. *National Center for Education Statistics*. Retrieved from http://eric.ed.gov/?id=ED509514

Greenhow, C., Robelia, B., & Hughes, J. E. (2009). Learning, teaching, and scholarship in a digital age: Web 2.0 and classroom research: what path should we take now? *Educational Researcher*, *38*(4), 246–259. http://doi.org/10.3102/0013189X09336671

Greeno, J. (2006). Learning in activity. In K. Sawyer (Ed.), *The Cambridge handbook of the learnng sciences* (pp. 79–96). New York, NY: Cambridge University.

Guzey, S., & Roehrig, G. (2009). Teaching science with technology: Case studies of science teachers' development of technology, pedagogy, and content knowledge. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 25–45.

Ham, V. (2010). Introduction. In V. Ham & D. Wenmoth (Eds.), *eLearnings: Implementing a national srategy for ICT in education, 1998-2010* (pp. 8–15). Christchurch, New Zealand: CORE Education Ltd.

Ham, V., & Wenmoth, D. (Eds.). (2010). *eLearnings: Implementing a national ICT strategy for ICT in education, 1998-2010*. Christchurch, New Zealand: CORE Education.

Hargreaves, A., & Fullan, M. (1992). *Understanding teacher development*. New York, NY: Teachers' College.

Harris, J. (2008). TPCK in in-service education: Assisting experienced teachers' planned improvisations. In M. Koehler & P. Mishra (Eds.), *Handbook of Technological Pedagogical Content Knowledge* (pp. 251–271). New York, NY: Routledge.

Harris, J., & Hofer, M. (2011). Technological Pedagogical Content Knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on Technology in Education*, *43*(3), 211. http://doi.org/10.1080/15391523.2011.10782570

Harris, J., Mishra, P., & Koehler, M. (2009). Teachers' Technological Pedagogical Content Knowledge and learning activity types: Curriculum-based technology integration reframed. *Journal of Research on Technology in Education*, *41*(4), 393–416. http://doi.org/10.1080/15391523.2009.10782536

Harwood, C., & Compton, V. (2007). Moving from technical to technology education: Why it's so hard!! Presented at the Technology Education New Zealand (TENZ) conference, Auckland, New Zealand.

Hennessy, S. (1993). Situated cognition and cognitive apprenticeship. *Studies in Science Education*, *22*, 1–41. http://doi.org/10.1080/03057269308560019

Hennessy, S., Ruthven, K., & Brindley, S. (2005). Teacher perspectives on integrating ICT into subject teaching: Commitment, constraints, caution, and change. *Journal of Curriculum Studies*, *37*(2), 155–192. http://doi.org/10.1080/0022027032000276961

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development*, *55*(3), 223–252. http://doi.org/10.1007/s11423-006-9022-5

Hoffman, J. L., Wu, H.-K., Krajcik, J. S., & Soloway, E. (2003). The nature of middle school learners' science content understandings with the use of on-line resources. *Journal of Research in Science Teaching*, *40*(3), 323–346. http://doi.org/10.1002/tea.10079

Ho, K., & Albion, P. (2010). Hong Kong home economics teachers' preparedness for teaching with technology. In *Proceedings of Society for Information Technology & Teacher Education International Conference 2010* (pp. 3849–3856). Chesapeake, VA: AACE.

Hooper, S., & Rieber, L. P. (1995). Teaching with technology. In A. C. Ornstein (Ed.), *Teaching: Theory into practice* (pp. 154–170). Needham Heights, MA: Allyn and Bacon.

Hughes, J. (2005). The role of teacher knowledge and learning experiences in forming technology-integrated pedagogy. *Journal of Technology and Teacher Education*, *13*(2), 277–302.

Jones, A. (1997). Technology education in the New Zealand curriculum. In J. Burns (Ed.), *Technology in the New Zealand curriculum: Perspectives on practice*. Palmerston North, New Zealand: Dunmore.

Jones, A. (2004). A review of the research literature on barriers to the uptake of ICT by teachers. Retrieved from http://dera.ioe.ac.uk/1603/1/becta_2004_barrierstouptake_litrev.pdf

Jones, A. (2009a). The development of technology education internationally. In A. Jones & M. de Vries (Eds.), *International handbook of research and development in technology education* (pp. 15–20). Rotterdam, Netherlands: Sense.

Jones, A. (2009b). Towards an articulation of students making progress in learning technological concepts and processes. In A. Jones & M. de Vries (Eds.), *International handbook of research and development in technology education*. Rotterdam, Netherlands: Sense.

Jones, A., Buntting, C., & de Vries, M. (2013). The developing field of technology education: A review to look forward. *International Journal of Technology and Design Education*, *23*(2), 191–212. http://doi.org/10.1007/s10798-011-9174-4

Jones, A., & Compton, V. (2009). Reviewing the field of technology education in New Zealand. In A. Jones & M. de Vries (Eds.), *International handbook of research and development in technology education*. Rotterdam, Netherlands: Sense.

Kennewell, S. (2001). Using affordances and constraints to evaluate the use of information and communications technology in teaching and learning. *Journal of Information Techology for Teacher Education*, *10*(1), 101. http://doi.org/10.1080/14759390100200105

Kennewell, S., Beauchamp, G., Jones, S., Meiring, L., Morgan, A., Norman, N., … Thomas, G. (2007). *The use of ICT to improve learning and attainment through interactive teaching* (Final report). Swansea Metropolitan University.

Knezek, G., & Christensen, R. (2008). The importance of information technology attitudes and competencies in primary and secondary education. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 321–331). doi: 10.1007/978-0-387-73315-9_3: Springer US.

Koehler, M., & Mishra, P. (2005). What happens when teachers design educational technology? The development of Technological Pedagogical Content Knowledge. *Journal of Educational Computing*, *32*(2), 131–152. http://doi.org/10.2190/0EW7-01WB-BKHL-QDYV

Koehler, M., & Mishra, P. (2008). *Handbook of Technological Pedagogical Content Knowledge*. New York, NY: Routledge.

Koehler, M., & Mishra, P. (2009). What is Technological Pedagogical Content Knowledge? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60–70.

Koehler, M., Mishra, P., & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. *Computers & Education*, *49*(3), 740–762. http://doi.org/10.1016/j.compedu.2005.11.012

Kuiper, E., Volman, M., & Terwel, J. (2005). The web as an information resource in K–12 education: Strategies for supporting students in searching and processing information. *Review of Educational Research*, *75*(3), 285 –328. http://doi.org/10.3102/00346543075003285

Kvale, S. (2007). *Doing interviews*. London, United Kingdom: SAGE.

Kwakman, K. (2003). Factors affecting teachers' participation in professional learning activities. *Teaching and Teacher Education*, *19*(2), 149–170. http://doi.org/10.1016/S0742-051X(02)00101-4

Lai, K.-W. (1997). *Net-working: Teaching, learning & professional development with the Internet*. Dunedin, New Zealand: University of Otago.

Lai, K.-W. (2001). Professional development: Too little, too generic. In K.-W. Lai (Ed.), *e-Learning: Teaching and professional development with the Internet*. Dunedin, New Zealand: University of Otago.

Lai, K.-W. (2008). ICT supporting the learning process: The premise, reality, and promise. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 215–230).

Lai, K.-W. (2010). The impact of the New Zealand ICT strategies on learning and teaching: What the research says. In V. Ham & D. Wenmoth (Eds.), *eLearnings: Implementing a national srategy for ICT in education, 1998-2010*. Christchurch, New Zealand: CORE Education.

Lai, K.-W., & Pratt, K. (2007). Positive to a degree: The effects of ICT use in New Zealand secondary schools. *Computers in New Zealand Schools*, *24*(3-4), 95–109. http://doi.org/10.1300/J025v24n03_07

Lave, J. (1991). Situated learning in communities of practice. In *Perspectives on socially shared cognition*. Cambridge, NY: Cambridge University.

Lave, J., & Wenger, E. (1991). *Situated learning. Legitimate peripheral participation*. Cambridge, NY: Cambridge University.

Lawless, K. A., & Pellegrino, J. W. (2007). Professional development in integrating technology into teaching and learning: Knowns, unknowns, and ways to pursue better questions and answers. *Review of Educational Research*, *77*(4), 575–614. http://doi.org/10.3102/0034654307309921

Leahy, N., & Torff, B. (2013). When the teacher becomes the student: Increasing teacher engagement in professional development activities. In Y. Bashevis & Y. Weidenseld (Eds.), *Professional development: Perspectives, strategies and practices* (pp. 99–116). Retrieved from http://site.ebrary.com/lib/waikato/reader.action?docID=10677642&ppg=111

LeCompte, M., & Goetz, J. (1982). Problems of reliability and validity in ethnographic research. *Review of Educational Research*, *52*(1), 31–60. http://doi.org/10.3102/00346543052001031

Lee, M.-H., & Tsai, C.-C. (2010). Exploring teachers' perceived self efficacy and Technological Pedagogical Content Knowledge with respect to educational use of the World Wide Web. *Instructional Science*, *38*(1), 1–21. http://doi.org/10.1007/s11251-008-9075-4

Lichtman, M. (2013). *Qualitative research in education* (3rd ed.). Thousand Oaks, CA: Sage.

Lincoln, Y. (1995). Emerging criteria for quality in qualitative and interpretive research. *Qualitative Inquiry*, *1*, 275–289. http://doi.org/10.1177/107780049500100301

Lincoln, Y., & Guba, E. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage.

Loveless, A. (2011). Technology, pedagogy and education: Reflections on the accomplishment of what teachers know, do and believe in a digital age. *Technology, Pedagogy and Education, 20*(3), 301–316. http://doi.org/10.1080/1475939X.2011.610931

Lowenberg, J. (1993). Interpretive research methodology: Broadening the dialogue. *Advances in Nursing Science*, *16*(2), 57–69. http://doi.org/http://dx.doi.org/10.1097/00012272-199312000-00006

Lunt, J. (2009). Primary school children's perceptions of design and technology. In A. Jones & M. de Vries (Eds.), *International handbook of research and development in technology education*. Rotterdam, Netherlands: Sense.

Mangan, J. (2000). *Implementation of the New Zealand Technology Curriculum: Secondary school teachers' perceptions of change* (Unpublished directed research project). Hamilton, New Zealand: Centre for Science and Technology Education Research, University of Waikato.

Maykut, P., & Morehouse, R. (2003). *Beginning qualitative research: A philosophic and practical guide*. London, United Kingdom: Routledge Falmer.

Mergel, B. (1998). *Instructional design and learning theory* (online). Retrieved from http://etad.usask.ca/802papers/mergel/brenda.htm

Merriam, S., B. (1998). *Qualitative research and case study applications in education.* San Francisco, CA: Jossey-Bass.

Ministry of Education. (1995). *Technology in the New Zealand Curriculum*. Wellington, New Zealand: Learning Media.

Ministry of Education. (2006). *Enabling the 21st century learner: An e-learning action plan for schools, 2006-2010*. Wellington, New Zealand: Learning Media.

Ministry of Education. (2007). *The New Zealand Curriculum*. Wellington, New Zealand: Learning Media.

Ministry of Education. (2012). *Technology curriculum support*. Retrieved from http://technology.tki.org.nz/Technology-in-the-NZC/What-does-learning-in-technology-look-like/Indicators-of-Progression

Mishra, P., & Koehler, M. (2006). Technological Pedagogical Content Knowledge. *Teachers' College Record*, *108*(6), 1017–1054. http://doi.org/10.1111/j.1467-9620.2006.00684.x

Mishra, P., & Koehler, M. (2009). Too cool for school? No way! Using the TPACK Framework: You can have your hot tools and teach with them, too. *Learning & Leading with Technology*, *36*(7), 14–18.

Mitchell, B., Bailey, J., & Monroe, E. (2007). Integrating technology and a standards-based pedagogy in a geometry classroom. *Computers in Schools*, *24*(1&2), 75–91. http://doi.org/10.1300/J025v24n01_06

Moreland, J., Jones, A., & Northover, A. (2001). Enhancing teachers' technological knowledge and assessment practices to enhance student learning in technology: A two-year classroom study. *Research in Science Education*, *31*(1), 155–176. http://doi.org/10.1023/A:1012670514238

Mouza, C., & Wong, W. (2009). Studying classroom practice: Case development for professional learning in technology integration. *Journal of Technology and Teacher Education*, *17*(2). Retrieved from http://search.proquest.com.ezproxy.waikato.ac.nz/docview/200073630/13FE05897BB5BAF818A/2?accountid=17287

Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: A review of the literature. *Journal of Information Technology for Teacher Education*, *9*(3), 319–342. http://doi.org/10.1080/14759390000200096

National Research Council. (1999). *Being fluent with information technology*. Washington, DC: National Academy.

Nicholl, B., & McLellan, R. (2009). "This isn"t my project [work]. It's...just do it...you just do research'. In A. Jones & M. de Vries (Eds.), *International handbook of research and development in technology education*. Rotterdam, Netherlands: Sense.

Nielsen, B. (2012). Science teachers' meaning-making when involved in a school-based professional development project. *Science Teacher Education*, *23*, 621–649. http://doi.org/10.1007/s10972-012-9300-5

Niess, M. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education*, *21*(5), 509–523. http://doi.org/10.1016/j.tate.2005.03.006

Niess, M. (2008). Guiding preservice teachers in developing TPCK. In AACTE Committee on Innovation and Technology (Ed.), *Handbook of Technological Pedagogical Content Knowledge (TPCK) for educators* (pp. 223–250). New York, NY: Routledge.

Niess, M. (2011). Investigating TPACK: Knowledge growth in teaching with technology. *Journal of Educational Computing Research*, *44*(3), 299–317. http://doi.org/10.2190/EC.44.3.c

Noss, R., Cox, R., Laurillard, D., Luckin, R., Plowman, L., Scanlon, E., & Sharples, M. (2012). System upgrade: Realising the vision for UK education. Retrieved from http://sro.sussex.ac.uk/39944/

Opfer, V. D., & Pedder, D. (2011). Conceptualizing teacher professional learning. *Review of Educational Research*, *81*(3), 376–407. http://doi.org/10.3102/0034654311413609

Palak, D., & Walls, R. T. (2009). Teachers' beliefs and technology practices: A mixed methods approach. *Journal of Research on Technology in Education*, *41*(4), 417–441. http://doi.org/http://dx.doi.org/10.1080/15391523.2009.10782537

Papert, S. (1987). Computer criticism vs. technocentric thinking. *Educational Researcher*, *16*(1), 22–30. http://doi.org/10.2307/1174251

Papert, S. (1994). *The children's machine: Rethinking school in the age of the computer*. New York, NY: HarperCollins.

Patton, M. (1980). *Qualitative evaluation methods*. Beverly Hills, CA: Sage.

Patton, M. (2002). *Qualitative research & evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage.

Perakyla, A., & Ruusuvuori, J. (2011). Analysing talk and text. In N. Denzin & Y. Lincoln (Eds.), *The Sage handbook of qualitative research* (4th ed.). Thousand Oaks, CA: SAGE.

Polly, D., & Brantley-Dias, L. (2009). TPACK: Where do we go now? *TechTrends*, *53*(5), 46–47. http://doi.org/http://dx.doi.org/10.1007/s11528-009-0324-4

Powney, J., & Watts, M. (1987). *Interviewing in educational research*. London, United Kingdom: Routledge & Kegan Paul.

Pratt, K. (2005). Searching for information from the web. In K.-W. Lai (Ed.), *e-Learning communities: Teaching and learning with the web* (pp. 157–178). Dunedin, New Zealand: University of Otago.

Pratt, K. (2009). Children's Internet searching: Where do they go wrong? *Computers in New Zealand Schools*, *21*(1).

Prensky, M. (2001). Digital natives, digital immigrants part 1. *On the Horizon*, *9*(5), 1–6. http://doi.org/10.1108/10748120110424816

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher*, *29*(1), 4–15. http://doi.org/10.3102/0013189X029001004

Resnick, L. B. (1991). Shared cognition: Thinking as social practice. In *Shared cognition: Thinking as social practice* (pp. 1–20). Washington: American Psychological Association.

Ruthven, K., Hennessy, S., & Deaney, R. (2005). Incorporating Internet resources into classroom practice: Pedagogical perspectives and strategies of secondary-school subject teachers. *Computers & Education*, *44*(1), 1–34. http://doi.org/10.1016/j.compedu.2003.11.001

Ryan, G., & Bernard, R. (2000). Data management and analysis methods. In N. Denzin & Y. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed., pp. 769–802). Thousand Oaks, CA: Sage.

Salomon, G. (2006). The systemic vs analytic study of complex learning environments. In J. Elen & R. E. Clark (Eds.), *Handling complexity in learning environments: Theory and research* (pp. 255–265). Boston, MA: Elsevier.

Savenye, W. C., & Robinson, R. S. (2004). Qualitative research issues and methods: An introduction for educational technologists. In D. Jonassen (Ed.), *Handbook of research for educational communications and technology*. Mahwah, NJ: Lawrence Erlbaum.

Sawyer, K. (2006). The new science of learning. In K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 1–16). New York, NY: Cambridge University Press.

Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences*. Cambridge, NY: Cambridge University.

Schunk, D. (2008). *Learning theories: An educational perspective* (5th ed.). Upper Saddle River, NJ: Merrill Prentice Hall.

Schwandt, T. (2000). Three epistemological stances for qualitative inquiry. In N. Denzin & Y. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed., pp. 189–214). London, United Kingdom: Sage.

Schwandt, T. A., Lincoln, Y. S., & Guba, E. G. (2007). Judging interpretations: But is it rigorous? trustworthiness and authenticity in naturalistic evaluation. *New Directions for Evaluation, 2007*(114), 11–25. http://doi.org/10.1002/ev.223

Seale, C. (1999). Quality in qualitative research. *Qualitative Inquiry*, *5*(4), 465–478. http://doi.org/10.1177/107780049900500402

Selwyn, N. (1999). Differences in educational computer use: The influence of subject cultures. *Curriculum Journal*, *10*(1), 29–48. http://doi.org/10.1080/0958517990100104

Shear, L., Gallagher, L., & Patel, D. (2011). *Innovative teaching and learning research: 2011 Findings and implications*. Retrieved from http://www.itlresearch.com/research-a-reports/2011-itl-research-findings

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14. http://doi.org/10.3102/0013189X015002004

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1–21. http://doi.org/10.17763/haer.57.1.j463w79r56455411

Siemens, G. (2004). Connectivism: A learning theory for the digital age. *eLearnspace*. Retrieved from http://www.ingedewaard.net/papers/connectivism/2005_siemens_ALearningTheoryForTheDigitalAge.pdf

So, H.-J., & Kim, B. (2009). Learning about problem based learning: Student teachers integrating technology, pedagogy and content knowledge. *Australasian Journal of Educational Technology*, *25*(1), 101–116.

Somekh, B. (2008). Factors affecting teachers' pedagogical adoption of ICT. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 449–460).

Stake, R. (2010). *Qualitative research: Studying how things work*. New York, NY: The Guilford Press.

Tapscott, D. (1999). Educating the Net generation. *Educational Leadership, 56*(5), 6–11.

Thompson, A. D., & Mishra, P. (2007). Breaking news: TPCK becomes TPACK! *Journal of Computing in Teacher Education*, *24*(2), 38–64.

Timperley, H. S., Wilson, A., Barrar, H., & Fung, I. (2008). *Teacher professional learning and development: Best evidence synthesis iteration*. Wellington, New Zealand: Ministry of Education.

Voogt, J. (2008). IT and curriculum processes: Dilemmas and challenges. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 117–132). Retrieved from 10.1007/978-0-387-73315-9_7

Voogt, J. (2010). Teacher factors associated with innovative curriculum goals and pedagogical practices: Differences between extensive and non-extensive ICT-using science teachers. *Journal of Computer Assisted Learning*, *26*(6), 453–464. http://doi.org/10.1111/j.1365-2729.2010.00373.x

Voogt, J., Erstad, O., Dede, C., & Mishra, P. (2013). Challenges to learning and schooling in the digital networked world of the 21st century. *Journal of Computer Assisted Learning*, *29*(5), 403–413. http://doi.org/10.1111/jcal.12029

Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & van Braak, J. (2013). Technological Pedagogical Content Knowledge - A review of the literature. *Journal of Computer Assisted Learning*, *29*, 109–121. http://doi.org/10.1111/j.1365-2729.2012.00487.x

Wallace, R. M. (2004). A framework for understanding teaching with the Internet. *American Educational Research Journal*, *41*(2), 447–488. http://doi.org/10.3102/00028312041002447

Watson, G. (2006). Technology professional development: Long-term effects on teacher self-efficacy. *Journal of Technology and Teacher Education*, *14*(1), 151–165.

Webb, M. (2005). Affordances of ICT in science learning: Implications for an integrated pedagogy. *International Journal of Science Education*, *27*(6), 705–735. http://doi.org/10.1080/09500690500038520

Webb, M., & Cox, M. (2004). A review of pedagogy related to information and communications technology. *Technology, Pedagogy and Education*, *13*(3), 235. http://doi.org/10.1080/14759390400200183

Wetzel, K., & Marshall, S. (2011). TPACK goes to sixth grade: Lessons from a middle school teacher in a high-technology-access classroom. *Journal of Digital Learning in Teacher Education*, *28*(2), 73–81. http://doi.org/10.1080/21532974.2011.10784683

Wright, N. (2010). *e-Learning and implications for New Zealand schools: A literature review*. Ministry of Education. Retrieved from http://edcounts.squiz.net.nz/__data/assets/pdf_file/0006/77667/948_ELearnLitReview.pdf

Zhao, Y., & Frank, K. A. (2003). Factors affecting technology uses in schools: An ecological perspective. *American Educational Research Journal*, *40*(4), 807–840. http://doi.org/10.3102/00028312040004807

Zhao, Y., Pugh, K., Sheldon, S., & Byers, J. (2002). Conditions for classroom technology innovations. *The Teachers College Record*, *104*(3), 482–515. http://doi.org/10.1111/1467-9620.00170

APPENDIX A: SEMI-STRUCTURED INTERVIEW QUESTIONS

Questions for interview one

1. Tell me about your background in teaching. E.g., previous work experience/career, years teaching/teaching technology curriculum, years in current position.
2. How would you describe your school? E.g., size, decile, clientele, special character, type of community served.
3. Can you tell me about your technology department and implementation of the technology curriculum. E.g., Number of teachers, number of classes at junior and senior level, time allocated, technology areas taught/integrated, programme consistency/alignment across department, student attitudes to technology.
4. Please describe your department ICT facilities and access, including Internet, technical support and PD. E.g., how much, how often, nature of, how helpful.
5. Please can you tell me about your background experience, and confidence in using computers and the Internet both personally and in teaching.
6. What are the main challenges you face integrating Web-based resources in your teaching? How do you overcome the challenges?
7. How do you currently use Web-based resources in teaching technology? E.g., purpose/type of content, teaching strategies/activities, frequency of use.
8. Please describe how your current use of Web-based resources impacts on your teaching? E.g., preparation, classroom organisation and management, interaction with students.
9. Please describe how your current use of Web-based resources impacts on student learning? E.g., engagement, attitudes, understanding of concepts, level of thinking and application knowledge.

Questions for interview two

To support this interview please have your original and current planning documents for the unit highlighting changes you've made to integrate WBRs. Also, any supporting documents, for example, student information, worksheets, etc. Examples of student work may also be useful to illustrate impacts on learning, and to support discussion.

1. (A) Can you tell me about the unit of work you are implementing that uses web-based resources? (B) Why you have chosen this unit to work with?
2. (A) What WBRs are you using in the unit?

   (B) What technology ideas & concepts are they supporting?
3. Why have you chosen these particular WBRs for this particular content?

   (Eg, do they represent these particular concepts in new ways or more clearly than more traditional resources?)
4. (A) What scaffolding strategies have you used/planned to use to support student learning with the WBRs? (B) And how do you feel they have or will support learning? E.g., Student information and worksheets, student-student or teacher-student interactions, other resources, key questions, etc.
5. How is this different from how you previously taught (or might have taught) this content? E.g., Resources used, teaching strategies used, interaction in classroom, etc.
6. (A) How do you think using these WBRs has impacted on student engagement? (B) Can you give me some examples?
7. (A) In what ways do you think integrating these WBRs has impacted on student learning or understanding of specific ideas & concepts?

   (B) Can you give me some examples?
8. Do you think it has deepened or broadened understanding? If so, how and why? Do you have any examples of student work that illustrate this?
9. (A) Based on your experience using WBRs and supporting strategies so far, would you consider making any changes in your use of WBRs in the rest of

the unit or next time you teach it? (B) If so what might those changes be and why?

10. What challenges have you faced in using WBRs in this unit of work? And how have you managed these? E.g., finding relevant and appropriate WBRs, developing supporting resources, technical issues, computer and internet access, organising and managing the class etc.
11. Would you say that using WBRs in the classroom is different from what you expected?

Questions for interview three

1. Tell me about the final outcome of the unit of work using WBRs? E.g., student learning, how students responded, and how you felt about the experience, egs of student work?
2. How does this compare with teaching a similar unit previously?
3. Can you tell me more about what you did with WBRs in the unit? E.g., what WBRs you used, teaching strategies, examples of teaching resources developed?
4. What worked well and what would you change - how and why?
5. What were the surprises?
6. Has this impacted on your use of WBRs in other classes? If so, how?
7. So what do you think are the benefits of using WBRs in teaching?
8. Would you say that WBRs have particular value for the technology curriculum? Why? Examples?
9. What sorts of WBRs have you found particularly helpful for technology? Why? Examples?
10. Can you tell me how you think you might build on your experiences with WBRs next year?
11. Can you tell me how you felt about the online forum?

APPENDIX B: LETTER TO PRINCIPALS

The Principal
xxx
xxx

10 February, 2011

Dear

I am currently carrying out research for my doctorate degree at the University of Waikato. My interest lies in how online resources can be used effectively to enhance teaching and learning in technology. I am seeking your approval to invite xxx from your school, who has already expressed an interest, to be involved in the study. This letter briefly explains what my study involves and what you may need to consider before agreeing to participate.

To gather my data in your school I will carry out a case study of the teachers' ongoing experiences implementing a unit of work which integrates the use of online resources.

The teachers' participation in this case study research will involve:

- three individual interviews of about 45 minutes at the beginning, middle and end of a unit of work in 2011;
- participation in a group workshop with approximately seven other participants to share preliminary research findings and strategies for integrating online resources into classroom teaching. We will also explore the Biotechnology Learning Hub resources and how these and others may be integrated into an existing unit of work;
- participation in an online forum for discussion and collaboration with the other participants during the implementation of the unit of work;
- if it is deemed relevant and appropriate, some classroom observation sessions;
- participation in a final workshop with the other participants in term four 2011, to evaluate the strategies used and the impact on student learning.

Teachers will have the opportunity to see transcribed notes of their interviews to ensure they are accurate records of their responses.

Any reports of the research findings will present broad themes only and the identities of the teachers and your school will be carefully protected. Where selected data from transcribed material is used to support the summary of themes, I will use pseudonyms to prevent identification. The findings will be presented as part of my doctoral thesis, at seminars and conferences, and published in research journals to help others involved in technology education and developing online resources, to understand the issues.

If you would like to know more, or meet with me to discuss the project before making a decision, please feel free to contact me. I am happy to elaborate on any points or discuss any concerns. My contact details are:

Home phone number:	07 834 9299
Work phone number:	07 8384500 ext 6664
e-mail:	jmangan@waikato.ac.nz

If you agree to xxx involvement please record your contact details and signature on the consent form enclosed and return it to me in the stamped, addressed envelope. Once I have received your consent I will make contact with xxx and formally invite her to participate.

Having agreed to be involved in this research, if you have any questions or concerns about the project you can contact:

My supervisor: Dr Mike Forret: mforret@waikato.ac.nz
Dean of the Faculty of Education: Dr Alister Jones: ajones@waikato.ac.nz

I look forward to hearing from you.

Kind regards,

Jenny Mangan

Research Invitation Principal's Acceptance

I have read the proposal in this letter and am happy to accept the invitation for my school to participate. I understand that the teacher/s will be involved in:

- three individual interviews ☐
- two workshops ☐
- an online forum, and potentially ☐
- some classroom observation sessions ☐

My contact details are:

*Name:*____

*School:*____

*Signature:*____

*Date:*____

*Email:*____

*Phone:*____

Please return the completed form in the enclosed envelope.

APPENDIX C: LETTER TO PARTICIPANTS

Dear

I am currently carrying out research for my doctorate degree in education at the University of Waikato. My interest lies in how online resources can be used effectively to enhance teaching and learning in technology. I am inviting you to participate in this research, as your views are important in helping to understand the issues involved. Your participation is entirely voluntary and you will have the right to withdraw at any time. This letter briefly explains what my study involves and what you may need to consider before agreeing to participate.

To gather my data I would carry out a case study of your ongoing experiences implementing a unit of work with one class that integrates the use of online resources.

Your participation in this case study research will involve:

1. three individual interviews lasting about 45 minutes at the beginning, middle and end of a unit of work in 2011;
2. participation in a group workshop with approximately seven other case study research participants to share preliminary research findings and present strategies for integrating online resources into classroom teaching. We will explore the Biotechnology Learning Hub resources and how these and others could be integrated into a unit of work for teaching in term two or three, 2011;
3. participation in an online forum for discussion and collaboration with the other participants during the implementation of the unit of work;
4. if it is deemed relevant and appropriate, some classroom observation sessions;
5. participation in a final group workshop with the other participants in term four 2011, to evaluate the strategies used and the impact on student learning.

You will have the opportunity to see transcribed notes of your interviews to ensure they are accurate records of your responses.

Any reports of the research findings will present broad themes only and the identities of yourself and your school will be carefully protected. Where selected data from transcribed material is used to support the summary of themes, I will use pseudonyms to again prevent identification. The findings will be presented as part of my doctoral thesis, at seminars and conferences, and published in research journals to help others involved in technology education and developing online resources, to understand the issues.

If you would like to know more, or meet with me to discuss the project before making a decision, please feel free to contact me. I am happy to elaborate on any points or discuss any concerns. My contact details are:

Home phone number	07 8349299
Work phone number	07 838 4500 ext 6664
e-mail:	jmangan@waikato.ac.nz

If you agree to participate and feel happy with this information, please record your contact details and signature on the consent form enclosed and return it to me in the stamped, addressed envelope. Once I have received your consent I will contact you to arrange times for the first stage of the research.

Having agreed to participate in this research if you have any questions or concerns about the project you can contact:

My supervisor: Dr Mike Forret: mforret@waikato.ac.nz
The Dean of the Faculty of Education: Dr Alister Jones: ajones@waikato.ac.nz

I look forward to hearing from you.

Kind regards

Jenny Mangan

Research Invitation Teacher's Acceptance

I have read the proposal in this letter and am happy to accept the invitation to participate in this research. By giving my consent I understand that I will be involved in:

- three individual interviews ☐
- two workshops ☐
- an online forum, and potentially ☐
- some classroom observation sessions ☐

My contact details are:

Name:____

Signature:____

Date:____

Email:____

Phone:____

Mobile:____

Address:____

Please return the completed form in the enclosed envelope.

APPENDIX D: ETHICS APPROVAL

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THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

MEMORANDUM

To:	**Jennifer Mangan**
cc:	Dr Mike Forret; Dr Margaret Franken
From:	**Dr Rosemary De Luca** Faculty of Education Research Ethics Committee
Date:	23 July 2010
Subject:	Supervised Postgraduate Research – Ethical Approval – FOE071/10

Thank you for submitting the amendments to your research proposal:

Effective use of internet resources to enhance teaching and learning in technology

I am pleased to advise that your application has received ethical approval.

Please note that researchers are asked to consult with the Faculty's Research Ethics Committee in the first instance if any changes to the approved research design are proposed.

The Committee wishes you all the best with your research.

Rosemary De Luca

Dr Rosemary De Luca
Chairperson - Faculty of Education Research Ethics Committee

APPENDIX E: ETHICS APPROVAL OF REQUESTED CHANGE

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THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

MEMORANDUM

To:	**Jennifer Mangan**
cc:	Dr Mike Forret; Dr Margaret Franken
From:	**Professor Roger Moltzen** Faculty of Education Research Ethics Committee
Date:	18 November 2010
Subject:	Supervised Postgraduate Research – FOE071/10 – Further Changes

Thank you for submitting the proposed changes to the project *Effective use of internet resources to enhance teaching and learning in technology* approved in July 2010.

It is noted that there will be no change to the project other than the inclusion of a third interview (mid-way through the project) of the same participants.

I am pleased to advise that ethical approval has been granted for the addition of a third interview and for the questions as tabled in your documentation. A copy of this approval memo related correspondence will be filed with the original documentation – Mangan FOE071/10.

Professor Roger Moltzen
Chairperson
Faculty of Education Research Ethics Committee

APPENDIX F: ACADEMIC READING ABSTRACT

Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge

PUNYA MISHRA

MATTHEW J. KOEHLER1

Michigan State University

Abstract

Research in the area of educational technology has often been critiqued for a lack of theoretical grounding. In this article we propose a conceptual framework for educational technology by building on Shulman's formulation of ''pedagogical content knowledge'' and extend it to the phenomenon of teachers integrating technology into their pedagogy. This framework is the result of 5 years of work on a program of research focused on teacher professional development and faculty development in higher education. It attempts to capture some of the essential qualities of teacher knowledge required for technology integration in teaching, while addressing the complex, multifaceted, and situated nature of this knowledge. We argue, briefly, that thoughtful pedagogical uses of technology require the development of a complex, situated form of knowledge that we call Technological Pedagogical Content Knowledge (TPCK). In doing so, we posit the complex roles of, and interplay among, three main components of learning environments: content, pedagogy, and technology. We argue that this model has much to offer to discussions of technology integration at multiple levels: theoretical, pedagogical, and methodological. In this article, we describe the theory behind our framework, provide examples of our teaching approach based upon the framework, and illustrate the methodological contributions that have resulted from this work.

APPENDIX G: WORKSHOP ONE PROGRAMME

9.30 – 10.15am Slides 1-14	Introductions and introduction to the workshop About the research Background – what led me to this research project? - brief overview of Biotech Hub - discussion of technology and implementing the new strands Why integrate WBRs? The current situation and key challenges? Research findings from literature as well as survey & interview
Morning tea	
10.45 -12.30 Slides 15-23	Introduce the TPACK framework (refer to reading given at I/V) Building on PCK – some background to PCK and – as experienced teachers they already possess this Developing TPACK - review the TPACK framework - ideas on developing TPACK – from literature Teachers share their use of one WBR Summarise common themes Activity: In pairs fit the common themes onto relevant section of the TPCK framework
Lunch	
1.15-2.45 Slides 24-32	Moving forward: Affordances & constraints, teachers' role Activity: evaluate affordances & constraints of one WBR in pairs – present advice you'd give to other teachers about how to use it in technology Feedback to group
2.45-3.30 Slides 33-38	What next? Incorporating WBRs into a unit of work Questions to consider Sharing and contributing to moodle Sharing the unit of work 3 things to try Conclusion - recap