

**An Elementary Teacher's Feelings of Self-Efficacy,
Needs, and Pedagogical Strategies When Learning to Use
the Interactive Whiteboard to Teach Science**

by

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Abstract

Studies have shown elementary teachers may not be well prepared to use technology in their classrooms. This study examines one elementary teacher's feelings of technology self-efficacy (TSE), needs and pedagogical strategies when using the interactive whiteboard (IWB) to teach elementary science. It employed a single case study design, where the researcher and participant worked together during supportive professional development (PD) sessions. Data sources are twelve PD sessions, the Computer Technology Integration Survey (adapted for IWB use in the classroom), and two interviews, three in-class observations of IWB science lessons, and three lesson debriefs. Descriptive and thematic analysis show the participant's TSE was positively influenced by the PD. Five factors were determined to influence TSE: the participant's level of interest, attitude, experience with technology, student assistance, and familiarity with the setting. Teacher, contextual and IWB- level needs were explained. Pedagogical strategies for technology use based on interactive IWB features are also discussed. Findings could contribute to current trends in teacher PD, continuing education, and preservice teaching programs related to science teaching.

Key Words: Interactive Whiteboard (IWB); Science Education; Technology Self-Efficacy (TSE); Technological Needs; Pedagogical Strategies Using Technology; IWB Tools; Technology Integration; Thematic Analysis; Professional Development (PD); Elementary Science Teaching.

Résumé

Plusieurs enseignants ne sont pas bien préparés pour utiliser la technologie en classe. En particulier, le tableau blanc interactif (TBI) n'est pas utilisé de façon optimale par les enseignants lorsqu'ils enseignent les sciences et la technologie à l'élémentaire. Cette thèse présente l'étude de cas unique d'une enseignante de l'élémentaire ayant cheminé dans un processus de développement professionnel (DP) pour l'aider à intégrer le TBI en sciences et technologie. Douze sessions de DP, un questionnaire sur l'efficacité avec le TBI (CTIS adapté), deux entrevues, trois sessions d'observation en classe et trois discussions sur les leçons constituent les sources de données. La participante est devenue plus confiante pour utiliser le TBI suite au DP.

Elle a rehaussé son sentiment d'autoefficacité et accru son intérêt et sa connaissance du TBI. Elle a acquis des compétences techniques et une connaissance des contenus d'enseignement adaptés au TBI, bien que plusieurs besoins perdurent. Certaines stratégies pédagogiques avec le TBI expérimentées en classe par l'enseignante sont discutées. Cette thèse peut contribuer à fournir des pistes pour aider les enseignants au primaire à mieux intégrer le TBI en sciences et technologie, que ce soit lors de leur formation initiale à l'enseignement ou en cours d'emploi.

Mots clés : Tableau blanc interactif (TBI); l'enseignement des sciences au primaire; sentiment d'autoefficacité avec la technologie; besoins technologiques des enseignants; stratégies pédagogique avec le TBI; outils du TBI; l'intégration des technologies en salle de classe; analyse thématique; développement professionnel (DP); l'enseignement des sciences à l'élémentaire.

Dedication

This thesis is lovingly dedicated to my mother, Monique Sauvé Roy, who has been there for me every step of the way.

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It would not have been possible to write this thesis without a network of supportive people around me, some of whom I will give particular mention here.

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List of Acronyms and Abbreviations

CTIS - Computer Technology Integration Survey

ICT – Information Communication Technology

IWB - Interactive Whiteboard (e.g., SMART Board)

PD – Professional Development

TSE – Technology Self-Efficacy

Legend for Source Referencing

f. i. – final interview

f. d. – first debrief

i. i. – initial interview

s. d. – second debrief

t. d. – third debrief

Note: All sources are referenced by their line number as displayed in *NVivo*.

Introduction

Technology is one of the major focuses in developing school infrastructure, policy and curriculum as it can be used as a powerful tool in the teaching and learning process (Roblyer, 2006). Teachers are encouraged to use information communication technologies (ICTs), any traditional computer-based and digital communication technologies, to enhance the teaching and learning processes. ICTs can assist science teachers to increase student engagement in their learning by incorporating them in the presentation of scientific texts and lectures, discussions and collaborations, data collection and representation, and simulation and modeling (Kershner, Mercer, Warwick, & Staarman, 2010; Linn, 2003; Murcia, 2008; Schnittka & Bell, 2009). “Educational” technologies, those that can be used in the classroom to aid in the advancement of student learning such as computers, interactive whiteboards (IWBs) such as the SMART Board, tablets, android phones, internet access, and online resources, have also been shown to play a significant role in enhancing student learning and stimulating interest in the sciences (Hennessy, Deane, Ruthven, & Winterbottom, 2007a; Murcia, 2008).

Science education plays a critical role in developing scientific literacy, as science class can provide as student with a unique skill set including critical thinking, inquiry, and problem-solving in order to make well-informed decisions as citizens (Knighton, Brochu, & Gluszynski, 2010). As student attitudes and experiences in learning science are connected to competencies that are central to developing scientific literacy, it is imperative science be taught in a way to which students can relate as they recognize the application of scientific concepts in society (Murcia, 2008). Given the importance of scientific literacy, teachers should find meaningful ways of presenting scientific concepts to their students and maintain student interest to ensure the longevity of science. Research has shown elementary teachers to lack confidence when teaching science and many teachers are not well prepared to use the technology in their classroom (Coates, 2006; Dionne & Couture, 2010; 2013). Therefore, adequate professional development (PD) should be provided in order to assist elementary teachers to make better use of technology such as the IWB when teaching the science (Desantis, 2012; Kumar, Rose, & D’Silva, 2008; Murcia, 2008). Limited research examines the ways in which educators can be assisted when learning to integrate ICTs in the science classroom (Chaplin, 2003; Higgins & Spitulnik, 2008;

Taylor & Corrigan, 2006). There is also a limited understanding of how pedagogy is developing in response to IWBs (Schuck & Kearny, 2007), especially in their application to science teaching (Hennessy et al., 2007b).

This thesis is divided into six chapters:

The first chapter summarizes the existing literature starting with contextualizing scientific literacy in Canada and technology integration in Ontario schools. This precedes the contextual framing of the key concepts of this thesis leading into the research rationale and guiding questions.

Chapter 2, the conceptual framework, defines the key construct of this research, namely technology self-efficacy (TSE), and its role in facilitating teacher change when learning to use technology to teach science. This chapter also delineates the link between self-efficacy and PD and presents a framework for categorizing teachers' needs when learning to use the IWB. The notion of interactivity in the science classroom and pedagogical strategies for IWB integration in the science classroom are also presented.

The methodology is the subject of chapter 3, which introduces the details of the research design and the systematic process involved for collecting and analyzing the data. This includes details of the PD sessions format and schedule, the researcher's epistemological stance, as well as the data sources and their respective descriptive and thematic analyses.

Chapter 4 is the presentation of the results, which are organized relative to the research questions. The discussion of these results, along within the supporting literature, are the focus of chapter 5.

The final chapter is an article based on the results associated with feelings of TSE and PD needs when using the IWB to teach science that will be submitted to a peer-reviewed journal for publication. Results associated with the pedagogical strategies and IWB tools for teaching science at the elementary level will be the focus of a different article, to be submitted for publication to another journal at a later date. Anticipated contributions of this study and a brief conclusion summarizing main findings are presented at the end of this thesis.

Chapter 1: Literature Review and Research Problem

This chapter situates the current study within the body of literature and introduces the research problem. First, the importance of developing scientific literacy through science education is explained as well as the potential of technology as a teaching tool to enhance science teaching. Other critical concepts underpinning this thesis, such as technology self-efficacy (TSE,) PD needs, and pedagogical strategies when learning to use an IWB in science teaching are discussed within the literature, leading to the research rationale and questions.

1.1 The Importance of Developing Scientific Literacy in Canada

The Organisation for Economic Co-operation and Development (OECD) Program on International Student Achievement (PISA) defines scientific literacy as “the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity” (Knighton et al., 2010, p.29). One who is scientifically literate can be described as

a person [who] can ask, find, or determine answers to questions derived from curiosity about everyday experiences. This means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science and to engage in social conversation about the validity of conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately. (National Research Council, 1996, p.22)

Science education plays an essential role in developing scientific literacy, which includes providing students with skills to have an informed and active role in the community. Experiential science learning can enable students to develop critical thinking and problem-solving capabilities that can improve the quality of their own lives by making informed decisions and creatively exploring and understanding the world around them (Knox & Schmidt, 2006). The goals for Canadian science education are explained in *The Common Framework of Science Learning*

Outcomes K to 12, and include (1) encouraging students at all grade levels to develop a critical sense of wonder and curiosity about scientific and technological endeavours; (2) enabling students to use science and technology to acquire new knowledge and solve problems; (3) preparing students to critically address science-related societal, economic, ethical, and environmental issues; and (4) providing students with a foundation in science that creates opportunities in terms of science-related occupations and/or science-related hobbies appropriate to their interests and abilities (Council of Ministers of Education, Canada, 1997). With science and technology playing a significant role in modern-day society, scientific literacy is not only a key outcome of education for all students, but also for those who aren't pursuing a science-related career (Orpwood, Schmidt, & Jun, 2012). Therefore, science education has a distinctive interconnectedness with real-life application and can have a profound impact on students' lives.

On an international stage, Canada scored above the OECD average ranking seventh out of sixty-five countries in the science domain of the PISA 2009 test (Fig. I). The PISA test is designed to evaluate students' ability to recognize and use scientific information and logically apply this information to explain natural phenomena. Ontario was among the Canadian provinces that performed above the OECD average and at the Canadian average in science. Although Canada's results have been stable from 2003 to 2009, there is concern that approximately one-third of Canadian youth are not performing at expected levels as student performance fell in 2004 compared to 1999 (Knox & Schmidt, 2006). In order to compete in an economic culture based on science and innovation, stimulating student interest in the sciences could increase the number of young people pursuing science-related careers, which could elicit success globally in the scientifically-driven and knowledge-based economies of the 21st century (Orpwood et al., 2012).

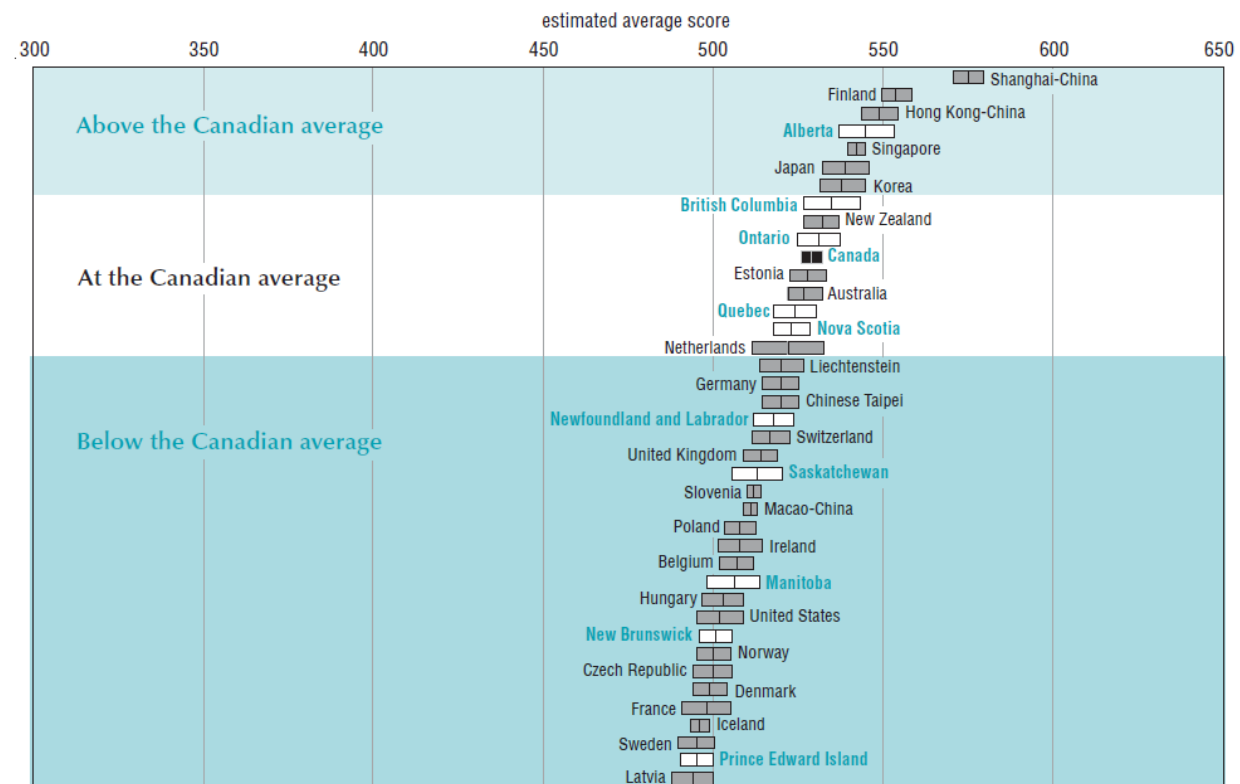


Figure I: A cross-section of the figure in the 2009 PISA Report ranking Canada sixth out of sixty-five in science performance on an international level (p.32).

Examining student knowledge and attitudes toward science have been found to contribute to students' competencies that are central to developing scientific literacy (Knighton et al., 2010). The development of scientific literacy is best supported when teachers create an instructional environment that engages students in active inquiry, problem solving and decision making (Council of Ministers of Education, Canada, 1997). This source also states that science learning activities should be set in meaningful contexts to promote a sense of discovery and invite students to see its significance to their lives on technological, societal and environmental levels. The use of ICTs to teach science can assist teachers in increasing student engagement in their learning because students can relate to technology (Abduwa-Ogiebaen, 2009; Murcia & Sheffield, 2010).

1.2 Technology Integration in Ontario Schools

The integration of technology into curriculum is one of a series of strategies being implemented in Canadian schools to enhance the learning process. In the province of Ontario, several official documents encourage teachers to use ICTs to facilitate student learning. The Ontario Ministry of Education released a document titled *Schools on the Move: Lighthouse Program* in 2008, which suggests teachers increase the use of technologies in their classrooms as a strategy to enhance student engagement and improve literacy and numeracy achievement (Ministry of Education, 2008). In addition, both the Ontario Arts, and Science and Technology curricula articulate the importance of ICTs in the teaching of their respective subjects by outlining the role of ICTs in extending teachers' instructional strategies and supporting student learning (The Ontario Curriculum, Grades 1-8: Arts, 2009; The Ontario Curriculum, Grades 1-8: Science and Technology, 2007). Specifically, multimedia sources and software for musical notation, animation, video editing and graphic design are encouraged in arts teaching, as they can be helpful for students to collect, organize, edit, sort, write and present their findings (The Ontario Curriculum, Grades 1-8: Arts, 2009). Equally, incorporating computer programs, databases, internet resources and simulations can enrich the learning experience, while also enabling students to be connected to the global community (The Ontario Curriculum, Grades 1-8: Science and Technology, 2007). When used properly, technology can support components of learning such as active engagement, collaboration, frequent interaction and feedback, and connection to real-world experts (Hew & Brush, 2007; Jonassen, 2000).

With curriculum guidelines supporting technology integration, the Ontario Ministry is also considering the influence of ICTs on teaching practices. A challenge for incorporating technology in the classroom is providing teachers with the necessary skills to learn how to effectively use ICT to engage students and enhance their learning (Plante & Beattie, 2004). An Ontario Ministry document, *A Shifting Landscape: Pedagogy, Technology, and the New Terrain of Innovation in a Digital World* (2012), outlines a project by the Lakehead District School Board which focuses on the use of the IWB as a tool to support innovative teaching practices. This project enables teachers to more easily enhance their lessons by adding relevancy and creativity. It also considers teachers' confidence and use of the IWB. The way teachers use the

IWB in their practice is also discussed in *What Works? Research Into Practice* (a research monograph released by the Ministry of Ontario by Bruce, 2012), which considers the IWB's teaching and learning potential in the mathematics classroom.

1.3 The Use of Technology to Support Science Teaching

Elementary teachers may experience difficulties when teaching science, and this is often due to a lack of confidence in science content knowledge, preparation in inquiry teaching, and exposure to real-life classroom contexts (Dionne & Couture, 2010; 2013; Yoon, Joung, & Kim, 2012). Coates (2006) identified main categories of elementary teachers' concerns when teaching science and these included understanding scientific concepts (science knowledge), performing science investigations, and organizing science teaching to allow for extension and differentiation, especially for gifted and talented children. Furthermore, elementary teachers can be hesitant to implementing new instructional methods in science because of a lack of resources, including both equipment and curriculum materials (Schnittka & Bell, 2009).

ICTs have been shown to assist teachers in gaining a better understanding of science, establishing various strategies for teaching science, and locating meaningful science resources for their classroom (Duran, Brunvand, & Fossum, 2009b). With ICTs being integrated into curriculum, teachers are challenged to reshape the way they present scientific concepts to their students as part of an incentive to motivate and relate to the new technologically-savvy generation of students (Abduwa-Ogiebaen, 2009; Hargreaves, Earl, Moore, & Manning, 2001; Murcia, 2008). IWBs are reported to be an effective way for teachers to interact and integrate digital content and multimedia learning resources in the classroom (Murcia & Sheffield, 2010). It enables students and teachers to interact with all functions of a desktop computer through a large surface, providing a space for interactive communication and exploration of ideas between teacher and student (Murcia, 2008). Therefore, incorporating the IWB as part of a science teaching tool could provide the necessary resources and information needed to increase their confidence when presenting scientific concepts to their students.

1.4 The Use of the IWB to Support Science Teaching

The IWB is part of an interactive display system (IDS), which consists of a computer, digital projector, and Internet connection to support science teaching and learning (Schnittka & Bell, 2009). It enables teachers and students to interact with a desktop computer through the board's large touch sensitive surface, with the IWB acting as a port through which any computer run ICT function can be displayed and interacted with (Murcia & Sheffield, 2010). This means that the IWB can enhance the benefits of computer-based learning, such as the use of interactive websites and ICT, by sharing this experience with the whole class, or small-group learning, without being hidden behind a desktop screen or isolating learners at a computer. As the use of technology for instruction can vary depending on its classroom purpose and the inherent challenges each one may present, the IWB and its use in science teaching can be considered distinct from using other technologies for instructional purposes (Schnittka & Bell, 2009). It can be distinguished from other technologies in science teaching because of its interactive nature, its ability to link to internet sites and online activities, and the support it provides to a range of learning styles (Beauchamp & Parkinson, 2005; Hennessy et al., 2007b; Mohon, 2008; Murcia, 2008). Thus, the IWB will be examined as a subset of the umbrella concept of “educational technologies” as it presents unique opportunities for science teaching in terms of online access and pedagogical strategies.

The use of the IWB as an instructional tool has been found to have several benefits for student learning. Morgan (2008) reported a positive change in student response as students are better engaged and motivated throughout the lesson. The use of an IWB in a classroom can also be an opportunity for teachers to create shared dialogue space between students as students are encouraged to co-construct knowledge (Warwick, Mercer, Kershner, & Staarman, 2010). It is also a means by which the teacher is encouraged to use rich resources, appropriate pacing, and multimodal presentation throughout a lesson (Rivers 2009). Also, it can be a means to increase interactivity between teacher and students through digital culture (Schuck & Kearney, 2007). Although several benefits have been recorded, Warwick et al. (2010) caution the most important contributor to the IWB as part of an effective learning environment is the teacher who becomes the facilitator of the collaborative environment and who outlines learning objectives and devises

tasks which use board affordances to promote active learning. Similarly, whether technology can improve student learning and impact student success depends on many factors such as the teacher's 'effectiveness' and teaching ability (Zhao, Pugh, Sheldon, & Byers, 2002).

The IWB can be a useful tool to assist teachers in developing teaching resources for their elementary science classroom. It has been shown to facilitate science lesson planning by enabling teachers to access to real life science contexts and support a wide range of learning styles, ultimately placing the students at the centre of the learning by encouraging interactivity in the classroom (Beauchamp & Parkinson, 2005; Murcia, 2008). Hackling and Prain (2005) argue the IWB to be conducive to effective science teaching, which they define as creating life and community relevant science learning experiences, promoting active engagement and inquiry-based learning and focusing on outcomes that contribute to scientific literacy. In their study, teachers used the IWB during science lessons as a means of presenting online science resources, organizing hands-on experiments, facilitating minds-on discussion questions, and providing interactive experiences for their students. This is consistent with findings from Rivers (2009), who concluded elementary science teachers who used IWBs incorporated more resources to accommodate learning objectives and the varied abilities and learning styles of their students. Additionally, Schuck and Kearney (2007) investigated the use of IWB in K-12 science pedagogy in primary and secondary schools in Australia and found the IWB to be beneficial for teachers for its ease of use, value as a catalyst for teacher learning, and flexibility for lesson diversity. With the IWB acting as a toolbox of resources, teachers are able to create an "active science learning" environment where real-life and meaningful science contexts are presented to students and a range of learning styles are supported (Hackling & Prain, 2005; Murica, 2008). This approach not only promotes strong problem-solving skills and conceptual knowledge required in science learning, but also places the students at the centre of the learning. Finally, the IWB supports specific technology-integrated pedagogical approaches to science teaching that supports student engagement in an interactive classroom environment, which is further developed in section 2.7.

1.5 Technology Self-Efficacy (TSE) and Science Teaching

Several factors are considered to be crucial for successful integration and development of technologies in educational practice and these apply to teaching when using the IWB in science. Factors including the teacher's personality, self-concept, attitudes, motivation and needs have been shown to influence technology integration in classrooms (Paraskeva, Bouta, & Papagianni, 2008). Research has shown there is a link between high levels of teacher self-efficacy and increased student achievement (Ross, Hogaboam-Gray & Hannay (2001) in Watson, 2006). Given the potential benefits IWBs have to offer teachers and students, it is imperative that known barriers such as low self-efficacy when using technology be addressed in order to find ways to encourage teachers to effectively integrate the IWB in science classrooms.

Self-efficacy may be defined as the belief in one's own abilities to perform an action or activity necessary to achieve a goal or task (Bandura, 1977, as cited in Watson, 2006). An important question for educators is how self-efficacy and outcome expectancy beliefs are related to teaching performance (Bleicher & Lindgren, 2005). Based on Bandura's definition, people with low self-efficacy tend to dislike being in situations where they feel they have little control or ability to handle a task; low self-efficacy toward technology integration is likely to lead to high levels of anxiety, possibly leading to some resistance when asked to incorporate technology in the classroom (Kovalchick, Milman, & Elizabeth, 1998). More specifically, technological self-efficacy (TSE) can be defined as the judgement of one's capability to successfully perform a technologically-sophisticated task (Farah, 2011). "Teacher self-efficacy" and "technology self-efficacy" are further discussed in chapter 2, as part of the conceptual framework.

Recent studies have focused on determining which factors affect teachers' feelings of self-efficacy when integrating general technologies in the classroom. Paraskeva et al. (2008) examined the relationship between individual characteristics of secondary school teachers and computer self-efficacy, general feelings of self-efficacy compared to computer self-efficacy, as well as teacher prospects with regard to technologies. Multiple factors influence teachers' TSE on personal, behavioural and environmental levels (Farah, 2011). Personal factors, including subject matter, gender, and teaching experience are also strongly associated with teachers' attitudes and perceptions toward classroom technology usage (Jimoyiannis & Komis, 2007).

Frequency of technology use and teachers' beliefs were also found to be important in influencing technology self-efficacy. Furthermore, studies have shown that technology must become personally meaningful to teachers before they use it in a way that is helpful for students when learning science (Holden & Rada, 2011).

Consideration of teachers' self-efficacy has also been prevalent in the study of science teaching. Bandura's (1981) concept of self-efficacy may explain teachers' thought processes and behaviours related to science teaching and its impact on the quality of teaching and student learning (Duran et al., 2009b). Studies such as Lumpe, Haney, and Czerniak (2000) and Duran, Ballone-Duran, Haney, and Beltyukova (2009a) elaborate on this topic, with special focuses on PD programs in science and the improvement of science teaching self-efficacy. To the researcher's knowledge, no studies were found which examine a combination of teachers' feelings of technological self-efficacy, particularly for IWB use, in the context of elementary science teaching.

1.6 PD Needs When Learning to Use Technology to Teach Science

As teachers' response to technology integration is influenced by the extent to which they develop technology proficiency skills and feel confident in their own use of technology, studies have focused on determining their needs as they learn to use technology in their classroom (Williams, Coles, Richardson, Wilson, & Tuson, 2000). Aduwa-Ogiegbaen (2009) assessed Nigerian inservice teachers' technological skills and competencies to determine their needs in key areas of ICT. Their findings indicate PD should focus on developing a variety of technological skills in order for educators to assemble them to find ways to integrate into their curriculum. Williams et al. (2000) surveyed primary and secondary teachers' needs in terms of developing their ICT skills and suggested PD in technology should provide teachers with ongoing access to technology to develop technological proficiency as well as a supportive organisational culture (e.g., sharing of resources and IWB lessons). Donovan, Hartley and Strudler (2007) designed PD in integrating laptop computers with teachers' needs in mind and found teachers' initial situation (e.g., concerns, teaching routines, level of computer proficiency,

etc.) must be considered when planning their PD and reassessed periodically throughout to ensure it is in accordance with teachers' needs.

Others studies acknowledge teachers' needs when learning to use technology for teaching science. A study by Klieger, Ben-Hur and Bar-Yossef (2010) examined attitudes of science teachers to the integration of laptop computers and toward technology PD. They found that creating meaningful experiences by integrating the laptop computer in teachers' content field and having a support system in place for classroom and areas relating to technological management were found to positively influence teachers' use of technology in their classroom. Flick and Bell (2000) established a set of guidelines for preparing science teachers to use technology, which include introducing technology in the context of science content and taking advantage of specific technology features which cater to science instruction. Taylor and Corrigan (2006) examined the specific needs of primary teachers when learning to use ICTs to teach science. They suggested ways to effectively assist teachers in using ICTs in science by developing an action research plan to develop confidence and self-reliance amongst primary teachers when teaching the science curriculum.

1.7 PD Needs When Learning to Use the IWB to Teach Science

Teachers need to be well-prepared to use technology to teach elementary science as it requires they integrate multiple content areas and skills holistically in the science classroom (Kumar, Rose, & D'Silva, 2008). What the IWB can offer in terms of variety of teaching resources and its contribution to "effective and purposeful practice" as a teaching tool is still not clear (Mohon, 2008). Given the IWB is becoming a more prominent tool for science teaching, research should focus on determining which needs should be examined in order for teachers to optimize its use in the science classroom (Beauchamp & Parkinson, 2005; Murcia, 2008; Schnittka & Bell, 2009).

While research has looked into the use of the IWB as a teaching tool in developing scientific literacy and influencing student learning, few studies examine teachers' specific needs when learning to use the IWB to teach science (Bauer & Kenton, 2005; Flick & Bell, 2000; Hennessy et al., 2007a; Higgins & Spitulnik, 2008).

1.8 Research Rationale and Questions

The actual body of knowledge demonstrates many teachers are not well prepared to use the technology in their classroom when they teach science (Kumar et al., 2008). Studies have also shown that teachers should be provided with adequate PD in order to make better use of technology such as the IWB when teaching science (Murcia, 2008). Limited research examines what educators might gain from support for technology use to teach science (Duran et al., 2009b). It has been shown some elementary teachers feel a certain discomfort when teaching science because of their lack of science background and/or a lack of comfort when working with the content (Coates, 2006; Schnittka & Bell, 2009). Research has shown a link between high levels of teaching self-efficacy and increased student achievement (Dionne & Couture, 2010; 2013). Given educational practices and PD can have a significant effect on a person's self-efficacy (Milbrath & Kinzie, 2000), examining feelings of TSE is central to understanding teachers' predisposition to using technology in the classroom. Furthermore, intrapersonal factors, like self-efficacy, can play an essential role in whether teachers choose to integrate technology into their instructional practices (Niederhauser & Perkmen, 2008).

While technology is becoming more prominent in Ontario classrooms, not all teachers are using technology effectively to its full teaching and learning potential (Bauer & Kenton 2005; Plante & Beattie, 2004). Little research focuses on teachers' needs and confidence when using the IWB (Hennessy et al., 2007a; Higgins & Spitulnik, 2008). The purpose of this study is to examine one elementary teacher's feelings of TSE, needs and pedagogical strategies when using the IWB to teach science at the elementary level with the assistance of supportive PD. It is predicted PD may contribute to an increase in confidence when teaching with the IWB, ultimately encouraging the use of the IWB to teach science. This teacher's experiences could serve as a basis for future studies in IWB PD in science teaching for elementary teachers.

This study is guided by the following research questions:

- 1) Can supportive PD influence a teacher's TSE when using the IWB to teach science?
If so, what factors contributed to the change in TSE?

- 2) What teacher's needs are expressed when learning to use the IWB to teach science?
- 3) What pedagogical strategies emerged when using the IWB to teach science? Which IWB tools can be used to support science teaching?

Chapter 2: Conceptual Framework

This chapter provides a conceptual basis for the study by first defining the key concept of this research, self-efficacy, and then describing its role in facilitating teacher change when learning to use the IWB to teach science. Specifically, TSE and its relationship to PD are discussed within the context of a teacher change model inspired by Fullan and Stiegelbauer (1991) and Ertmer and Ottenbreit-Leftwich (2010). Teachers' needs when using the IWB to teach elementary science are integrated using an adapted technology implementation model developed by Zhao et al. (2002). Next, the use of the IWB to elicit interactivity in a science classroom is discussed and technology-integrated pedagogical strategies presented in Roblyer (2006) are compared to the science-specific IWB strategies developed by Hennessy et al. (2007b). Lastly, IWB features listed in Beauchamp and Parkinson (2005) that lend themselves to interactive science teaching are presented.

2.1 Teacher Self-Efficacy

Teacher efficacy has been shown to account for individual differences in teaching effectiveness and has become an important construct in teacher education (Gibson & Dembo, 1984). The construct is grounded in Bandura's social cognitive theory (1977; 1997), where self-efficacy is defined as a belief in one's own abilities to perform an action or activity necessary to achieve a goal or task (Gibson & Dembo, 1984). Bandura's theory posits that people are motivated to perform an action if they believe that the action will have a favourable result (i.e., outcome expectation), and if they are confident that we can perform that action successfully (i.e., self-efficacy). According to Gibson and Dembo (1984), outcome and efficacy expectations are differentiated because individuals can believe that certain behaviours will produce certain outcomes, while if they do not believe they can perform the necessary tasks, they will not initiate the relevant behaviours, or have difficulties seeing the task through until the predicted outcome is reached. Other researchers believe these two constructs, which are grounded in social sciences, can contribute to one another given they link social-cognitive beliefs and constructivist theories which suggest that behavioural outcomes cannot be distinct from social influences and human perspectives (on self-efficacy) (Bleicher & Lindgren, 2005). Niederhauser and Perkmen (2008) describe self-efficacy as 'an individual's level of confidence that he or she can accomplish a given goal' (p. 100). As confidence is an inherent part of self-efficacy, both terms are used synonymously in this study.

2.2 Technology Self-Efficacy (TSE)

Technology self-efficacy or technology integration self-efficacy evolved from the concept of “self-efficacy” suggested by Bandura (1981). Teachers’ computer and internet self-efficacy, two of its related constructs, have been the subject of numerous studies which provide some evidence that a correlation exists between a teacher’s confidence in the use of computers and the effective integration of them in the classroom (Compeau & Higgins, 1995, Holden & Rada, 2011; Morales, Knezek, & Christensen, 2011; Paraskeva et al., 2008; Watson, 2006). As Karsenti, Raby and Villeneuve (2008) explain, however, although using technologies in the classroom has shown advantages for student learning, factors such as technological familiarity and skills directly influence teachers’ ease in incorporating technologies in the classroom. Nolan (2009) distinguishes between computer self-efficacy, referring to an individual’s belief or confidence in his or her ability to perform computer-related tasks and TSE, which essentially has the same meaning, but referring to technology use in general. In tracing the evolution of these constructs, Nolan (2009) argues both computer and TSE have been used interchangeably. Furthermore, there is evidence TSE is a useful construct in defining and measuring preservice teachers’ confidence in their abilities to use technology in their classroom, and it can serve as a strong predictor when assessing preservice teachers’ level of technology use and of technology integration performance levels (Neiderhauser & Perkmen, 2008). These authors also state that recent studies are identifying ways of measuring (preservice) teachers’ self-efficacy or confidence levels in their abilities to successful use technology in the classroom. Consistent with the literature related to TSE and its definition, the construct of TSE and confidence will be used synonymously in this study.

This thesis considers the overall influence of supportive PD on an inservice teachers’ TSE and identifies factors affecting TSE. The *Computer Technology Integration Survey* (CTIS) originally used by Wang, Ertmer, and Newby (2004) measures the influence of vicarious learning experiences and goal setting on the self-efficacy beliefs for technology integration. They originally used the CTIS with a population of preservice teachers, but Skoretz (2011) extended its use for inservice teachers.

2.3 Self-Efficacy and PD

Using technology as a teaching tool is a process that could require a change on behalf of the teacher, especially if they are new to the process. Teacher learning is an “active, experiential process, through which knowledge is enacted, constructed and revised” (Fisher, Higgins, & Loveless, 2006, p. 2). Fullan and Stiegelbauer (1991) allege that when teachers are asked to use technology to facilitate learning, some degree of change is required along one or all of the following dimensions: (1) beliefs, attitudes, or pedagogical ideologies; (2) content knowledge; (3) pedagogical knowledge of instructional practices, strategies, methods, or approaches; and (4) novel or altered instructional resources, technology or materials. When learning to integrate technology into the classroom, the teacher is viewed as the agent of change, not the technology (Fisher, 2006). This reflects the teacher-as-learner, or the link between classroom and school improvement. In addition to being vital agents of change in this context, teachers themselves must undergo change given “[they]...are having to learn to teach in ways they have not been taught themselves” (Hargreaves et al., 2001, p. 197). Abbitt and Klett (2007) investigated the influence of self-efficacy on technology integration among pre-service teachers before and after completing a course on the integration of technology into teaching practices. Pre-service teachers participated in one of several technology courses ranging from 50 to 110 minutes weekly over 16 weeks. A significant change in self-efficacy beliefs within groups was detected in all of the groups suggesting not only that the course had a positive impact on a pre-service teacher’s beliefs about their own ability to integrate technology into teaching, but also the possibility for self-efficacy to change within a one-semester time period.

Fullan and Stiegelbauer (1991) identified four variables to teacher change: knowledge, self-efficacy, pedagogical beliefs, and subject and school culture. As PD can present opportunities for teachers to become learners in further developing their skills and practice while being agents of change to leverage information acquired with its application and effective use in the classroom, this model can be applied to technology PD. Ertmer and Ottenbreit-Leftwich (2010) elaborate on the Fullan and Stiegelbauer (1991) model by discussing the literature surrounding four key variables facilitating teacher change: (1) knowledge and skills; (2) self-efficacy; (3) pedagogical beliefs; and (4) school/subject culture. Consistent with Fullan and

Stiegelbauer (1991), PD contributes to an increase in teachers' confidence in their ability to transfer learning into the classroom, which establishes a connection between educational change and teacher self-efficacy. Given this thesis examines TSE within PD focusing on a teacher's learning to use the IWB in science teaching, the Ertmer and Ottenbreit-Leftwich (2010) framework can be applied to support technology use in the classroom (Fig. II).

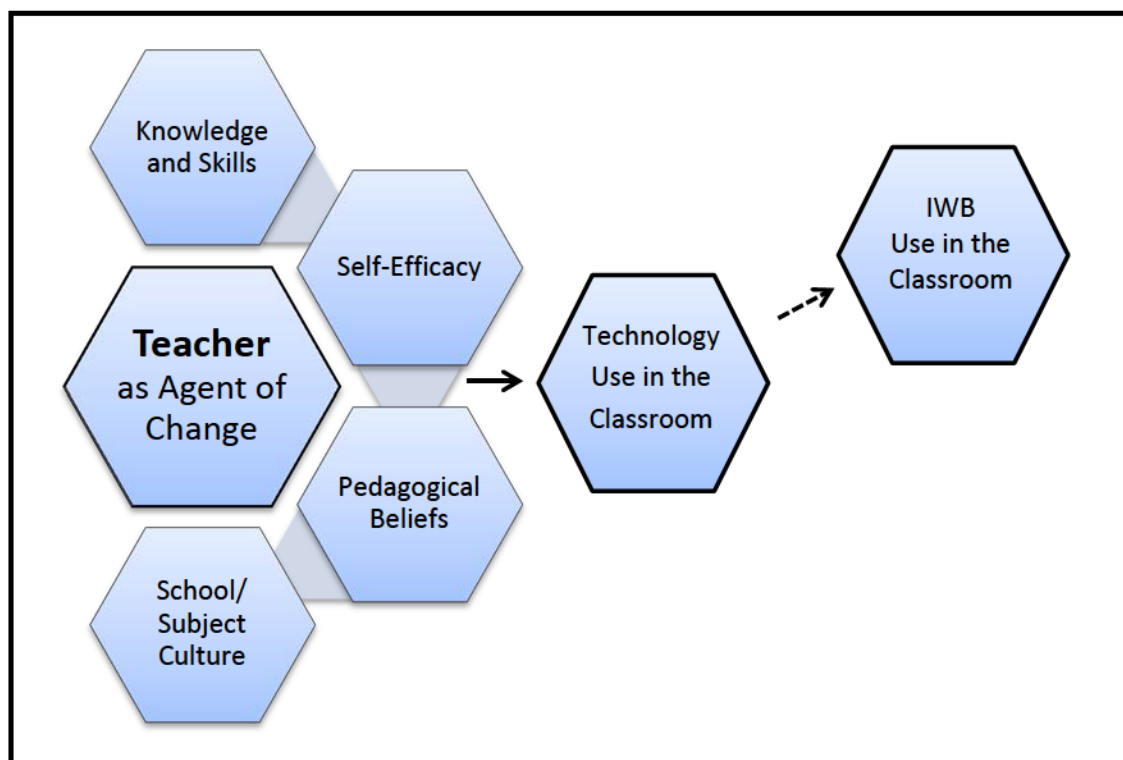


Figure II: Key variables facilitating teacher change when learning to use the IWB in the classroom (adapted from Fullan & Stiegelbauer, 1991, and Ertmer & Ottenbreit-Leftwich, 2010).

2.4 Technology Use vs. Technology Integration

The use of technology in the classroom can be grouped into three broad categories: (1) technology for instructional preparation includes the teacher's professional use of technology when developing various classroom activities such as combining instructional material, communicating or collaborating with peers, students and their parents; (2) technology for instructional delivery, which includes teacher and student use such as a presentation by means of a projector, or students using computer-assisted learning application such as drill and practice

and simulations; and (3) technology as a learning tool where students use software applications to extend their abilities to solve problems, create products, or communicate and share their perspectives with each other (Inan & Lowther, 2010). These authors argue that effective use of technology can be compared to technology integration. Technology integration into teaching and learning, as defined by Technology in Schools Taskforce (2003) is “the incorporation of technology resources and technology-based practices into the daily routines, work, and management of schools” (Lawless & Pellegrino, 2007, p. 577). This definition can be extended to include “strategies for selecting the desired technology, skill to demonstrate how the selected technologies will be used, skill to evaluate such technologies, as well as the skills to customize the use of such technological skills in a way that addresses instructional problems” (Okojie, Olinzock, & Okojie-Boulder, 2006). The study’s design is conducive to the use of the IWB in the classroom as a step toward future technology integration.

2.5 Teachers’ Needs When Learning to Use the IWB to Teach Science

In order to understand a teacher’s needs when learning to use the IWB in science teaching, the needs must be defined. Zhao et al. (2002) developed a model for successful integration of technology in the classroom by defining conditions for classroom technology innovation. This model is based on the “complex and messy process of technology integration” (Zhao et al., 2002, p. 484) and describes the conditions under which technology can be effectively used to improve student learning, including factors that facilitate teachers’ use of technology in the classroom. The three factors, or “interactive domains”, outline conditions for integrating innovative technologies in the classroom, which are: (1) The Innovator (Teacher), the main factor influencing technology use; (2) The Context (School); and (3) The Innovation (Project). The domain of teacher (innovator) is central to affecting classroom technology and encompasses factors such as technology proficiency (i.e., the ability to use the specific technology and its enabling conditions), compatibility between teacher pedagogical beliefs and the technology (i.e., views on technology, reflection on practice and connection to teaching goals) and social awareness (i.e., school culture). The context in which the IWB integration takes place considers factors such as human infrastructure (technological support and sharing of resources), technological infrastructure (i.e., accessibility and opportunity to use the technology),

and social support (peer example and collaboration). Lastly, the nature of the innovation itself has two dimensions: distance and dependence. These include factors such as distance from existing practice and availability of technological resources, as well as dependence on others in terms of support, participation and cooperation, and flexibility of the technological resources. If these are the enabling conditions under which technology can be used in the classroom to ultimately affect student learning, they are also PD needs of teachers' when learning to use technology as a teaching tool.

This model can be adapted for PD needs when learning to use a technology as a science teaching tool (Fig. III). The domain of "innovation" can be replaced by "technology" as the focus of this study was not in examining the contextual complexities of the nature of its implementation, but rather the immediate factors related to the technology itself that could influence its use in the classroom. The adapted model shows the IWB as distinct from general technology, as the IWB can act as a port through which any computer run ICT function can be displayed, and therefore can be considered as a subset of technology integration (Murcia & Sheffield, 2010). Furthermore, given science teaching with the IWB has been studied apart from its use in other subject teaching (e.g., Murica, 2008; Hennessy et al., 2007b), the conditions from this model can be adapted to define PD needs when learning to use the IWB in the science classroom, with the ultimate goal of IWB integration. Thus, PD needs when learning to use the IWB can be classified within the three domains suggested by Zhao et al. (2002), and IWB use to teach science can be presented as a step toward technology integration in the science classroom.

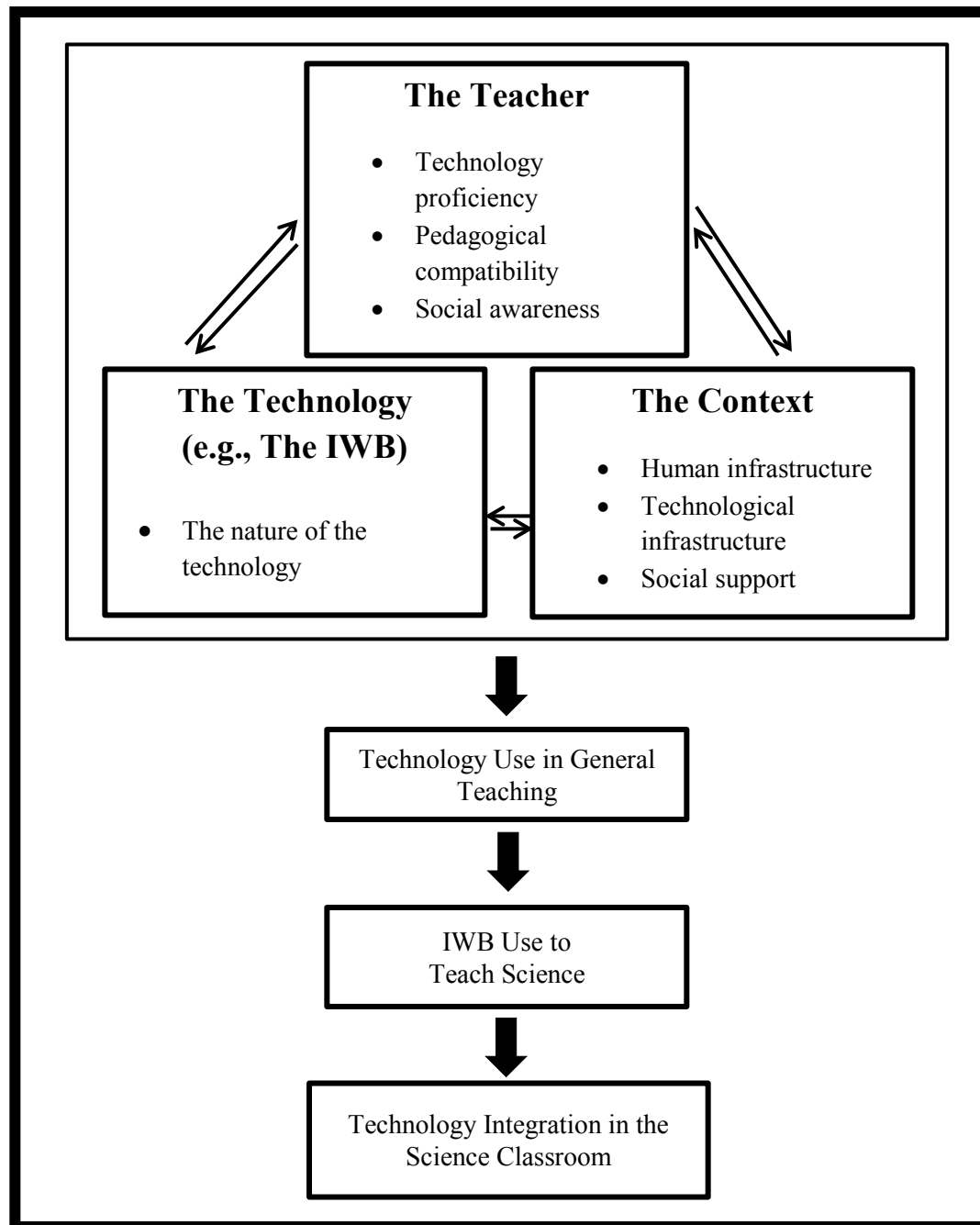


Figure III: Model for PD needs for the use and eventual integration of the IWB in elementary science (adapted from Zhao et al., 2002). Teachers' needs are categorized into three interactive domains: (1) The Teacher; (2) The Context; and (3) The IWB.

2.6 The Interactive Nature of the IWB

The IWB is distinct from non-interactive boards and conventional flipcharts, as well as the projection of *PowerPoint* slides onto an ordinary whiteboard:

The power of the IWB lies primarily in its annotation capability and the ability to move freely and easily between flipchart pages revealing an infinite range of pre-prepared resources incorporating text, graphics, video and sounds, as well as direct use of the Internet if the classroom has a suitable connection. (Beauchamp & Parkinson, 2011, p. 98)

Furthermore, it can be distinguished from other technologies because it incorporates the facility of touching a screen that controls the computer, which can be visualized by an entire group of students (Smith, Higgins, Wall & Miller, 2005). The major advantage it has as a teaching tool is that it promotes more opportunities for interaction and discussion, as it motivates students in lessons because they enjoy interacting physically with the board by manipulating text and images (Schuck & Kearny, 2007). Some studies have shown the IWB to promote interactivity on the pedagogical level as they enable the teacher to facilitate more interactive lessons. The notion of “pedagogical interactivity”, or increased student-teacher and student-student participation, is supported by the use of the IWB as a teaching tool (Smith et al., 2005). This type of interactivity was observed by teachers who reported increased teacher-student interaction during whole-class discussion because students are encouraged to offer answers to questions, which if correct can be noted at the board as well as the visual and conceptual appeal of the information and resources that are displayed on the board as part of the lesson (Levy, 2002).

Teaching can be characterized as interactive when students’ contributions are encouraged, expected and extended (Kennewell, Tanner, Jones, & Beauchamp, 2008). These authors also assert that teachers’ interpretation of interactive teaching varies as there are different forms of interactivity, from “surface” to “deep” student participation. Typical of how teachers initially use the IWB, surface interactivity occurs when teachers replicate traditional teaching methods, such as direct teaching and questioning such as inviting students to the board to manipulate or annotate on the board (i.e., technical interactivity) and broad student participation (Kennewell &

Beauchamp, 2007; Smith et al., 2005). Less-developed in practice, deeper levels of interactivity assess and extend knowledge, reciprocity and meaning making, and are attentive to students' thinking and learning skills as well as their social and emotional needs (Kennewell et al., 2008). This is consistent with Hennessy et al. (2007a) who discuss interactive teaching with the IWB to encompass student engagement on cognitive, social and physical levels. Similarly, Beauchamp and Parkinson (2005) suggest interactivity to follow a progression that moves from didactic approaches (e.g., information presented to the students by the teacher) to teaching methods that include greater student involvement (e.g., students' co-construction and interpretation of graphs using the IWB by students).

If used accordingly, the IWB can offer students more opportunities for interaction and discussion, but this could arguably be the same interaction that is encouraged without the presence of an IWB (Haldane, 2007). When teaching with the IWB, the *quality* of participation, or student interaction on cognitive levels rather than physical and verbal ones, should be considered when promoting an interactive classroom (Smith et al., 2005). These same authors argue reciprocal acts of communication for joint meaning making, as well as immediate exploration of ideas (i.e., through readily accessible resources) to be key when adding interactivity to the classroom. Although the IWB can lead teachers to believe interactivity will inherently be part of the lesson, the IWB is simply a medium for interactivity to occur and it is the user of the board (i.e., the teacher) who chooses whether or not to take full advantage of the IWB's interactive potential (Haldane, 2007). The way in which the teacher incorporates the IWB into the lesson, or the IWB's technical affordances exploited by the teacher, are likely to influence the way in which information and messages are presented to the students, ultimately influencing what and how students learn.

2.7 Pedagogical Strategies for Teaching Science with the IWB

Given technology has the potential to become part of the instructional process as a tool to facilitate learning, technology integration can be linked to pedagogy (Okojie et al., 2006). Science teaching is unique because learning the complex and counter-intuitive nature of scientific concepts and processes requires opportunities for discussion, reasoning, interpretation

and reflection (Hennessy et al., 2007a). It has also been shown that when science teachers use strategies to exploit the dynamic, manipulable objects and annotative tools afforded by the IWB, student participation is increased on cognitive, social and physical levels, which can lead to increase interest in science and positively influence science learning (Haldane, 2007; Hennessy et al., 2007a). In science, dialogic, interactive communication allows teacher and students to explore ideas together, pose questions and combine scientific and informal ideas in order to increase accessibility by creating a “scientific story” (Hennessy et al., 2007a). The IWB can represent shared space to promote dialogue and reflection as part of an approach to effective science teaching (Kershner et al., 2010).

Hackling and Prain (2006) identified the dominant characteristics of effective science teaching to be life and community relevant science learning experiences, active engagement and inquiry learning focused on outcomes that contribute to scientific literacy. Specific to science teaching, the IWB has been shown to be an effective teaching tool in facilitating science instruction because of its versatility in providing access to a variety of resources, while helping students to visualize abstract knowledge (Hennessy et al., 2007b; Murcia, 2008). The IWB is also an organizational tool to prepare, organize and store lessons, which can lead to highly-structured, well-sequenced lessons with access to useful (online) resources (Schuck & Kearney, 2007). This is especially relevant for science teaching, as presenting relevant online and up-to-date information in meaningful and real-life contexts can help students make sense of challenging scientific concepts (Murcia, 2008).

The interactive nature of the IWB suggests it can be used as a tool to teach science by supporting pedagogical strategies important in science teaching, while fostering learner participation in the science classroom (Table 1). Pedagogical strategies, often synonymously referred to as teaching or instructional strategies, are a series of curriculum-focused decisions based on the students’ prior experiences and knowledge, interests, learning styles and developmental levels of the learner that determine the approach a teacher may take to achieve learning objectives (Joyce & Weil, 1986). Although pedagogical strategies are not subject-specific, Hennessy et al. (2007b) discuss the potential of the IWB as a science teaching tool as it can assist teachers in supporting student learning in science.

Table 1

Technology-Integrated General Pedagogical Strategies (Roblyer, 2006, pp. 48-51) and IWB-Integrated Science Pedagogical Strategies (Hennessy et al., 2007b)

Technology-Integrated General Pedagogical Strategies	IWB-Integrated Science Pedagogical Strategies
The teacher fosters group cooperation skills by creating opportunities for students to be able to work with others to solve problems and create products.	The teacher fosters student participation and collaboration through interactivity and encourages scientific investigation.
The teacher promotes skill fluency and automaticity by providing students with opportunities to recall and apply lower-level skills quickly and automatically.	The teacher provides opportunities to assess learning informally in science and moves students' thinking through discussion of results or prompting them step by step.
The teacher allows for multiple distributed intelligences by creating opportunities for students to learn and demonstrate achievement in multiple ways.	The teacher designs and uses science-related resources that respond to varying learning needs and focuses student attention on key underlying concepts, relationships and processes.
The teacher generates motivation to learn by providing opportunities for students to see the relevance of new concepts and skills to their lives and to be active, rather than passive, learners.	The teacher creates "active" learning opportunities in the science classroom for student exploration, participation and manipulation.
The teacher optimizes scarce personnel and material resources when faced with limited budgets.	The teacher expands opportunities for learning by accessing science information and tools to share with students and integrating technology with other resources.
The teacher removes logistical hurdles to learning by recognizing students to find repetitive tasks boring and tedious and may lack motor skills to show their designs.	The teacher exploits the affordances of dynamic visual presentation, interactivity and immediate feedback to render underlying scientific concepts and processes more salient and accessible to learners.

Both general technology-integrated pedagogical strategies and science-specific IWB pedagogical strategies are similar in their focus on skill development and flexibility in catering to a variety of student learning needs, increasing student motivation to learn, and can act as alternative or additional resources. Interactivity distinguishes the science teaching with the IWB

from general teaching with other technologies, mainly because the visual nature of the board creates a unique classroom dynamic (Mohon, 2008; Murcia, 2008). Although both encourage “active” learning, the IWB pedagogical strategies can include manipulation at the board, which could increase student participation and engagement in the lesson, as well as the exploration of online and hands-on science-related opportunities.

2.8 IWB Software Tools and Uses

One of the main reasons for the IWB’s popularity in schools is the potential it offers for adding interactivity in classroom lessons. A study by Beauchamp and Parkinson (2005) lists IWB software tools that provide teachers with opportunities to complement their current teaching style. The authors argue several IWB features can foster interactivity, especially when teaching science and technology because strategies such as teacher input, group discussion, group presentation and confirmation of correct science are supported. IWB features can complement the use of pedagogical strategies for technology-integrated science teaching (Table 2).

Table 2

IWB Features That Complement the Use of Pedagogical Strategies for IWB-Integrated Science Teaching

IWB Features†	IWB-Integrated Science Pedagogical Strategy‡
Capturing • Copy and paste from other software, e.g., <i>Word</i>, graphics packages; • ‘Photograph’ screen images.	Integrating • Integration of technology with practical activities and other resources;
Emphasizing • Tickertape function (a word or phrase continuously moves across the screen); • Large text; • Spotlight function (the view is restricted to a circular area of the screen).	Amplifying and Interpreting • Focusing attention on key underlying concepts, relationships and processes; • Increased opportunity for strategic questioning and interpretation;
Storing • Storing on flipchart pages to be revisited later on in the lesson or in subsequent lessons; • Recording as flipchart files; • Storing in the link library.	Revisiting • Revisiting interactive whiteboard pages, simulations and graphs; • Saving pages to offer a permanent record for a follow up of students’ learning;
Annotating and Modifying • Using the pen, sometimes in conjunction with other features such as arrows or lines, to add writing to existing images and text; • Using the highlighter pen; • coloured pen is used to cover text and the whiteboard ‘rubber’ is used to reveal the hidden text).	Application and Differentiation • Guided-discovery teacher-led activities; • Exploration and manipulation at the board;

(table continues)

IWB Features†	IWB-Integrated Science Pedagogical Strategy‡
• Carrying out DART activities such as using drop and drag to match labels to features, rearranging objects or text into a correct sequence, close procedure exercises (a coloured pen is used to cover text and the whiteboard ‘rubber’ is used to reveal the hidden text).	
Linking • Linking to other pages in the flipchart; • Linking to files stored on the computer e.g., <i>Word</i>, <i>Excel</i>; • Linking to programs stored on the computer e.g., Concept cartoons, concepts mapping software; • Linking to Internet sites.	Supporting Knowledge Building • Navigating between IWB resources to adapt to students’ responses.
† IWB features listed in Beauchamp and Parkinson (2005); ‡ IWB-integrated science pedagogical strategies inspired by Hennessy et al., (2007b)	

The conceptual framework chapter outlines the connection between the main concepts of this thesis, which can be visually summarized (Fig. IV).

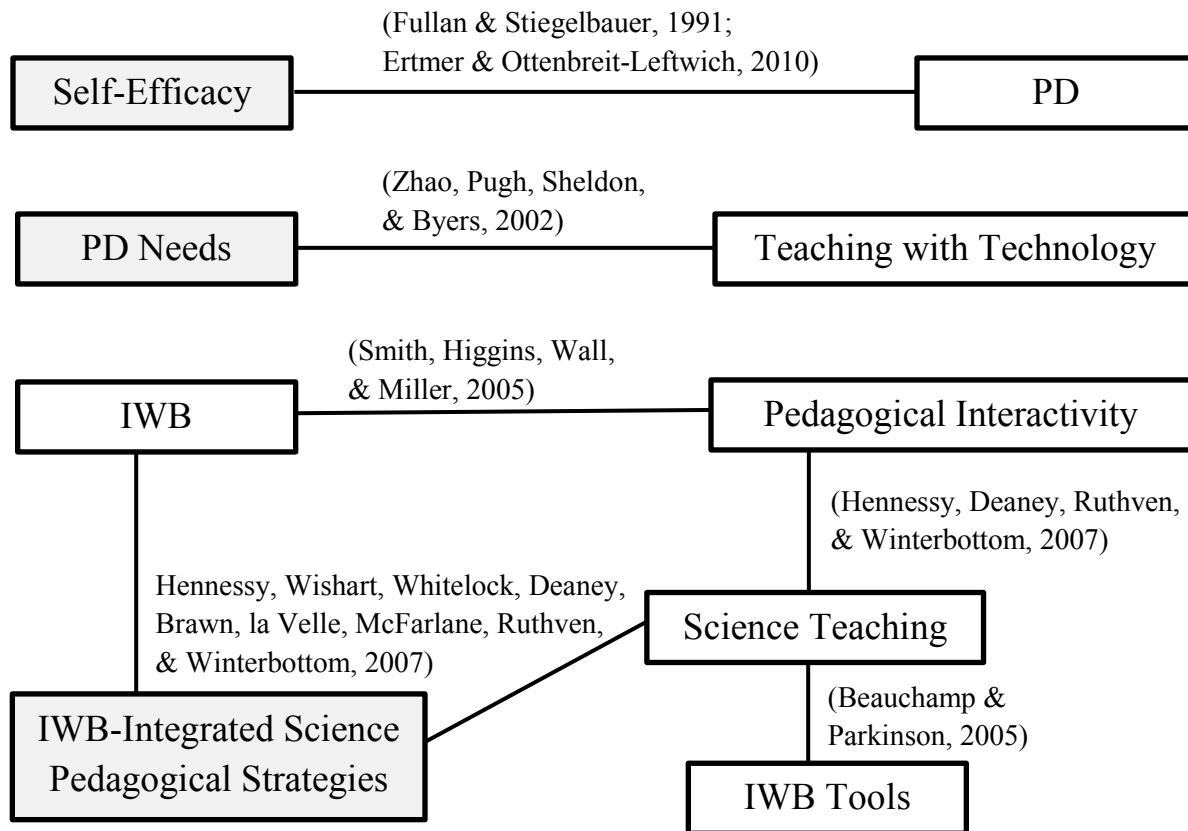


Figure IV: Visual summary of connections between key thesis concepts described in the conceptual framework.

Section Summary: Influencing TSE can be integral to facilitating teacher change, such as when learning to use and eventually integrate technologies as teaching tools. Teacher PD needs associated with using the IWB in the science classroom can be categorized at teacher, contextual and IWB specific levels. The IWB supports a variety of pedagogical strategies for teaching elementary science. IWB tools facilitate ways of treating information that relate to these strategies, ultimately leading to fostering interactivity in the classroom. Concepts forming the basis of this thesis can be connected using other published studies.

Chapter 3: Methodology

This chapter delineates the methodology and design of the research project. First, a description of the case study and PD design are communicated, followed by the researcher's epistemological stance. Next, a brief history of measuring self-efficacy is presented and data sources (i.e., the CTIS-IWB survey, interviews, researcher logbook and lesson debriefs) are specified along with their relevancy to the main research questions. Details regarding the qualitative data analysis and the quality and rigour of the research conclude this chapter.

3.1 Research Design: A Unique Case Study

The research design of this study is a qualitative single case study, an intensive, holistic description and analysis of a single entity (Merriam, 1988). Specifically, this case study is descriptive in nature as it presents innovative information as a basis for future comparison (Merriam, 1988). As Merriam (1988) explains, educational processes such as teacher PD can be examined using a case study design because of its strengths which include a means of gaining detailed insights and real-life accounts of a single entity, bringing about an understanding that can ultimately improve practice.

3.2 Case Details

The unique case is a grade 5/6 elementary teacher, “Julie”, who has taught a variety of subjects from kindergarten to grade 6 periodically over the last 20 years. At the time of data collection, this was her second year of teaching music and science from kindergarten to grade 6 students. Of main relevance to this research project, she taught two 45 minute periods of grade 5 science weekly. As she was a subject-specific teacher (i.e., teaching only science and music), she travelled between classrooms and did not have her own classroom.

3.3 Context

Data collection took place where the participant taught, an Early Immersion (K-6) school in the Upper Canada District School Board, located in the Stormont, Dundas and Glengarry County with a student population of approximately 200. There were four IWBs within the school: a small portable one, a large portable one setup in a classroom, and two large permanent

ones in the library and the kindergarten classroom. Most PD sessions took place in the library because of availability.

3.4 Supportive PD Design

The researcher worked with one participant during twelve (12) PD sessions that occurred over the first two months of a three-month data collection period at the end of the 2013 school year. The participant expressed specific needs related learning to use the IWB to teach science, which formed the basis of the PD's design. Needs expressed during the initial interview and during subsequent PD sessions on a weekly and/or bi-weekly basis guided the researcher to determine next steps in the planning of the PD. The flexible nature of the PD reflects an emergent and supportive design, where the initial plan for research and other phases of the research process changed further along the PD, or as the participant's needs shifted from technological needs through to more complex lesson design questions (Creswell, 2007).

Each PD session consisted of the researcher working with the participant in a one-on-one instructional and supportive environment. Becker (1994) suggests teachers who have access to other people from whom they can learn, such as experts who have already mastered the resource, are more likely to experiment with technology and be innovative when teaching with that technology. The researcher, or "IWB Expert", was prepared to cater to a variety of the participant's needs concerning the use of IWB to teach science by having completed beginner, intermediate and advanced courses on the use of the IWB in science education. The researcher's science teaching experience and IWB expertise credited the researcher to be a reliable source of information for the participant on using the IWB as a science teaching tool. Therefore, the use of "expert" to describe the researcher is relative, as the participant had limited experience using the IWB as a science teaching tool compared to the researcher. In this case, the researcher was sufficiently skilled and experienced to provide the necessary leadership and guidance required to facilitate learning opportunities for the participant related to IWB integration in the science classroom. Further details regarding the researcher's role during the PD sessions are described in section 3.4.2.

The duration of each session varied between 2 to 3 hours, depending on the participant's availability, preference, and needs, for a total of 45 contact hours between researcher and participant, including approximately 6 hours of in-class teaching observations. The PD format was short-term and intensive, with a focus on providing a quality PD experience, including regular opportunities for intensive and active learning and a focus on applications to the participant's planning and instruction that is more likely to have a positive and lasting impact on teaching practice (Birman, Desimone, Porter & Garet, 2000; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009). The sessions were recorded using an *Olympus WS-801 Mass Storage* Digital Voice Recorder for reference purposes for PD session planning.

3.4.1 PD phases. The PD can be divided into three phases: (1) Basic Skill Acquisition, which included the participant's learning of basic technology and IWB skills and becoming familiar with using an IWB; (2): Incorporation of IWB Tools for Lesson Design, which included skill and tool selection for science lesson design,; and (3) Classroom Implementation, which included the participant presenting IWB science lessons in the grade 5 science classroom (Table 3). During the final month of PD (third phase), the researcher observed the participant teaching three science lessons to grade 5 students, followed by lesson debriefs concerning ideas for future IWB lessons and next steps for future IWB use in the science classroom.

Table 3

PD Session Schedule and Phases

April 2014				May 2014							June 2014				
10 th	17 th	22 nd	29 th	1 st	3 rd	6 th	10 th	15 th	17 th	20 th	27 th	30 th	6 th /7 th	11 th /14 th	18 th /20 th
Basic Skill Acquisition				Incorporation of Tools for Lesson Design							Classroom Implementation				
<u>Computer basics</u> : file and folder, internet searches; downloading and saving files; USB options.				Practice with <i>SMART Notebook 11</i> on a laptop or school computer and using the IWB; inserting pictures, tables, files, attachments, videos and web links (e.g., from ‘YouTube’ and superteacherworksheets.com); working with shapes, pens, text and images in <i>Gallery Essentials</i> ; exploration of interactive and multimedia options in <i>Notebook</i> (i.e., games such as vortex, matching/memory and fill-in-the-blank); brief overview of iClicker SMART Response options for quizzes; video pausing options using SMART Video Player.							SMART Exchange; Internet resources and modification of already-existing <i>Notebook</i> lessons; Advice for lesson creation, design, and implementation; classroom observations based on the participant’s needs.				
<u>IWB <i>SMART Notebook 11</i> basics</u> : user registration; board setup; overview of <i>Notebook</i> features for classroom use; familiarization with touching/writing on the board; viewing options; slide organization; and practice/review of main menu options.															

3.4.2 PD session format. The content of each PD session varied between sessions depending on the needs and progress of the participant, but typically sessions followed a “Review-Exploration-Next Steps” format (Table 4). The amount of time spent within each part was contingent upon the participant’s needs and the availability of the IWB. Depending on the nature of each session, the researcher could take on an active role by methodically demonstrating and assisting the participant in learning IWB tools, and/or a passive role that included sharing of the participant’s ideas and interests relevant to future IWB science lessons.

Table 4

Description of PD Sessions: Review-Exploration-Next Steps Format

	Description	Tool	Actual Session Example
Review	Review of concepts and participant questions from the previous PD session.	L	The participant experienced troubleshooting difficulties with downloading the Gallery Essentials on her home laptop. The researcher was able to assist her in using SMART Exchange to add to her gallery.
Exploration	Introduction to and exploration of IWB features and their application in science teaching.	IWB	The researcher showed the participant how to use SMART Video Player as an alternative to embedded video links in science lesson. This would allow videos to be paused and screen captured for future classroom discussion.
Next Steps	Summarization of key learnings from the session and planning of next steps.	L; IWB	The participant recorded notes from the session and the steps involved for using an advanced IWB feature, which the participant could practice at home before the next session.

L = using the participant's laptop; IWB = using an IWB

Review. The first part of the PD sessions occurred in the school's staffroom using the *Notebook* software on the participant's laptop. The researcher began each session by addressing any questions the participant had from what was learned during the previous session. If the participant had continued to explore the *Notebook* software since the last session on an individual basis, participant queries (e.g., software difficulties encountered) could also be answered. It was also at this stage where points that could not be addressed at the end of the previous session could be explored in further detail. This included aspects such as troubleshooting issues to be looked into by the researcher, or an extension of the previous session that was not covered because of time limitations.

Exploration. The second part of the PD session consisted of the researcher introducing IWB features not yet explored by the participant based on the level of technological proficiency and needs expressed by the participant from the previous lesson. At this point, the researcher and participant would relocate to use one of the three IWBs in the school where the participant could

combine previously-learned concepts with features learned during the session by practising directly on an IWB. The amount of time spent using an IWB during the session was contingent upon its availability and varied from session to session. The introduction of new features also enabled the researcher and participant to strategize on how to apply the learned features in science teaching. Most commonly, this included the participant receiving troubleshooting assistance with using technology (i.e., the laptop or computer and the IWB), discussing the IWB tools within a science lesson design context, and examining templates of online IWB elementary science resources.

Next steps. The final minutes of each session were allocated for summarizing key learnings from the session that could be further practiced by the participant before the next session as well as discussing next steps in the planning of future PD sessions.

3.5 Epistemological Considerations

This study reflects a pragmatic epistemological view, where its results contribute directly to the improvement of educational research and present teaching practices found in schools (Creswell, 2007). Pragmatism links practice to theory (Creswell). A commonly accepted educational perspective, such as John Dewey's view on pragmatism, outlines an activity-based, hands-on, and learning-by-doing approach to learning, which is the perspective that is embedded in this thesis. This approach can be extended to teacher as learner perspectives, as summarized by Prawat (2000):

[The learner] bring[s] to the learning situation certain interests and needs, and a well-established set of habits and routines for dealing with those interests and needs. The key [...] is to design active learning situations that challenge habit and appeal to the [learner's] interests and needs. Interests and needs that are thwarted activate the [learner's] problem solving skills, latent or otherwise. The [instructor's] role is to guide the [learner] toward a resolution of the problem that stands between the person and his or her needs or interests. (p.834)

Therefore, Deweyan pragmatism supports progressive education and research practices, and serves as a point of reference for educational innovation and curriculum reform (Hammond, 2013).

Hammond also noted that this strand of pragmatism also considers knowledge to be consequential, or generated after action and reflection on action, even if antecedent knowledge is guiding the action. In this perspective, the learner inevitably faces problems to which he or she does not know how to respond, supporting the notion that knowledge must be continually generated in order to adapt to a changing world. In accordance with Dewey's view, the epistemological stance of this thesis considers people respond to situations through "intelligent action", which involves experimentation at a symbolic level as well as at a practical level (Hammond, p.606). Whether the solution will lead to a resolution, or "what works", is clear when examining the consequences of the action (Hammond, p.606).

In brief and consistent with this view, the researcher in this study considers the participant to be both a "teacher as learner" and a "learner". As the learner, the PD that is undertaken focuses on the needs and interests of the participant. Consequently, the PD is centered on the participant's interest in grade 5 science teaching, while recognizing her specific needs when learning to use the IWB. As a teacher, the participant will be incorporating technology into her science classroom to better relate to her students' (technology) interests and cater to their learning needs. Consistent with Dewey's view of pragmatism, the practical nature of the PD recognizes direct experimentation with the IWB and IWB teaching experience to be essential in simulating real-world learning contexts, which will enable the participant to build on existing and generate new knowledge relevant to technology integration in the science classroom. Ultimately, the participant will gain insight into "what works" when teaching science with the IWB and conclusions of this study will lend themselves to the development of on-going teacher education and the use of the IWB as a science teaching tool at the junior level.

True to the pragmatic perspective, this research highlights the importance of assisting teachers as they keep up with the integration of technology into curriculum as part of the increased use of ICTs to enhance the student learning experience by relating to a technologically-

savvy generation of students. Given the implications advancements in technology are having on all aspects of education, examining a teacher's needs and technology-integrated pedagogical practices can be a useful reference for teachers learning to integrate technology in the classroom from teacher as learner (i.e., PD) and pedagogical perspectives. Furthermore, the insight gained from directly working in an educational setting with an experienced elementary teacher will enable the researcher to gain a realistic sense of teaching and learning dynamics when integrating technology in the science classroom. As ICTs are having an impact on the nature and type of learning materials available to students as well as on educational methods, this project is of practical significance to the researcher, a science, math and music teacher in the early stages of a teaching career, and other teachers learning to use technology in the classroom.

3.6 Data Sources

Qualitative data were collected from the Computer Technology Integration Survey (CTIS) (adapted for IWB use in the classroom), two interviews (pre and post PD), three in-class observations of IWB science lessons, and three lesson debriefs.

3.6.1 Computer Technology Integration Survey – Interactive White Board (CTIS-IWB).

Measuring TSE. Few instruments are designed to measure self-efficacy relative to technology use (Neiderhauser & Perkmen, 2008). Gibson and Dembo (1984) were among the first researchers to investigate the dimensions of teacher efficacy with Bandura's 1977 theory in mind, while testing the internal consistency of this teacher efficacy measure. The purpose of their study was to develop an instrument to measure teacher self-efficacy, while justifying its validity in examining the relationship between teacher efficacy and observable teacher behaviours. They developed a 30-item "Teacher Efficacy Scale" which measures general pedagogical self-efficacy, not specific to any content area. It is based on two scales which correspond to Bandura's two-factor theoretical model. The first scale measures teachers' beliefs about how they feel confident to teach effectively and how they could help improve student achievement, which they label as "Personal Teaching Efficacy". The second scale measures teachers' belief

that their impact on student achievement could be influenced by external factors such as student's socio-economic background, and home environment, which they label "Outcome Expectancy".

Abbitt and Klett (2007) created their own survey to measure perceived comfort towards computer technology for general teaching based on two well-known recent surveys: (1) the Attitudes Toward Computer Technology (ACT) instrument (developed by Kinzie, Delcourt, & Powers, 1994; Milbrath & Kinzie, 2000), which assesses perceived comfort and anxiety as well as the perceived usefulness of computer technologies; and (2) the Computer Technology Integration Survey (CTIS) instrument (developed by Wang et al., 2004), which measures the participant's confidence and self-efficacy in using computer technology in teaching. Koul and Rubba (1999) also developed an instrument called the Personal Teaching Efficacy Beliefs Scale (PTEBS), which was designed and validated in their 1999 study to assess self-efficacy beliefs toward teaching with the Internet. Although this survey has been used in other studies to measure changes in self-efficacy (e.g., Watson, 2006), it merely evaluates participants' abilities when using the Internet in lesson planning and classroom teaching, and does not consider more modern technologies, such as IWBs and software programs, designed to complement student learning (e.g., online games, course webpages).

Niederhauser and Perkmen (2008) developed the Intrapersonal Technology Integration scale (ITIS) to collect demographic information and preservice teachers' perceptions of self-efficacy and other constructs as well as their behavioural intentions with respect to technology integration. Subscales of this tool were based on Lent, Brown and Hackett's (1994) Social Cognitive Career Theory (SSCT), which was found to measure three key mechanisms of the theory: self-efficacy, outcome expectations, and interest. Other researchers, such as Hammond et al. (2011), developed a questionnaire that measured preservice teachers' receptivity to and use of ICTs, covering eight themes: biographic details; access to ICT in school; support for using ICT; constraints on using ICT; use of ICT; attitudes to ICT; attitudes to PD; and general beliefs about teaching and learning. Given its recent development, it considers 'new' technologies such as the IWB (e.g., SMART Board). Also measuring self-efficacy, Erdemir (2011) created 'Technology Usability Self-Efficacy Instrument' (TUSEI), which measures TSE levels and rate of technology

implementation in the classroom in primary school teachers according to various settlement areas. Although this survey mentions the use of computers, the internet and educational technologies in the classroom, it does not specifically mention the IWB.

The CTIS-IWB survey. The Computer Technology Integration Survey (CTIS) by Wang et al. (2004) measures the influence of vicarious learning experiences and goal setting on the self-efficacy beliefs for technology integration (Appendix A). Skoretz (2011) extended its use for inservice teachers and, given that this study concerns practising teachers, the Skoretz version (adapted for IWB use by the researcher) was the instrument of choice. It is a 21-item Likert scale survey in which respondents are asked to rate how confident they are in integrating technology in their classroom teaching.

A definition for technology integration identical from the Skoretz (2011) version was provided to use as a baseline in answering questions on the survey. Modified questions from this survey accommodated the use of the IWB in the classroom rather than general technology. Instead of consisting of two parts like the Skoretz version, socio-demographic questions were removed and the modified survey consisted of one part, or a list of ‘I feel confident that I...’ statements with a response range from strongly disagree (1); disagree (2); neither agree nor disagree (3); agree (4); and strongly agree (5). The adapted survey was administered within the first week of meeting the participant, shortly after the first interview and during the last week of the PD (i.e., at the end of the research project) in order to examine possible variations in confidence when using the IWB when teaching science lessons. As this study was short-term in duration, the survey was used to predict technology use in a science classroom, with an ultimate future goal of integrating technology such as the IWB in the classroom. Given this is a unique case study, data from the survey was descriptively analyzed as no statistical data analyses could take place because of weak statistical power. Descriptive analyses of this survey were relevant to research question 1 regarding the participant’s feelings of TSE when teaching science and when using the IWB in the science classroom.

3.6.2 Semi-structured interviews. Two semi-structured interviews were held with the participant during the first and final PD sessions. The purpose of the interviews was for the

researcher to gain a deeper level of understanding of the participant's feelings, needs and comfort level when using the IWB in the classroom to teach science. Each interview consisted of questions similar to statements found on the CTIS-IWB survey, but worded in a way as to guide the participant to elaborate in detail about personal experiences and feelings with using the IWB to teach science. As suggested by Creswell (2012), the researcher followed a specific template to facilitate note-taking during interviews, which assisted in asking logical prompts based on the participant's responses (Appendix B). Each interview was approximately 30 minutes and covered topics relevant to all three research questions.

The purpose of the initial interview was to provide critical information which served as a means for the researcher to assess the participant's needs and expectations for the upcoming PD sessions, providing the researcher with a starting point to cater to the participant's needs. The first interview focused on socio-demographic details of the participant such as those removed from the original CTIS survey including prior teaching and technology-related experiences and level of comfort when teaching with technology and the IWB.

The final interview captured the participants overall experience with receiving supportive PD in using the IWB to teach science. It focused on the participant's feelings of TSE or teaching confidence when using the IWB in the classroom when teaching science, needs when learning the IWB, and IWB pedagogical practices. Questions were relevant to the PD experience such as the influence of the PD on IWB use in science teaching, the participant's specific needs when using the IWB in the science classroom, and the ease and likelihood of using the IWB in science teaching after the PD.

Interviews complemented data from the CTIS-IWB survey to determine if the PD had an influence on the participant's feelings of IWB self-efficacy, PD needs and current pedagogical practices when using the IWB to teach science. Initial and final interviews were recorded using an *Olympus WS-801 Mass Storage Digital Voice Recorder*, transcribed in *Microsoft Office Word 2010* and imported into *NVivo 10* for thematic analysis.

3.6.3 Classroom observations with researcher logbook. During the final month of PD (third phase), the researcher observed the participant teaching three grade 5 science lessons using

the IWB. A researcher logbook served as a note-taking guide during classroom observations, which were used by the researcher as discussion prompts during the debriefs. The researcher logbook consisted of three columns: technical observations, teaching observations and IWB tool use (Appendix C).

3.6.4 Lesson debriefs. Each lesson was followed by a semi-structured lesson debrief between the researcher and participant, where the researcher would ask questions related to previous themes from the PD and from observational feedback from the researcher during lesson. Debriefs after each classroom lesson provided the participant with an opportunity to elaborate on feelings concerning TSE, IWB needs when learning to use the IWB to teach science, and general approaches to teaching science with the IWB. It was also an opportunity for the participant to reflect on next steps for future lessons and for the researcher to provide constructive feedback to the participant. Although the researcher prepared some questions based on observations from the previous lesson as prompts, lesson debriefs were more informal by nature than the interviews. The purpose of the debriefs was for the participant to describe IWB teaching experience when using it to teach science on topics related to personal TSE, needs, pedagogical strategies. Ideas for future IWB lessons and next steps were also deliberated as part of the debriefs. Lesson debriefs were recorded using an *Olympus WS-801 Mass Storage* Digital Voice Recorder, transcribed in *Microsoft Office Word 2010*, and imported into *NVivo 10* for thematic analysis.

3.7 Data Relevancy

Twelve PD sessions, the CTIS-IWB survey, two semi-structured interviews, three classroom observations and lesson debriefs were used to describe the influence of supportive PD on a teacher's TSE (research question #1), needs (research question #2) and IWB pedagogical strategies and tools (research question #3) when learning to use the IWB to teach science. Data from each source was relevant to one or more research questions (Table 5).

Table 5

Data Source Relevancy to Research Questions

	PD Sessions	CTIS- IWB Survey	Interviews	Researcher Logbook (Classroom Observations)	Lesson Debriefs
Question 1: TSE		✓	✓		✓
Question 2: PD Needs	✓		✓	✓	✓
Question 3: IWB Strategies and Tools	✓		✓	✓	✓

3.8 Data Analyses

Qualitative research can have several benefits in context-driven case-based research. It tends to be inductive, where the researcher can identify patterns and relationships through a process of discovery (Schutt, 2012). Schutt also argues it to enable the focus to be on inter-related aspects of the person under investigation, the case, from their view-point, rather than breaking the whole into separate parts. The PD's emergent design lends itself well to qualitative analysis as the ultimate goal is to understand the experiences of the case in terms of TSE, needs and pedagogical strategies when using the IWB to teach elementary science. The analysis will allow the researcher to observe and interpret the workings of the case as it happens and redirect observations to refine or substantiate those meanings as part of a reflexive process (Schutt). Thus, as new factors influencing TSE, needs and pedagogical strategies surfaced throughout the data collection, the researcher was able to further explore those details in order to better understand and interpret the case.

The data was analyzed using two methods: (1) a descriptive analysis of the CTIS-IWB survey; and (2) a thematic analysis of the interviews, lesson debriefs and researcher logbook.

3.8.1 Descriptive analysis: The CTIS-IWB survey. The CTIS-IWB survey was descriptively analyzed by first identifying statements in which notable changes were recorded in the participant's response from the initial administration of the survey. A notable change occurred if the participant indicated a different response from an initial position of disagreement to neutrality, disagreement to agreement, and neutrality to agreement on a statement. Statements in which a notable change was recorded were grouped according to their relevancy to the topics covered during PD sessions (i.e., topics more emphasized and topics less emphasized).

3.8.2 Thematic analysis: Interviews, lesson debriefs and researcher logbook. The text from interview transcripts, lesson debriefs and researcher logbook was imported into *NVivo10* and manually coded using thematic analysis, a qualitative descriptive approach for identifying, analysing and reporting patterns (themes) within data (Braun & Clarke, 2006). Similar to content analysis, the aim of thematic analysis is to analytically examine narrative materials by breaking the text into relatively small units of content and submitting them to descriptive treatment; However, thematic analysis is unique in its approach as it provides a purely qualitative, detailed, and nuanced account of the data (Vaismoradi, Turunen, & Bondas, 2013). With the goal of outlining the theory, application and evaluation of thematic analysis as both a teaching and research tool, Braun and Clarke (2006) provide guidelines for conducting thematic analysis in a deliberate and rigorous way. The six phases presented by Braun and Clarke (2006) are described in detail and are illustrated using a specific example from this thesis.

Phase 1: Familiarising with data. This phase involves a complete immersion in the data on behalf of the researcher by *repeated and active data reading*, or reading through the data multiple times while searching for meanings and patterns. The researcher also takes notes and marks ideas directly on the guide sheets as part of a less formal coding process that can be revisited in subsequent phases. As the data collection involved the researcher working directly with the participant over three months, the researcher was able to refer to this experience informally by tracking the participant's progress throughout the PD and taking additional notes on the interview guide sheets, researcher logbook observations and lesson debriefs. These were considered when planning next steps during the PD and lesson planning and as discussion

prompts during lesson debriefs. Transcription of the data can also help the researcher to familiarize with the data by facilitating close-reading and interpretive skills needed to analyze the data. As part of the analysis, the verbal data from the interviews and lesson debriefs and the written observations from the researcher logbook were transcribed.

Phase 2: Generating initial codes. This phase is the start of the coding process, where data across the entire data set is gathered into meaningful groups for the purpose of initial organization of the data. Any interesting aspects relevant to the research questions or that could form the basis of repeated patterns or themes are identified. Interviews and lesson debrief transcripts as well as data from the research logbook were imported into *NVivo* software. Next, as an initial organizational structure to begin the coding process, the researcher created three nodes based on the three research questions: Technology Self-Efficacy, Needs, and IWB Pedagogical Strategies and Tool Applications. Segments of potential interest from each data source were manually selected into the most relevant node(s) (Fig. V). Manually selecting representative statements was the preferred coding method as this was a small-scale study on a narrow topic and a descriptive type of report was warranted (Kondracki, Wellman & Amundson, 2002). Segments of data relating to the participant's belief in her own abilities to use the IWB were classified under the node *Technology Self-Efficacy*, segments of data relating to the participant's needs when learning to use the IWB were classified under the node *Needs*, and segments relating to the participant's pedagogical strategies, practices and use of the IWB when teaching science were classified under the node *IWB Pedagogical Strategies and Tool Applications*. All segments of data with the potential for theme development were classified into as many different nodes as relevant as part of the initial coding process for the development potential themes (Braun & Clarke, 2006). As the data was approached with specific questions in mind, this process reflected thematic or deductive approach to coding (Braun & Clarke). Classifying data segments in this way provided a basis for future coding and theme identification and development within each node, or research question.

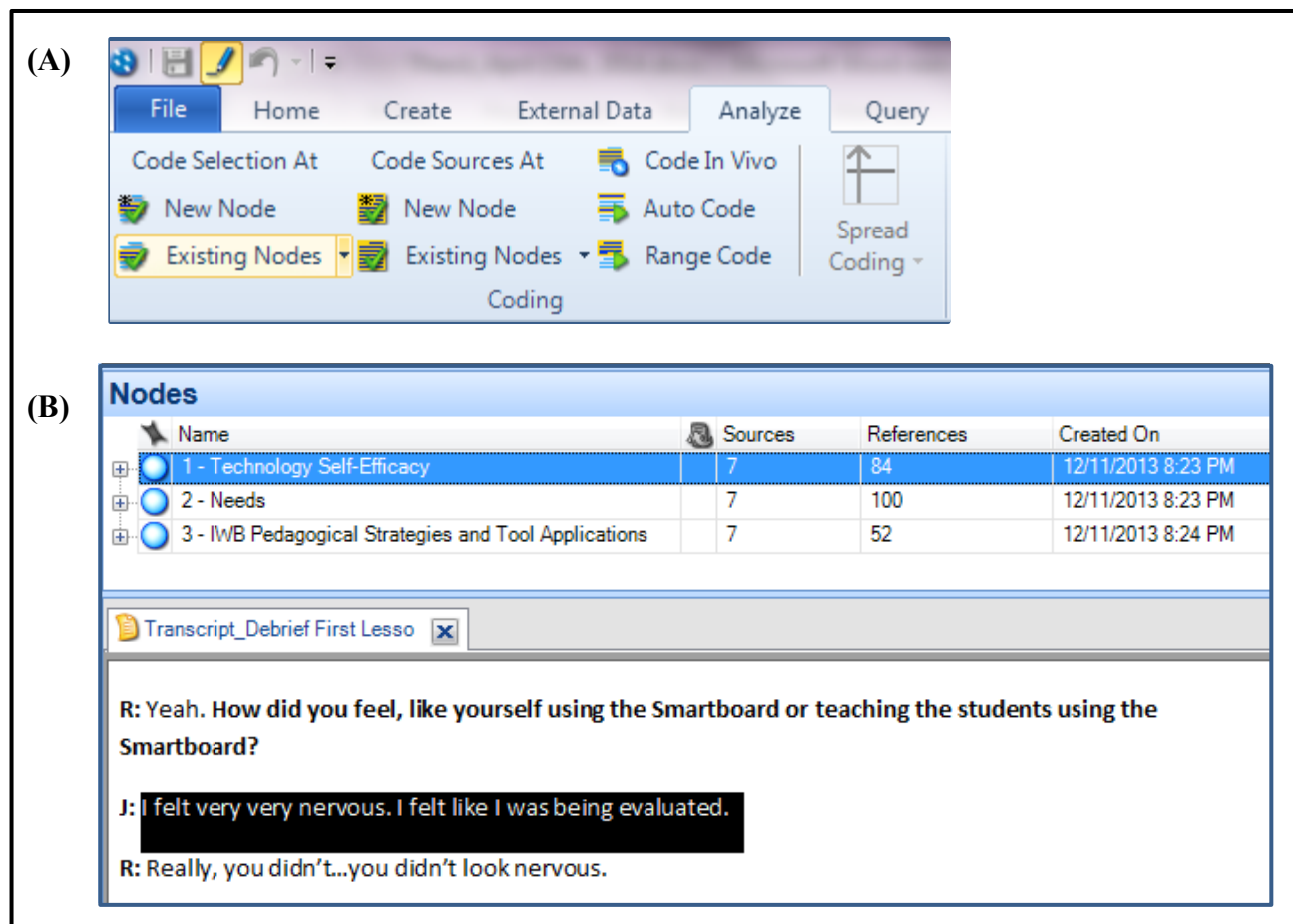


Figure V: (a) Segments from across the data set were selected and coded into nodes based on the research questions using the *Code Selection* analysis feature in *NVivo*; (b) Excerpt from the first lesson debrief added to the node *Technology Self-Efficacy*.

During this phase, writing notes directly on the text is recommended to assist the researcher in identifying the segments as well as indicate the potential of an emerging themes or patterns and for organizational purposes. The researcher used the memo feature from *NVivo* to insert reflective notes and identify potential themes and ideas for future consideration (Fig. VI).

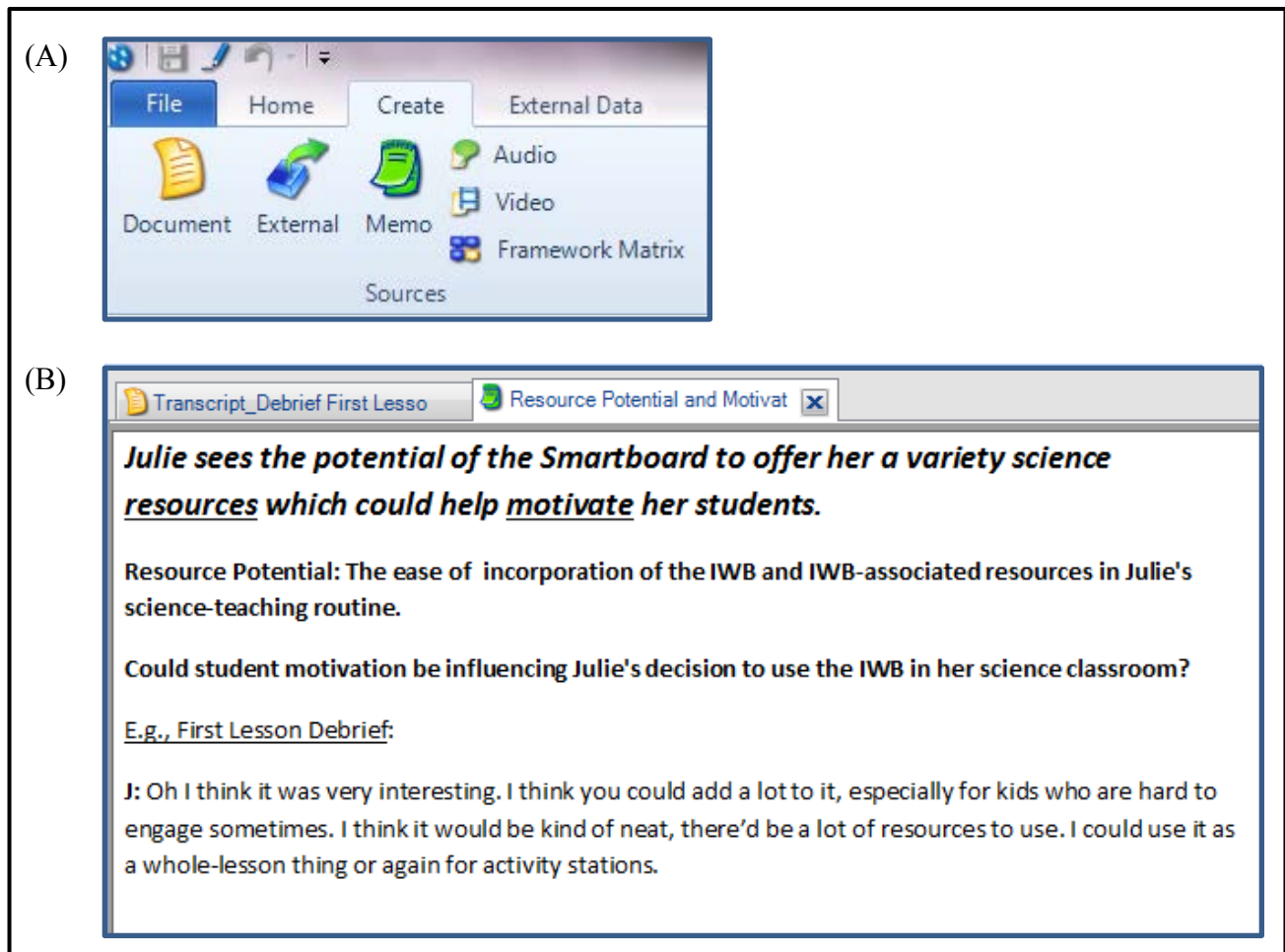
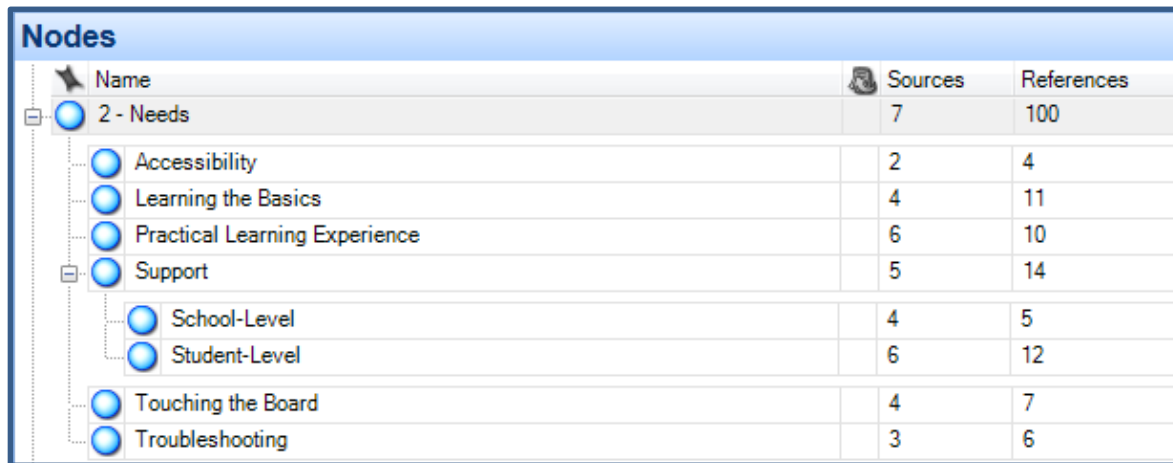


Figure VI: (a) Use of the memo feature in *NVivo* to assist with tracking of emerging themes; (b) Emerging themes were noted by the researcher and ideas were outlined for subsequent data coding.

Phase 3: Searching for themes. This phase involves identifying a broader-level of themes within the initial codes by sorting the different codes into potential themes. This constitutes the code analysis, where the relationship between codes is examined in order to re-focus the initial codes by collating them to generate potential themes. Within each research question node, the researcher examined the relationship between themes by combining initial themes, forming subthemes and discarding others if they were unclear or irrelevant (Fig. VII). Typical of thematic analysis, frequency counts did not determine prevalence of a theme, as rich and detailed accounts supported themes (Braun & Clarke, 2006). Both latent (hidden) and

semantic statements were considered as part of the analysis to capture the meaning behind the data, as the researcher had first-hand experience with the participant during the PD sessions adding credibility to the researcher's integrity (Braun & Clarke).



Name	Sources	References
2 - Needs	7	100
Accessibility	2	4
Learning the Basics	4	11
Practical Learning Experience	6	10
Support	5	14
School-Level	4	5
Student-Level	6	12
Touching the Board	4	7
Troubleshooting	3	6

Figure VII: A snapshot of the coding analysis process where themes from the initial coding are organized into themes and subthemes within each research question node. Here, some preliminary themes and subthemes within the *Needs* research question are shown.

Phase 4: Reviewing themes. At this point, the researcher reads through the extracts supporting each theme for coherence. Next, the relevance and meaning of each theme are considered by looking for clear and identifying distinctions between themes. This phase consists of reworking themes, deleting unclear or problematic themes and collapsing others into one significant theme while examining their validity across the entire data set. By the end of this phase, the themes have been identified and the dataset's story is revealed (Braun & Clarke, 2006, p.21). Using an example from this thesis, the researcher renamed the theme *Learning the Basics* to *Developing Technology Proficiency*, and combined the theme *Touching the Board* with *Practical Learning Experience* (refer to Fig. VII).

Phase 5: Defining and naming themes. This phase consists of a refinement of the themes in relation to the research questions and the researcher defines each theme as a means of

distinguishing it from other themes. For example, *Support* was defined as assistance, either direct (e.g., demonstrating a feature on the IWB) or indirect (e.g., rearranging a schedule to accommodate Julie's use of the IWB for a PD session) which contributed to Julie's learning to use the IWB. This theme was subdivided into support from students (e.g., student excitement, assistance at the IWB) and school support (e.g., encouragement from other teachers, rescheduling accommodations for Julie's PD sessions).

Phase 6: Producing the report. The final analysis involves choosing vivid examples and details that support the fully worked out themes for a written report. The researcher used the Report feature in *NVivo* and printed the report 'by node' for a complete summary of the analysis according to themes.

3.9 Research Quality and Rigour

This qualitative inquiry ensured the necessary approaches with respect to credibility, dependability and confirmability (Shenton, 2004). Sufficient detail of the context of the phenomenon (i.e., learning to use the IWB to teach science in the elementary classroom) is provided for the reader to decide whether the findings can be justifiably applied to similar settings or paralleled with existing literature (Shenton). Researchers may repeat the methodology of this study, but the unique case study approach will not necessarily lead to similar results (Shenton). The use of four data collection instruments (i.e., CTIS-IWB survey, interviews, researcher logbook and lesson debriefs) enabled cross-referencing between multiple sources, establishing confirmability of the emergent themes by triangulation of the data sources. Although a second coder would have established inter-coder reliability, triangulation of multiple sources improved the validity and reliability of the evaluation of the findings and controlled for bias in establishing valid themes (Golafshani, 2003). In addition, multiple opportunities for discussion of findings occurred as part of the data collection process, and a final member check by email with the participant provided informal feedback attesting confirming the findings (Anfara, Brown, & Mangione, 2002).

Chapter 4: Results

This section features the main findings of the study. Julie's TSE was characterized by the descriptive analysis of the CTIS-IWB survey, interpretations and excerpts from interviews and debriefs, and observations from the researcher logbook. Julie's needs when learning to use the IWB to teach science are presented using a compilation of excerpt interpretations from interviews and debriefs. The last section of this chapter outlines Julie's pedagogical strategies when using the IWB to teach science based on researcher logbook observations and lesson debriefs.

4.1 Julie's Feelings of TSE with Using the IWB

This section is divided into two sub-sections. The first describes Julie's feelings of TSE when teaching science using the IWB based on data collected from the CTIS-IWB survey. The second presents excerpts from the initial interview, the three lesson debriefs, and the final interview, in sequential order to describe Julie's confidence with using the IWB. These are summarized in a timeline as a visual guide to Julie's changing perspective on her confidence level when using the IWB, which is paralleled with the researcher's observations from the three lesson debriefs recorded in the researcher logbook.

4.1.1 The CTIS-IWB survey. The CTIS-IWB survey measured the participants' feelings of TSE when integrating technology, and specifically the IWB, into classroom teaching. It was administered pre and post PD to document possible changes in the participant's feelings of TSE after participating in supportive PD. Notable changes were recorded in fourteen of the twenty-one of statements (67%) (Table 6). A notable change occurred if the participant indicated a different response from an initial position of disagreement to neutrality, disagreement to agreement, and neutrality to agreement with a particular statement. Statements in which the participant indicated an initial position of disagreement to agreement were centered on topics emphasized during the PD sessions, such as learning basic IWB skills, teaching science with the IWB and building confidence when using the IWB in the classroom. Statements in which the participant indicated an initial position of disagreement to neutrality concerned topics which were mentioned, but not fully developed during the PD sessions as they required more advanced IWB techniques and technology expertise. These included student evaluation, mentorship, collection and analysis of data when using the IWB or technologies in general. The statement in which the participant indicated an initial position of neutrality to agreement concerned the ability

to creatively overcome the technical difficulties with the IWB. Statements in which notable changes were recorded are shown in table 5. They were grouped according to emphasis of the topic during the PD as determined by the participant's technological abilities.

Table 6

CTIS-IWB Statements with a Notable Change in Julie's Response Before and After PD*

Statement: 'I feel confident that I [can]...'	Before PD	After PD
<u>Topics More Emphasized During PD</u>		
<i>Have IWB Instructive Skills</i>	SD	A
<i>Teach Relevant Content Using the IWB</i>	SD	A
<i>Monitor Student Computer Development for Projects</i>	SD	A
<i>Regularly Incorporate IWB in Lessons</i>	SD	A
<i>Select Appropriate Technology for Instruction Based on Curriculum Standards</i>	SD	A
<i>Keep Curriculum and IWB in Mind for Student Assessment</i>	SD	A
<i>Be Comfortable Teaching While Using the IWB</i>	SD	A
<i>Develop Creative Ways to Cope with System Constraints and Continue to Teach effectively with IWB</i>	ND/A	A
<i>Carry Out IWB-Based Projects when Opposed by Skeptical Colleagues</i>	SD	A
<u>Topics Less-Emphasized During PD</u>		
<i>Evaluate IWB Software for Teaching and Learning</i>	SD	ND/A
<i>Mentor Students in Appropriate Uses of Technology</i>	SD	ND/A
<i>Consistently Use the IWB in Effective Ways</i>	SD	ND/A
<i>Provide Students with Feedback During Technology Use</i>	SD	ND/A
<i>Use Technology to Collect/Analyze Data from Formative Assessment</i>	SD	ND/A
*A notable change occurred if the participant indicated a different response from an initial position of disagreement to neutrality, disagreement to agreement, and neutrality to agreement with a particular statement. SD = strongly disagree; ND/A = neither disagree/agree; and A = agree.		

4.1.2 Description of Julie's confidence with using the IWB. During the initial interview, Julie was asked about her experience with using technology in the classroom. She reported having used an ELMO (a visual presenter similar to an overhead projector), but when asked about the IWB specifically, she lightheartedly stated “[She] just look[s] at it” (i. i., line 260), and “[does] not use it at all” (i. i., line 331). As a result, she judged her confidence level as non-existent: “I don’t have any confidence” (i. i., line 328). In addition, Julie was asked after each observed IWB lesson how she felt about the lesson she had just taught. After the first lesson, her response to teaching with the IWB for the first time was “I felt very very nervous. I felt like I was being evaluated” (f. d., line 13). She added, however, upon reflecting on the lesson the night before she looked forward to using the IWB again and continuing to improve her IWB skills because “[The students] were very helpful” (f. d., line 81).

After the second IWB science lesson, Julie seemed encouraged with her progress with using the IWB in the classroom, by stating the gradual improvement in her IWB use as “(...) we’re moving gradually, getting better and better” (s. d., line 12), and by commenting on her overall experience: “I enjoyed it. [The students] enjoyed it” (s. d., line 33). She also insisted she wanted to show the researcher she had the ability to use the IWB in her science lesson without any assistance, and not as intimidated by it as she once was: “I wanted to show [the researcher] I could do this (...) I know I could figure it out” (s. d., lines 45-48); however, she mentioned “[She] still felt nervous, but once [she] get[s] warmed up, then it’s okay (...) I was terrified of it. I’m not anymore” (s. d., line 177).

The third IWB science lesson, which was held in the library where the PD took place, yielded an initial response of “I thought it was fun. I thought it was interesting” (t. d., line 7), and focused on the students increased motivation in the lesson as “[She] felt more comfortable in the library than in [the classroom]...because we’ve actually used that one, we practised on it” (t. d., lines 151-152). Her overall remarks from the final IWB lesson: “(...) it was a nice change for [the students] (...) it was exciting for them and for me at the same time” (t. d., lines 228-229). During this debrief, there was no mention of her feeling nervous about using the IWB and she focused on the importance of using the IWB to motivate her students to learn science and its potential as to cater to her students’ needs. Her increased comfort level when using the IWB

during the last lesson (most obviously when using the IWB setup in the library) was articulated (“I felt much more comfortable in the library than I did in (...) the other classroom” (t. d., lines 103-104)), mainly because she used the same computer, IWB, and projector with which she familiarized herself during the PD sessions. In the final interview, when asked specifically about any change in her confidence when working with technology, she responded: “I know more about my computer and at least I can use a Smart board in a classroom now” (f. i., line 437). When asked if the PD affected her confidence level with using the IWB and if she would consider using it in her classroom, she replied “Absolutely! (...) I wouldn’t be afraid of it anymore. It’s just a board” (f. i., line 73), while also reflecting upon her initial feelings before the PD: “Before I was really really afraid of it” (f. i., line 76). Notably, when asked about her original confidence level before the PD with using technology, she rated herself as a 2 out of 10, while after PD she rated herself as a 6.5 or 7 (f. i., lines 444-446). When using the IWB specifically, she rated herself as a 0 out of 10 before the PD, and “either a 5 or a 6” out of ten, or “not a beginner, but not an expert either” (f. i., lines 452-459) after supportive PD sessions.

From the beginning to the end of the PD, Julie gained confidence in her ability to use the IWB to teach science (Fig. VIII). This change is similar to that recorded by the researcher in the researcher logbook.

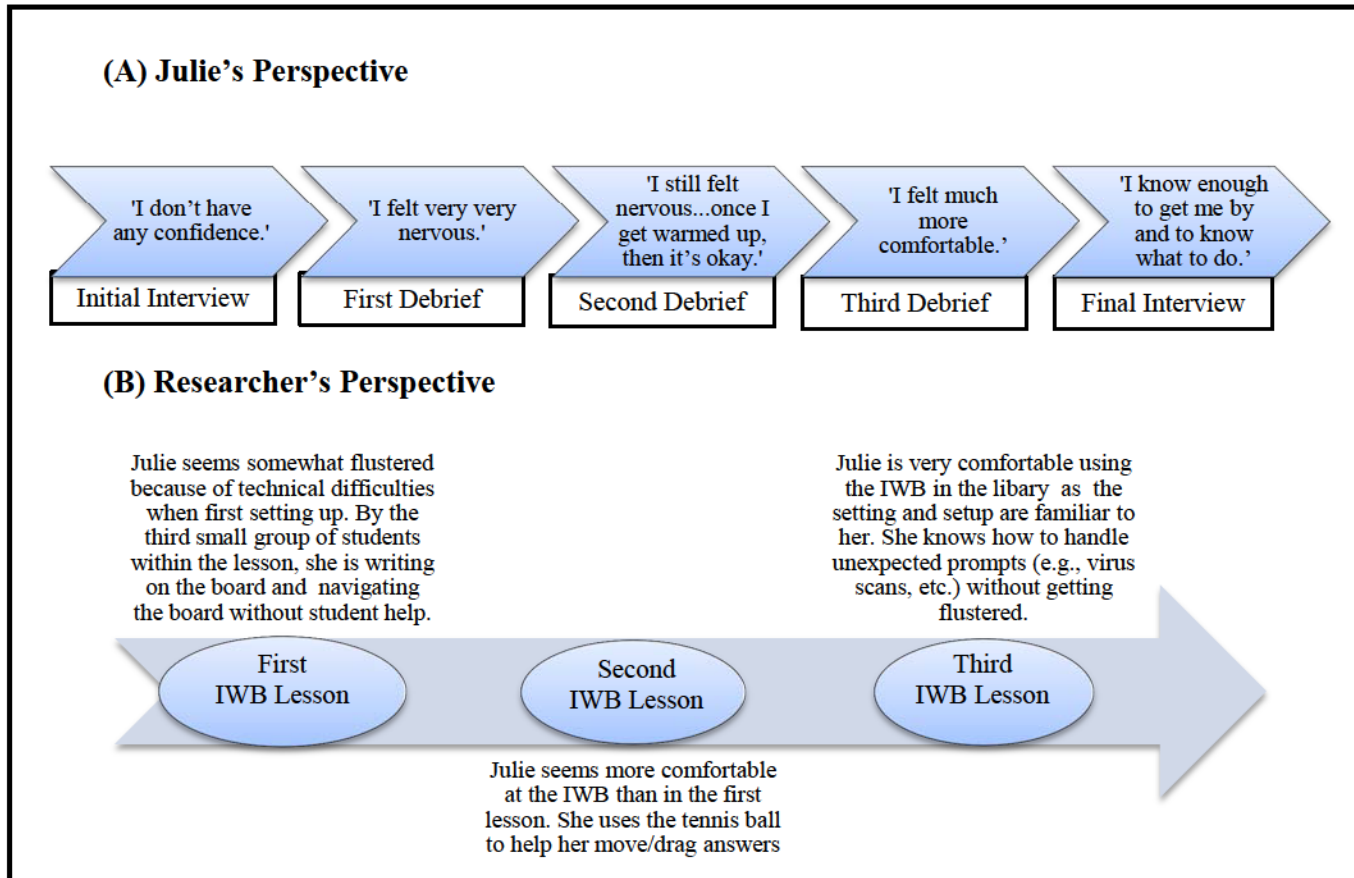


Figure VIII: Julie's confidence level over time with teaching using the IWB from (a) Julie's perspective, supported by selected excerpts articulated during the initial interview, first, second and third lesson debriefs, and final interview, and, (b) the researcher's perspective, supported by observations of each IWB science lesson recorded in the researcher logbook.

Section Summary: Significant changes in Julie's responses on the CTIS-IWB survey revealed Julie's feelings of TSE when using the IWB in the classroom had changed. The most notable increase in confidence was shown on statements concerning the topics more-emphasized during the PD, such as learning basic IWB skills, teaching science with the IWB and building confidence when using the IWB in the classroom. Excerpts from the initial interview, first, second and third lesson debriefs, and final interview can be sequentially illustrated to show an increase in confidence when using the IWB to teach science, which is further supported by observations from the researcher logbook of each IWB science lesson.

4.2 Factors Influencing TSE

This section reports five factors found to influenced Julie's feelings of TSE when using the IWB to teach elementary science. Each factor is supported by passages from the initial and final interviews, and/or the three lesson debriefs. Additional evidence for each factor is presented in Appendix D.

Thematic analysis of selected interviews and debrief statements were categorized into five factors that contributed to Julie's increased TSE when learning to use the IWB to teach elementary science (Fig. IX). The five most influential factors were Julie's (1) level of interest; (2) attitude toward technology; (3) experience with technology; (4) student support; and (5) familiarity with the setting.

4.2.1 Interest. Julie had a desire to learn about how to use the IWB in her classroom to teach science and was curious about the IWB resources available. During the first interview, she stated "I look forward to trying to use it and learning (...) and getting more resources in science" (i. i., lines 343-344). Furthermore, she had looked up the IWB's potential for teaching science prior to meeting with the researcher: "I was watching some YouTube videos on Smart boards, and one of the examples that they showed was a science lesson on the planets. I thought that would be really neat to use" (i. i., lines 363-365). Her interest carried through well into the final interview where she shares some IWB resources that could be useful to her in the teaching of other subjects as well such as music and languages (f. i., lines 203-204; lines 215-217).

4.2.2 Attitude toward technology. One of the reasons why Julie was able to take advantage of the PD despite her limited experience with technology is her positive way of viewing technology in seeing its potential for resources she can use as well as her open-mindedness to further developing her skills in technology. She acknowledged not being "against" the use of technology in the classroom (f. i., lines 141) and remained open to the idea of incorporating technology in the classroom. But, she stipulated "It depends on if [teachers] are willing to do it. If they're not willing, and they're set in their ways, then there is no sense in showing them because they won't use it [in the classroom]" (f. i., lines 383-385). From this her experience with

teacher PD, “having the right attitude” determines what teachers get out of the PD and if they choose to incorporate what they’ve learned into their teaching practice (f. i., lines 430-431).

4.2.3 Experience with technology. Julie was able to develop her IWB skills and technology capabilities by building upon her level of knowledge. The PD catered to working with her abilities and enabled her to gain hands-on experience with the IWB. As Julie explained “The more you encounter [technical difficulties], the more you start to solve them (...) you might know what to do or you might not, but at least you won’t think ‘oh no, what do I do?’ and panic, like I used to do” (t. d., lines 160-161).

4.2.4 Student support. The students were supportive while the participant practised using the IWB to teach her science lesson. They openly offered their assistance with setting up the IWB and with troubleshooting. Part of the reason Julie felt at ease using this technology in her classroom was the fact they “were a nice group of kids” (f. d., line 84) and were “supportive” (s. d., line 285) and “helpful” (s. d., line 85) during the technical IWB challenges that occurred while Julie taught with the IWB. The students’ increase in motivation and positive reaction when Julie incorporated the IWB in her science lessons also gave her incentive to further develop her IWB skills to be able to have the confidence to try it with future classes. In the first interview, Julie stated she was ‘looking forward to having the kids interact with it’ (f. i., lines 346-347). After her first experience with the IWB teaching a science lesson, she is motivated by the potential it offers “I could add a lot to it, especially for the kids who are hard to engage [in science class] because (...) [the IWB] gets them excited to learn” (f. d., lines 37-39) and “[The IWB] was exciting for them and exciting for me at the same time” (t. d., lines 227-229).

4.2.5 Familiarity with the setting. Julie’s third and final lesson was taught twice because of technical difficulties – once in the classroom and again in the library. The IWB in the classroom was a portable one, and not Julie’s usual classroom. The library was where most of Julie’s PD sessions had occurred and had a permanent IWB setup. The type of IWB and the familiarity of the classroom setting influenced her level of comfort when using the IWB in her science lesson. She was reassured during her science lesson in the library and was not worried about technology malfunctions as using the projector, computer and IWB she had practiced on in: “I wasn’t even

worried about it. I felt it would work because we had done it before” (f. i, line 47). As she did not have her own classroom, Julie taught her IWB science lessons in a classroom foreign to both her and her students and students were sitting at desks far away from the board, where she felt a slight disconnect. Student groupings were also important in decreasing her level of nervousness when teaching with IWB. She comments on working with a small group of students rather than a large group collected around the IWB: “When I had the students [in small groups] it worked well because we had a small group at the Smart board, giving all students a chance to participate (...) and chances to work in smaller groups with me. I can get everyone involved that way and have an idea of if they’re getting it or not (...) I kind of feel more comfortable doing things that way” (t. d., lines 175-177). As Julie taught an IWB science lesson in the library only once, there is less evidence supporting this factor, although a recognizable change in confidence was observed by the researcher and experienced by Julie when teaching the same science lesson in the (familiar) library versus the (less familiar) classroom setting.

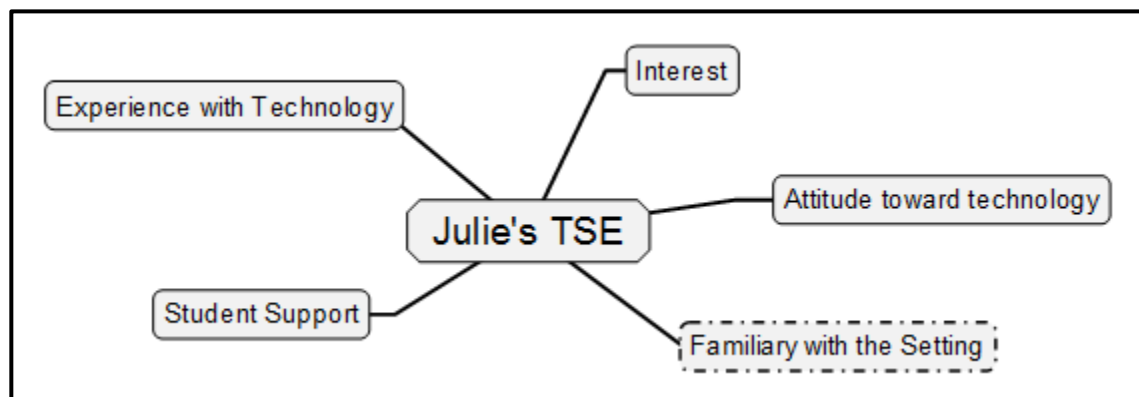


Figure IX: Map of factors that influenced Julie’s TSE when using the IWB.

Note: There was less evidence for the familiarity with the setting factor as Julie taught in the library only once; however, a noticeable change in TSE was articulated by Julie and observed by the participant between the classroom and library (where the PD took place).

Section Summary: Interest, attitude, experience with technology, student support, and familiarity with the setting were found to have an influence on Julie’s feelings of TSE when using the IWB to teach grade 5 science.

4.3 Julie's PD Needs when Using the IWB to Teach Science and Technology

This section details the Julie's needs when learning to use the IWB to teach elementary science based on communications during the interviews and lesson debriefs, as well as observations by the researcher. They are classified using a modified version of the Zhao et al. (2002) model (see conceptual framework in chapter 2) based on three interactive domains: (1) The Teacher, (2) The Context, and (3) The IWB (Fig. X).

4.3.1 Teacher-Level Needs.

Technology proficiency. Julie had very little experience with using an IWB and her past experiences with learning about the IWB were “overwhelming” and “scary” (i. i., lines 267-268). She enjoyed her PD experience with the researcher as it catered to her level of technology proficiency: “The other [IWB] PD, I couldn't keep up with it (...) [I was] frustrated (...) This time it wasn't like that. It was step-by-step-by-step and (...) it really helped me to get used it” (f. d., lines 294-297). She also explained: “If you don't have that basic knowledge behind you then you don't like it, and then it can become scary, like with me before we started working together” (f. d., lines 279-281). Learning to use the IWB requires basic computer, projector and IWB knowledge, which can be overwhelming for someone with little experience with technology both inside and outside the classroom. Starting at Julie's level of technology knowledge contributed to what she took away from the PD: “I had never learned so much about my own computer in my life as I have with [the researcher] teaching me” (f. d., lines 263-264). As Julie pointed out: “(...) it took me a while to have it sink into my head, but all-in-all, it's not really difficult to get used to. I mean it was for me at first and [the researcher] had to really show me a lot of about computers, but if you have that basic already, then it's fairly easy” (f. d., lines 54-58). Julie also mentioned how working with other teachers who at a more advanced level of technology proficiency during the PD can be intimidating. When asked if the PD with the researcher would have been with a group of advanced teachers instead of the one-on-one format, Julie matter-of-factly stated: “[I] probably would have left (...) because I would have felt left out” (f. i., lines 135-136), and emphasized the importance of working with people with “similar abilities” (s. d., line 237) to lower if not eliminate the level of intimidation.

Practical learning experiences. During most PD sessions, Julie had access to an IWB where she could practice her IWB skills by directly touching the board. This helped her to develop her IWB skills at a faster rate, as she explains: ‘Yes, I’m a lot faster on [the IWB] because I got used to touching it, whereas before, I hadn’t even touched it’ (f. i., lines 85-86).

The frequency with which Julie and the researcher met also helped her to deal with the “many steps to remember” (f. i., line 64): “You need more than one or two little sessions (...) it has to be continual (...) twice per week so you don’t forget stuff in between and have a chance to practice it [in the classroom]” (f. i., lines 152-155). Another important point is the showing *how* the IWB can be used in the classroom: “Show [teachers] exactly how you could use it in a classroom, like the practical things that we’ve been doing, you know, like taking the grade 5s and doing a lesson with them” (s. d., lines 286-287). Furthermore, given Julie was new at integrating technology in her classroom, “small steps” (s. d., lines 181-182), and “quick and easy tips” (f. d., lines 320-322) were helpful for Julie to learn IWB lesson design. Julie also commented on how “fortunate [she] is to have this opportunity to learn as it is not often teachers have a chance to [learn about] the IWB on a one-on-one basis” (s. d., lines 172-174).

Experience with troubleshooting. One of the main complications for Julie to learn to work with the IWB was to overcome troubleshooting challenges. These were especially evident when using the portable IWB in the classroom (as opposed to the permanent one in the library) with issues with sound, network and internet connections, multiple realignments of the IWB, and equipment malfunctions. Although Julie struggled with troubleshooting, she feels they are to be expected when working with any technology: “The videos we were watching with the internet being so slow, it’s part of [learning] technology to learn to adapt to these glitches” (t. d., lines 156-158). She does stipulate, however, that limited time during the lesson does not lend itself well for her to “fiddle around with it” (f. i., lines 295-296), or if using a portable IWB where there are wires (which Julie considers a tripping hazard for the students) as well as problems with having to recalibrate often, “it’s not worth it” (f. i., line 331). She adds she “would really have to know it, know what [she’s] doing to be able to prevent those delays” (f. d., lines 170-171) and “remembering how to do it (...) all the little steps” (f. d., lines 369-370) become easier the more they are more frequently encountered. She explains: “The more you encounter [troubleshooting

issues], the more you start to solve them” (t. d., lines 166-167). Notably, only troubleshooting issues related to *Notebook* tool use occurred during the last IWB lesson.

Unlike her past PD experience of only two days, extended PD with frequent interactions helped her to gain additional experience with using the IWB. The addition of a weekly session, or increasing the frequency of sessions to two per week, impacted her learning: “The frequency of twice a week [rather than once] (...) made more of a difference” (s. d., lines 250-251), especially in Julie’s case as she entered the PD with basic knowledge of technology.

Observations of Julie’s troubleshooting were documented in the researcher logbook. Troubleshooting issues occurred when using the IWB to teach a science lesson (Table 6). A more-detailed description of the troubleshooting observations from the researcher logbook can be found in Appendix E. Julie’s troubleshooting encounters were categorized into five types: (1) *Setup*, which included any difficulties with the initial and/or organization of the IWB and its associated equipment (i.e., the projector and desktop); (2) *Alignment*, which was considered a troubleshooting encounter if the board needed to be recalibrated more than once within one lesson; (3) *IWB Software and Tools*, which included any complications with Notebook software features and IWB manipulation; (4) *Lack of Equipment and/or Connectivity*, which encompassed difficulties with improper or lacking equipment and/or failed network or internet connectivity; (5) *IWB Inconvenience*, which considered any other technology-related issues such as cord-tripping hazards and password resets.

Table 7

Julie's Most-Common Troubleshooting Encounters When Using the IWB to Teach Three IWB Science Lessons

	Setup	Alignment	IWB Software and Tools	Lack of Equipment and/or connectivity	IWB Inconvenience
1	✓	✓	✓		✓
2	✓	✓	✓		✓
3a		✓	✓	✓	✓
3b			✓		

3a – first attempt at the third lesson using the portable IWB in the classroom;

3b – second attempt at the third lesson using the permanent IWB in the library.

All three of Julie's lessons contained troubleshooting encounters, but only difficulties with IWB software and tools were present during each lesson. All lessons had similar encounters, with the exception of the third lesson, where the first attempt halted the lesson because of a lack of speakers to play the videos, not network and internet connectivity. The second and final attempt of the third lesson had significantly fewer troubleshooting issues as Julie was able to setup the equipment without any assistance from the researcher or students and did not need to align the IWB as projector and board remained aligned because of setup permanency.

Integration potential and resource relevance. Julie expressed to the researcher regarding more interactive science resources for her classroom. She also wanted “quick and easy” (f. d., lines 320-322) ways to integrate these resources in her classroom, as she did not have a lot of experience with using technology or the IWB. IWB features such as table options, photo capturing (graphic, image and video inserts), interactive games such as vortex and matching through *Gallery Essentials*, diagram labelling, pull-tab and erase-and-reveal designs, as well as online resources from *SMARTExchange*. These features complemented her teaching approach (i.e., interactive science lessons to motivate the students) and catered to her need to acquire relevant science resources. Subject-specific PD is “a good idea as teachers should learn the tools

that apply to the grade level [they teach]. As a science teacher, I don't want to sit there and learn math tools" (s. d., lines 288-289). As there are multiple features available for science, math and language teachers, Julie indicated that PD addressing content which is relevant to what she is teaching can be part of her motivation to learn the technology and likelihood of incorporating it in her classroom. Another motivating factor to learn the IWB was her interest in adding some interactive science resources to her collection. She admitted some of the science resources at her disposal are out-of-date, and given the students seem to respond well to the IWB, learning how to use the IWB was a chance to add some resources to her repertoire. Julie felt she could benefit from IWB resources in her science teaching and she experienced the ease with which resources can be acquired online and see the potential for whole lessons or for activity stations (f. i., line 39). She was also able to see the value of the IWB as a "different way of presenting material" (f. d., lines 113-116).

Julie admitted her favourite aspects of using the IWB to teach science were the interactive games, which motivated the students to learn, as well as the large collection of online resources at her disposal on sites such as *SMART Exchange*. In addition, she appreciated the option to customize already-existing online lessons to cater to her students' needs and level of knowledge on the topic for her classroom ("I can modify and use [the lessons] the way I want" (t. d., lines 243-245), which can save time when designing IWB lessons. She also enjoyed the fact that it's different experience for the students: "It's a different medium to write on and something they can relate to. It's different because it's special, technological and has lots of features like choice of colour" (t. d., lines 248-249). She adds the IWB is a great learning tool because students are more likely to relate to it: "They've been raised on it (...) and they know a lot about it at such a young age" (t. d., lines 251-252).

4.3.2 Contextual-level needs.

Technology support. Having someone available at the school is another important aspect to support technology use in the classroom. Julie received support from the researcher during the PD sessions as well as from the students while teaching her science lessons. Having support readily available when learning to work with a new technology was very helpful for her

especially with troubleshoots as she voices her concern “What happens if something goes wrong with the projector? Or the board itself?” (f. d., lines 160-161). Julie expressed having someone in the school to help with troubleshooting and other concerns is an important consideration when looking to have teachers work with new technologies in the classroom, specifically one who is “patient” (f. d., 267-269) and “willing to repeat as there are a lot of steps to remember” (f. i., line 64).

School support. As Julie did not have her own classroom with an IWB, the principal and other teachers at the school agreed to rearrange their schedule to allow for her to practice using the IWB during PD sessions as well as for her in-class lessons. Staff seemed to welcome this opportunity for Julie and encouraged her throughout by asking how she was progressing and commenting on students’ excitement to have Julie using the IWB in her science classroom.

PD design. The PD was based on Julie’s specific needs when using the IWB to teach grade 5 science, Julie’s experience with the IWB to gaining practical one-on-one (rather than group) format, and the fact that the PD was geared to her (beginner) level. This is part of what made the PD sessions and IWB lessons “fun” (f. d., line 88) and “interesting” (f. d., line 37).

Classroom setup. Julie did not have access to her own classroom and in order to be able to teach a science lesson to her students using the IWB, the students had to be relocated to another classroom. The room Julie usually taught in was set up “totally different from the classroom [she] usually teaches in” (s. d., lines 24-25), which she feels is something she and the students had to adjust to as it changed their routine. Julie often commented on the classroom setup as being an important factor how she felt about the lesson as she felt having students sit at desks far from the IWB made her feel like she was “leaving out or excluding some students” (t. d., lines 166-167), or not giving all students a fair opportunity to answer. She commented about her second IWB lesson with the whole group: “when we had them all close to the board in the classroom, there were little (disciplinary) incidences that started to happen (...) and, [they] were just so crowded and close together” (t. d., lines 202-203), whereas in the library (third lesson), although they were gathered around the IWB, there were fewer students present. At the other extreme, students should not be too far from the IWB, she argues, “because when we put them

farther away, they're farther away from learning" (t. d., lines 205-207). With the extra space and few students in the library setting, students "were more comfortable and weren't nitpicking or anything like that which made it easier on [her]" (t. d., lines 212-213). When working in her colleague's classroom for two of her in-class lessons, this was an issue. The third lesson in the library had "more space" (t. d., line 215), and had students "gathered around the Smart board where everyone could feel a part of the group" (t. d., line 175-176). The library itself had fewer distractions than the classroom, which led to less competition on behalf of the students to access the board.

Student support. Julie specifically chose this grade 5 group of students to help her practice her classroom IWB skills because they were "very helpful and understanding" (f. d., lines 85-86) and "a nice group of kids" (f. d., line 84). As mentioned by Julie in every debrief, students were supportive in letting her try out the IWB with them and were patient during IWB setup and eager to help with the alignment and viewing features as part of the setup. She admitted she would not have attempted teaching with a new technology with just any group of students. Fewer students seemed to offer a more supportive environment and seemed to play a role in how Julie used the IWB as she reflected on the first lesson when the students were divided into three small groups for activity stations: "I felt [dividing the students into small groups] worked well and gave everyone a chance to participate" (t. d., lines 27-28), but admits her confidence level teaching using the IWB was the same as teaching the whole group vs. the smaller groups for the activity stations.

Julie compared her experience working with the students in smaller groups (i.e., activity station format) vs. using the IWB with the whole class. She feels the first lesson with the smaller groups "worked well because everyone could have a chance" (s. d., lines 132-133) to approach the IWB, promoting a more inclusive environment. When working with the whole class, she would want to have enough choices so she could encourage everyone to participate. She explains using a vortex game example: "To do it with the whole class, let's say there were 16 choices, you could choose at least 16 different kids and then at the end (...) have someone read over the answers to give another person a chance [to participate]" (t. d., lines 185-189).

4.3.3 IWB-level needs.

Board type. During PD sessions, Julie had a chance to practice on various boards in the school. Most sessions she practiced using the permanent IWB in the school library. For two out of her three in-class science lessons, she used a portable IWB located in another teacher's classroom. This caused several problems including wire-tripping hazards for the students, complications in setup (i.e., placement of the projector, use of a laptop Julie unfamiliar to Julie), realignment issues having to realign the IWB nearly every time she or a student pushed too hard on the board and faster internet connection. The third in-class lesson was in the library, where there was a notable difference in the way Julie felt about using the IWB: "It's anchored (...) there's a little more room and we're not tripping over the wires. And the little step was handy for the students" (t. d., lines 59-62). This difference also enabled Julie and her students to use a tennis ball in lieu of their fingers to play the games, which would not have been possible with a portable IWB.

Accessibility. Julie did not have access to her own classroom or an IWB, not all classrooms in the school had an IWB, and there were only four in the school. Unfortunately, she almost never had access to three of the IWBs because they were reserved for specific grades or setup in the library.

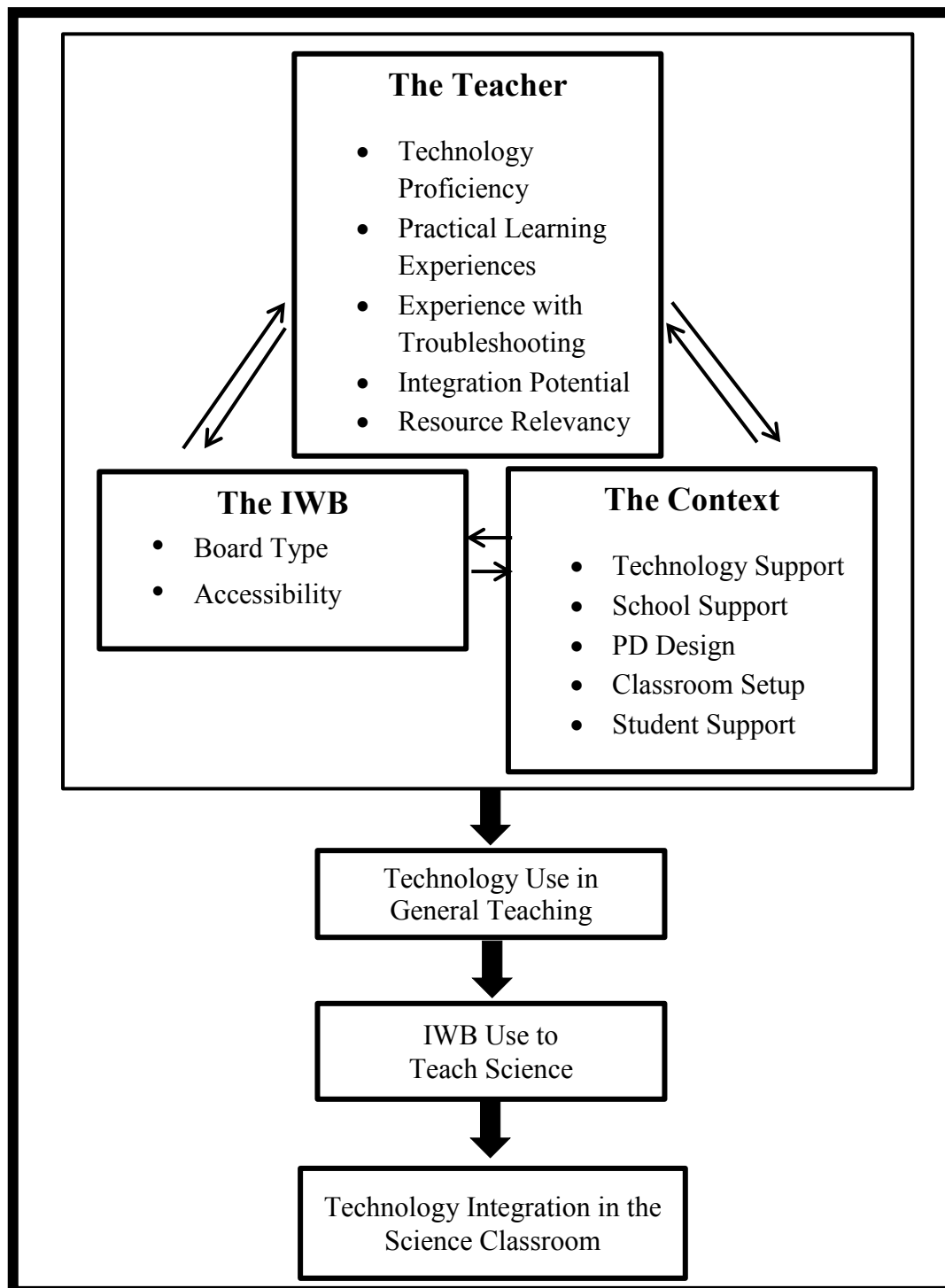


Figure X: Julie's needs when learning to use the IWB to teach elementary science classified into three interactive domains: (1) The Teacher, (2) The Context, and (3) The IWB, based on the Zhao et al. (2002) model.

4.4 Pedagogical Strategies When Using the IWB to Teach Science

This section presents the IWB-integrated pedagogical strategies used by Julie during the three IWB science lessons. The strategies were identified based on researcher observations during each science lesson as well as the discussion during the three lesson debriefs. Julie's use of the IWB's tools and their application to elementary science teaching are also examined.

Julie taught three science lessons using the IWB (Appendix F). As observed by the researcher and discussed in the lesson debriefs, she incorporated a variety of IWB-integrated pedagogical approaches specific to science teaching. Examples relating to less-specific IWB-integrated pedagogical strategies that were presented in chapter 2 are listed in Appendix G, while the focus of this section is sub-specific IWB-integrated science pedagogies.

4.4.1 Visual display of important scientific concepts and processes. The dynamic visual display of the IWB was appealing to students, as this was a tool Julie had never used with them in the science classroom. By importing and capturing pictures, diagrams and photos, Julie produced visually-appealing lessons. These were displayed in an interactive fashion as she and her students could edit, move objects or annotate information at the board, making the lessons more interactive, which in turn, engaged the students to focus on the lesson. As Julie commented in her third debrief, the IWB is “a modern bigger and brighter overhead projector [that’s easier for students to see and relate to technology-wise], “kind of like comparing an HD TV to an older TV [...] a better picture [...] it’s very colourful too” (f. d., lines 148-150). She described the IWB as interesting and motivating for the students and something they look forward to: “When I’d tell the students we’re going to do a Smart board activity today, they are excited and they say alright! (...) because it’s not something they usually do with me and is something new [for them]” (f. i., lines 361-365).

Given the visual appeal of the board, Julie was able to engage the students during the three IWB science lessons on key concepts she felt were in need of review for her students. During the first lesson, the IWB station was attractive to students, as each small group of students had a chance to interact with Julie and the board to focus on renewable vs non-renewable resources by approaching the board and classifying them in a vortex-style game (Fig. XI). There was also a chance for students to discuss and write examples of natural resources and

expand on concepts such as crude oil extraction, ground water contamination and environmental concerns related to resource depletion that was also interactive by nature because students were able to write at the board.

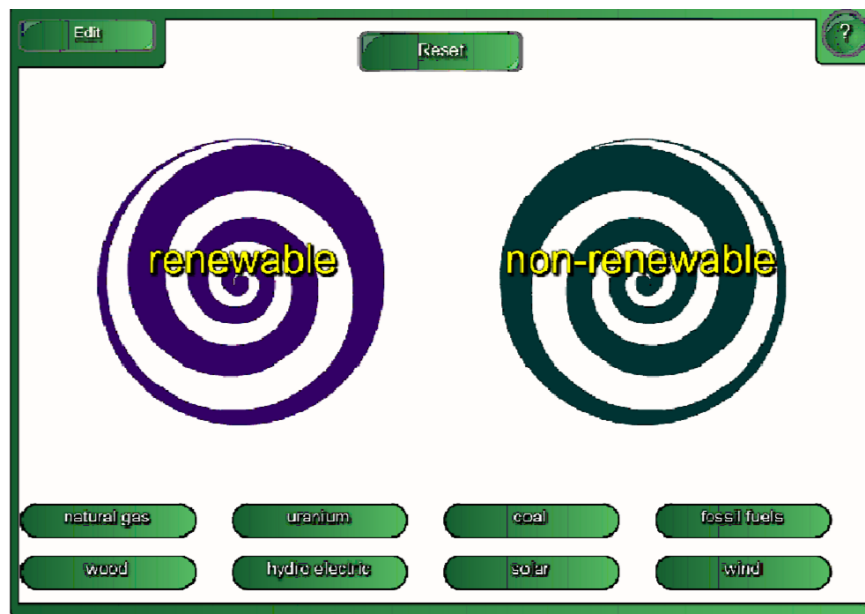


Figure XI: IWB activity where students were asked to classify over 20 words (not all shown here) into two categories of renewable and non-renewable resources.

By the third lesson, Julie explains how the change in routine helped the kids to better pay attention to the science lessons: “I had never done anything like that with any students so it was a nice change for them. It was exciting for them and exciting for me at the same time (...), which helped them to pay attention and be interested. (...) It’s nice not to have to do pencil and paper tasks with them as those can be boring” (f. i., lines 355-357). She also admits her eagerness to use the IWB: “I think it helped to motivate the kids [to learn science] and I enjoyed it too for (...) using it to teach science and for learning [about science]” (t. d., lines 480-483).

4.4.2 Strategic questioning using IWB resources. Julie incorporated strategies for questioning to engage the students in her first lesson as her main goal was to review and further their learning on a topic they had already briefly touched upon earlier in the school year. The

first lesson opened with asking the students the difference between renewable and non-renewable resources. Although the lessons were filled with visuals and few words, Julie frequently asked questions when encountering various resources such as where the resource was located in nature and what the resource was used for. This was a straightforward classification game, but Julie animated the activity by having the students justify when they would drag their answer into the vortex, emphasizing the *why* behind the classification (e.g., Why do you think wood is a renewable resource?). As sometimes the students could get a little excited and try either vortex without much thought, Julie paused the game and asked the students to share ideas as to why the resource was rejected when being placed in the incorrect vortex, or encouraging them to add other ideas to the classification table (Fig. XII).

Use the pen to write your answers. The word bank will help you.

3 sources of renewable energy	
2 harvested resources	
3 products made from oil	
another word for oil	
conserve	
renewable	
extract	

trees water sun petroleum asphalt makeup wind

plastics to store up or save resources taken from earth

a natural energy source that can be replaced corn

Figure XII: IWB lesson on renewable vs non-renewable resources using debate technique with hints from the word bank or their own ideas.

The second lesson was different from the first in that it involved whole-group instruction on the topic of the human digestive system. The lessons design was mostly in quiz format and titled “What do you know about parts of the digestive system?” with one slide/question per organ. This lesson acted as a review for the students and Julie was looking to get feedback on their level of knowledge on this topic. Some students read each question on the slide to the class, while others later attempted to answer the question or approached the board to reveal the answer. As students would offer their answer to the question, Julie would encourage them to justify their answer. Some even shared personal stories related to health problems, which led to a discussion about Crohn’s disease and facts about intestine length. Each slide built upon next slides to as the digestive pathway was traced in a final ‘story’ of how food makes its way throughout the body. The IWB components of the lesson (e.g., drop-and-drag, erase and reveal, and moving-parts diagrams) elicited other questions such as similarities between part location and organ sizes) (Fig. XIII).

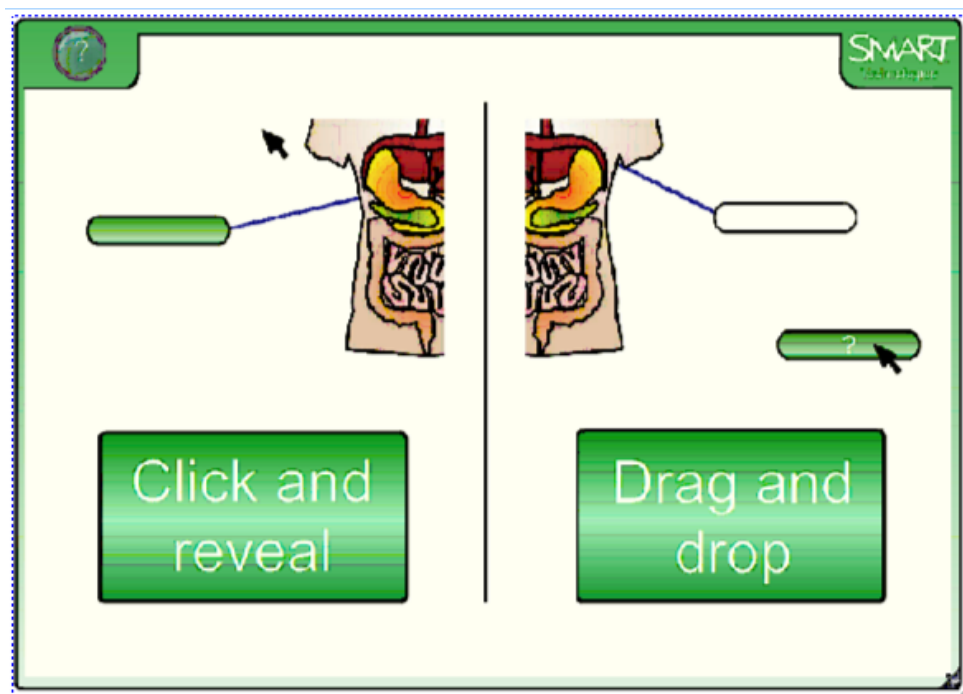


Figure XIII: Human digestion lesson using click and reveal and drag and drop options.

Another example of strategic questioning occurred during the video portion of the Recycling and Compost (third) lesson. The videos covered topics, such as how glass, plastic and aluminum are made, that sparked students' interest and provided an entry into several discussion points on similar topics. Julie pause each video at key questioning points and asked the students questions, which helped to keep them engaged and adds to the basic video content. These questions were "real-life" application questions, such as listing other examples of consumables and alternative disposal options, in addition to those presented in the video.

4.4.3 Step-by-step discussion. After the first lesson, Julie states "It's a different way to present something or a different way to review something with them. It can also bring out components (...) they don't know much about and (...) it brings out things that maybe should be explored a little bit further" (f. d., lines 113-116). The specific example Julie was referring to was students' asking about biomass, one of the words present in the word bank she prepared. Julie did not realize students at this level had such an advanced science vocabulary related to this topic and was able to take the lesson to a more advanced level than was previously anticipated.

A step-by-step discussion was evident in the design of the third science lesson on the topic of recycling and compost. The first part of this lesson was a classification activity where students could approach the board to sort the items. This prompted the intended discussion of how some items could be included in more than one category and how recycled materials are recycled differently depending on the city. This led to a discussion of waste management and community involvement and initiatives as part of what Julie had planned for the lesson (Fig. XIV). At this point, students were so captivated by the lesson, they were reluctant to proceed to their next class.

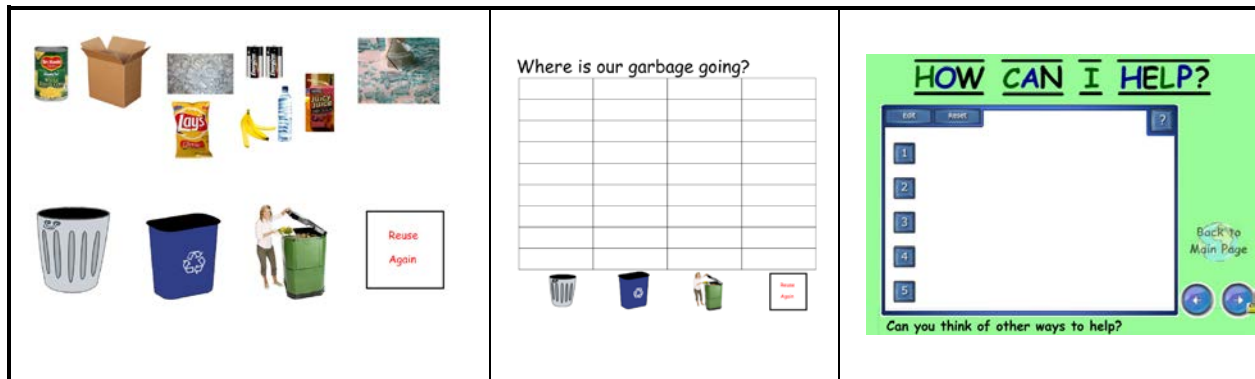


Figure XIV: Recycling and compost lesson involving the classification of everyday items that led to a discussion of community waste programs and involvement.

4.4.4 Promoting an (inter)active learning environment. Julie sees the potential of the IWB as a teaching tool that is “a different way of presenting material to the kids” (t. d., lines 67-69). Some of the features she most enjoyed were the “interactive games and [other interactive] aspects such as having the students participate in the lesson by approaching the Smart board” (t. d., lines 242-243). She also liked the idea of the pull-tabs and vortices as they “added interactivity to the classroom and get the kids up and involved instead of sitting down doing pencil and paper tasks” (f. i., lines 355-357).

Creating opportunities for student participation and manipulation. Another reason why the IWB science lessons were so successful in Julie’s opinion was because of the excitement and motivation students had for using the IWB. Julie involved the students as much as possible in order as her main goal with using the IWB to teach science was to add interactivity to her classroom. During the first lesson, Julie was able to include most students from each small group to manipulate items at the board. In her opinion, the small-group vs whole-group IWB instruction offered students a more inclusive environment for answering questions and sharing their opinions and this was also remarked by the researcher. Julie had also designed her lessons with the idea of providing as many opportunities as possible as this was a new science class experience for them and they enjoyed approaching the board as part of the incentive to pay attention. The plethora of examples incorporated by Julie into her science lessons allowed for

most students to participate by approaching the board, or reading aloud what was written on the board.

During the third lesson debrief, Julie commented how students, who were not usually as involved in her (science) lessons, were actively involved in approaching the board. It was an alternative for getting students motivated during the lesson, especially with “very very shy students like Amanda [pseudonym]” (t. d., lines 23-24). Julie elaborated on how she had remarked Amanda had participated in both small-group (activity stations) and whole-class activities equally as much, which is not typical of her behaviour in the science classroom. Julie thought the IWB as a tool to “bring students out of their shell” (f. i., line 312), such as was the case with Amanda who is “usually quite timid and doesn’t normally say anything in class” (s. d., lines 154-155), but who approached the board a few times to check her answer by erasing or pressing a “check answer” button. She noticed the same in other students: “Even Trisha [pseudonym] came up and did write on the board and so did Patrick [pseudonym] [who participated in whole-group discussion] and he is usually very quiet” (t. d., line 209).

Julie explains that part of getting students to participate in the lesson is knowing how to manage the classroom. The researcher noted by the third time of presenting the IWB lesson during the activity station lesson, Julie had developed tricks to help manage student excitement such as giving instructions prior to the start of the game and limiting the amount of time students were writing on the IWB. By the third lesson, Julie seems to have a routine established with the students such as they knew they would have a chance to interact with the IWB and would give their full attention in anticipation of the lesson.

4.4.5 Integrating technologies with other resources. The first lesson consisted of three activity sessions: one of which was led by Julie at the IWB (i.e., the station with technology) concerning renewable and non-renewable resources, while the other two were small-group energy conservations activities (i.e., worksheets and poster-making without technology). Students were able to work in pairs within their small groups at the other stations, while Julie taught a small-group activity at the IWB. The IWB was also integrated in the second science lesson to extend a previous activity that involved an accompanying large flipchart with diagrams

of the human digestive system. This flipchart was helpful for students as part of the IWB lesson as students were familiar with this resource. It complemented the lesson and was used as a point of reference when labelling the diagram. Julie also commented on how interesting it was for her to use the IWB in a science lesson and the potential it has to offer for motivating students because of the nature of the IWB to offer a variety of technology resources: “I could add a lot to it, especially for the kids who are hard to engage [in science class] because (...) [the IWB] gets them excited to learn” (f. d., lines 37-39) and “[She] thinks it would be helpful as (...) there are a lot of resources to use and to show the kids [in terms of online science resources and IWB lessons]” (s. d., lines 137-138)”.

Julie also noted the potential of using the IWB as a teaching tool in part or in whole for a variety of subjects other than science. During the second debrief, Julie remarked on the many ways a teacher could integrate the IWB in their classroom, such as the graphing feature for teaching numeracy and the importing of vocabulary worksheets for teaching literacy. During the third lesson debrief, Julie mentioned her IWB lesson on recycling and compost could have easily been combined with other resources such as a pamphlet from the city with the recycling and garbage schedule and dump information for the community because the students could use more ideas about “what community is and their role in [it] and [the IWB] could lead us to share more ideas” (t. d., lines 97-99). As there was time left of the science period, Julie showed the students some of her pictures she had inserted into *Notebook* while practising these skills with the researcher. She used the pictures as prompts for a discussion on biodiversity, a topic she felt students could benefit from learning more in depth using real-life examples.

The IWB is also another resource for Julie as it gave her “different ways to approach a certain topic the students may need to revisit” (f. d., lines 113-116). After gaining experience with the IWB, she immediately decided she will look up an IWB lesson on flight as it can be a complicated topic to explain (f. i., lines 493-494). The fact “There are a lot of resources to use (...) for both whole-group and small-group [activity stations] can be beneficial for her classroom, especially for students who need a bit more motivation to pay attention” (f. d., lines 40-41). Although she finds the IWB useful for reviewing concepts as “colourful reinforcement” (s. d., line 135), she would make sure to “balance the traditional and more modern [teaching]

approaches” by complementing her lessons with the use of the IWB with worksheets, scavenger hunts and group discussions (s. d., lines 123-124).

4.4.6 Obtaining immediate student feedback. The IWB lessons provided Julie with insight as to what the students know or need some extra review in what she called “[The IWB provides me with] important feedback. Students respond to [the IWB] because they can relate to technology” (s. d., lines 100-101). At the first lesson debrief, Julie mentioned “[The IWB] could be a good tool for kids who have certain learning difficulties” (f. d., line 302), such as those who have trouble with fine motor skills (e.g., writing) or as a possible assessment tool for those students (“I could use it as a way (...) to see what they know like as an assessment” (f. d., line 387). She elaborated on this using the example of Allison (pseudonym), one of her students who has a “very difficult time putting things down on paper...but who is very good orally” (f. d., lines 390-391). She participated in the lesson by offering the example of geysers, an advanced concept for the class. At the third debrief, Julie comments on the IWB enabling to get to know her students on a different level such as Allison, who has trouble with her fine motor skills. What surprised Julie is Allison wrote on the IWB using both her right and left hand, which could explain why she struggles with her written work. “[The IWB] would be a good alternative to having her write, such as during tests” (t. d., line 384). The IWB seemed to work for Alison as Julie stated she would often ask her to give her the answer orally during summative assessments such as tests, but she would refuse and often become discouraged at being assessed differently than the other students. But, “If [Allison] did something like a vortex game as well as an oral assessment, that would be something she’d enjoy and would be more interesting for her...and allow her to [better] show off her abilities” (t. d., lines 402-403). As an alternative means of assessment, the IWB could offer students an alternative means of sharing what they know “whereas otherwise you may not have gotten that same amount of [important] information from [the students]” (t. d., line 16).

4.5 Linking IWB Tools to Science Teaching

Julie used specific IWB tools that involved capturing, emphasizing, storing, annotating, modifying and linking information, all ways of treating information conducive to interactive science teaching. These tools can be used for science teaching in specific ways (Table 8).

Table 8

IWB Tools and Their Pedagogical Application to Elementary Science Teaching

IWB Tools Used By Julie	Pedagogical Application to Elementary Science Teaching	Specific Example of How Julie Used the IWB Tools
Capturing - Using pictures for discussion, and brainstorming, shared reading, peer-teaching - Capturing screenshots from web pages	- Engaging and appealing interactive displays; - Constructing a series of interactive activities to develop the scientific story; - Pausing animations or using pictures to build up a process step by step (H) - Clarifying and interpreting with teacher-led discussion (H);	Julie copied and pasted a variety of images related to recycling and compost from the Internet using the camera feature.
Emphasizing - Hiding and revealing (e.g., pull-tab), drag and drop, and matching item activities - Using diagrams - Touching the board (student) - Accommodating lower ability and special needs - Playing games (e.g., vortex)	- Adding interactivity with online activities and during lessons; - Supporting and consolidating sequential knowledge building by using IWB annotation, revisit and reveal features (H)	Julie discussed various parts of the digestive system with prompt such as using ‘erase-and-reveal’, ‘pull-tab’, ‘checker tool’, and ‘click-to-reveal’ tools, which drew the students’ attention to a particular organ and its function.
Storing - Using the ‘save as’ function - Saving a collection multimedia and online resources	- Reviewing learning - Harnessing feedback(H) - Assessment Options - Building up libraries of electronic resources and a variety of science-related activities and lessons (H)	As this lesson was discussion-based, Julie is able to save the lesson with students’ responses for future lesson ideas and prompts.

(table continues)

IWB Tools Used By Julie	Pedagogical Application to Elementary Science Teaching	Specific Example of How Julie Used the IWB Tools⊕
Annotating and Modifying • Highlighting, coloring, or annotating important content • Inserting Tables • Touching the board (student) • Accommodating lower ability and special needs • Correcting mistakes in the materials • Using online resources (e.g., <i>SMARTExchange</i>)	• Framing and structuring tasks to increase attention on most salient subject content; • Amplifying and interpreting representational display (H) using animations or simulations; • Adaptation and differentiation supporting a range of science activities(H) • Guided-discovery learning • Student participation supporting ‘active’ learning (H)	Julie allows students to complete the table using a word bank and/or the drag-and-drop feature to explain natural resources and environmental concerns if they are depleted.
Linking • Flipping back and forth to review previous content providing review • Observing different media (e.g., videos) • Accommodating lower ability and special needs • Using online resources (e.g., <i>SMARTExchange</i>)	• Linking to science-related media files • Accessing online science information • Combining multiple resources linking practice to theory (H) • Making connections to ‘real-life’ contexts	Julie inserts links to Youtube videos from the television show ‘How It’s Made’ on topics related to recycling such as the making of plastic bottles and aluminum cans.

⊕ Refer to Appendix H for more examples

***Section Summary:** Julie incorporated a variety of pedagogical strategies when using the IWB to teach science such as emphasizing important scientific concepts and processes, strategic questioning, step-by-step discussion. She also created an active learning environment by creating opportunities for student participation and manipulation, while integrating the IWB with other resources, and obtaining immediate student feedback.*

Chapter 5: Discussion

5.1 Influencing TSE with Supportive PD

Individual factors related to the teacher's personality, such as self-efficacy, have been shown to affect the use, integration and development of modern technologies in education (Paraskeva *et al.*, 2008). Teachers with a strong sense of self-efficacy are more open to new ideas and new methods of presenting new learning opportunities and experiences for their students (Tschannen-Moran & Woolfolk Hoy, 2001). Gaining a better understanding of what factors influence self-efficacy beliefs is essential as TSE can have a direct impact on how technology is used in teaching and learning (Abbitt & Klett, 2007). This thesis is unique in that it considers the influence of supportive PD on a teacher's TSE when learning to use the IWB for teaching elementary science.

As supported by the results of this thesis, Julie's feelings of TSE were positively influenced after participating in supportive PD on learning to use the IWB to teach elementary science. This is consistent with Koul and Rubba (1999), where PD for inservice teachers led to an increase in TSE (Watson, 2006). In addition, Gonzales, Pickett, Hupert and Martin (2003) found teachers who participated in technology PD to be more confident about using technology in their classrooms. Watson (2006) not only showed PD workshops could influence inservice teachers' TSE, but also how once such feelings were developed, they remained nearly identical a few years after the PD.

The duration of PD activities, or the number of contact hours that participants' spend in the activity as well as the span on time over which the activity takes place, has been shown to positively influence the extent of teacher change (Garet, Porter, Desimone, Birman, & Yoon, 2001). Results of Garet et al. also showed PD of sustained duration to be beneficial as longer activities are more likely to provide an opportunity for in-depth discussion of content and pedagogical strategies, as well as allow teachers to try out new practices in the classroom and obtain feedback on their teaching. The nature of Julie's PD was intensive, as there was a progression from learning basic technology skills to classroom implementation of the IWB in less than three months. Despite its being short-term, the PD had a significant influence on Julie's

TSE. It was designed with each one-on-one session consisting of an opportunity for discussion relevant to Julie's technology needs and accommodated her teaching practice. Furthermore, the researcher was able to provide Julie with feedback as she was observed teaching science with the IWB in the classroom, which was a chance for Julie to apply what she learned during the PD, learning how to incorporate the use of the IWB as part of her classroom routine.

5.2 CTIS-IWB Survey Result Implications

Although there were notable increases recorded in fourteen of the twenty-one CTIS-IWS survey statements, Julie did not report the highest levels of TSE. Aduwa-Ogiegbaen (2009) argues as long as the technology PD is relevant to teachers (which they explain to be designed based on teachers' technological skill level and on the appropriate grade level), they may not have to have a high-level of TSE in order to implement the technology into their classroom practice. Contrasting with her initial fear of using an IWB in her classroom, Julie's change in TSE by the end of the PD enabled her to have the confidence to use the IWB to teach elementary science.

According to Julie's responses on the CTIS-IWB survey, her most notable changes in TSE are in the development of her IWB skills, the use of the IWB for teaching elementary science, and her overall confidence with using the IWB. A lesser, though notable increase in TSE concerned advanced topics, such as using the IWB software for student evaluation, data analysis, student-led projects as well as her ability to resolve technical difficulties associated with the IWB. This is consistent with findings from Kovalchick, et al. (1998), who found (preservice) teachers to work at their present skill-level and complete technology-related tasks consistent with their level of expertise when participating in a technology integration course. As the PD emphasized basic IWB skill development and considered her specific needs, Julie did not feel the same increased confidence with advanced IWB techniques.

Julie's TSE increased in advanced IWB techniques despite the fact they were less emphasized during the PD and she did not use these features in her science and technology lessons. This finding is consistent when working with low-level technology users, as teachers are more likely to fully change their practices and incorporate high-level of technology integration

over a five to six year period (Ertmer, 2005). Furthermore, Ertmer asserts even though many teachers may report knowing basic computer skills (e.g., getting information from the Internet, sending emails), most do not know how to use high-tech tools such as spreadsheets and presentation software to enhance their lessons and engage their students in basic computer-related activities such as internet research or using computers as a reward system or practice drills. Perhaps as Julie continues to develop her IWB skills and gains experience with using the IWB in her science classroom, she will be able to incorporate some advanced IWB techniques, ultimately integrating technology in her science classroom.

5.3. The Importance of Influencing TSE as Part of Technology PD

The change in Julie's TSE was important as she was able to progress from developing basic IWB skills and technology proficiency to eventually using the IWB to teach three science lessons. It has been suggested self-efficacy may be more important than skills and knowledge among teachers who implement technology in their classroom (Piper, 2003). Bauer and Kenton (2005) also suggest technology PD should be devoted not only to developing teachers' technological skills, but also to increasing their feelings of self-efficacy. Furthermore, Wozney, Venkatesh and Abrami (2006) found a main predictor to teachers' technology use was their confidence that they could achieve their instructional goals using technology. Thus, as Julie's PD was centered on her technology proficiency and science teaching needs, her increase in TSE could be significant in supporting future use of the IWB in her science classroom as a step toward its integration of it as well as other technologies in her science classroom.

Positively influencing teachers' self-efficacy during PD has been shown to facilitate teachers' experimentation with technologies in their classroom, regardless of their level of technological proficiency. Desantis (2012) points out the importance of building TSE as part of a series of guiding principles he believes lay the groundwork for designing effective PD for IWB integration in the classroom. He argues successful adoption of IWB technology requires teachers to possess a combination of technology skills, self-efficacy, and a school environment that encourages teachers to utilize the IWB. Based on a survey of the literature, Desantis details how to build TSE by stating PD should be: ongoing and embedded in teacher contexts; flexible in design to build efficacy among teachers of all technical ability levels (e.g., scaffolding the

introduction of technical skills and training teachers in their own classroom); basic in nature emphasizing the core functions of the board to lead to faster planning of IWB instruction; and purposeful in introducing new concepts one at a time to allow for opportunity for teacher reflection on its integration into their own lesson planning. As Julie's PD experience was designed with her level of technology experience, subject matter and lesson ideas in mind, she was able to gain self-confidence throughout the PD, ultimately using the IWB to teach science and technology in her science classroom to achieve her personal instructional goals.

Another importance of creating PD which influences teachers' TSE is described in Levy (2002), who examined teachers' confidence levels as predictors of developing their own IWB uses and having increased experimentation with ICTs in general. Specifically, teachers who were already confident ICT users tended to become enthusiastic 'early adopters' after initial training with the IWB. Teachers with less confidence, however, were less able to be self-reliant and preferred to have sustained and individual guidance on a 'need-to-know' basis or more structured continuing support such as working alongside more experienced users. This is also supported by Kovalchick et al. (1998) in that people with low self-efficacy toward technology integration are likely to feel high levels of anxiety, potentially resisting learning to use computers. Julie's low feelings of TSE and little technology experience before the PD were coupled with high anxiety, but by the end of the PD, Julie's increased TSE meant she believed she could use the IWB as a supplementary resource for teaching elementary science. As full IWB integration was not the ultimate goal of the PD offered in this study, Julie's long-term use of the IWB to teach elementary-level science is unknown.

5.4 Factors Influencing TSE

Factors such as interest, experience with technology, student support, attitude toward technology, and familiarity with the setting were found to influence Julie's TSE when learning to use an IWB to teach elementary science. Inan & Lowther (2010) argue factors such as these are not mutually exclusive, but often interconnected and hierarchical in nature, which contributes to the complexities of the technology integration process. Using a path analysis approach, they examined the direct and indirect effects of teacher characteristics (e.g., age, years of teaching,

computer proficiency, beliefs, and readiness), and school-level factors (e.g., computer availability, overall support, technical support) on teachers' technology integration. Not only did they find teachers' beliefs and readiness to positively influence their technology integration, but also school-level factors, such as availability of computers, technical support, and overall support, had a positive influence on teachers' beliefs and teachers' readiness. Another important finding was teachers' beliefs and readiness mediated the indirect effects of school- and teacher-level factors on teachers' technology integration. Given the complexities that exist when investigating human behaviour, factors influencing TSE are often hard to differentiate and as a result, factors influencing Julie's TSE will be discussed as distinctly as possible in the next few paragraphs.

5.4.1 Interest. One of the reasons Julie participated in the PD was because of her interest using the IWB to acquiring more science and technology resources for her classroom to help motivate her students to learn science. Studies have shown the IWB to offer several potential benefits, such as versatility and flexibility in lesson planning, multimedia/multimodal presentations, interactivity and participation in lessons, and motivation from both teacher and student perspectives (e.g., Bell, 2002; Beauchamp & Parkinson, 2005; Murcia, 2008). As Julie was in need of science resources, the IWB was a means by which she could introduce new and interactive science resources into her classroom, complement her already-existing science lessons, while motivating her students to learn. Using the Lent, Brown and Hackett Social Cognitive Career Theory (1994), Niederhauser and Perkmen (2008) explain how self-efficacy, outcome expectation and interest are mechanisms at work to predict behaviour. They elaborate on Bandura's theory by stating interest to be not only a motivational tool to learning, but also a means of encouragement for to visualize more positive outcomes. Julie's interest in learning to include the IWB as a resource for science and technology teaching contributed to her ongoing motivation to develop her IWB integration skills. Consequently, a maintained interest in IWB integration in science lessons led her to visualize herself using the IWB in the science classroom, ultimately positively affecting her feelings of technology integration self-efficacy.

5.4.2 Level of experience with technology. Another factor found to have influenced Julie's TSE is her level of experience with technology. Paraskeva et al. (2008) examined the

relationship between individual characteristics of secondary schools teachers and computer self-efficacy and found teachers' subject area and prior experience with computers and software use as educational tools to be strongly and positively correlated with computer self-efficacy. As Julie's level of experience with technology increased over the course of the PD, she had a chance to develop a higher level of technology proficiency which could have enabled her to gain more confidence in using technology, positively influencing her feelings of TSE.

Interest and experience with technology are also important considerations when helping teaching to gain confidence during technology PD, ultimately influencing their TSE. Ertmer and Ottenbreit-Leftwich (2010) present a variety of strategies found in the literature for helping teachers to develop confidence when learning to use technology in their classroom. These include providing meaningful personal experiences to help with personal mastery (Ertmer and Ottenbreit-Leftwich, 2010), giving time to play with the technology (Somekh, 2008), focusing on teachers' immediate needs (Kanaya, Light, & Culp, 2005), starting with small successful experiences (Ottenbreit-Leftwich, 2007) and situating the PD within the context of teachers' ongoing work (Cole, Simkins, & Penul, 2002). Kovalchick et al. (1998) also outline ways of facilitating self-efficacy during technology education courses with novice technology users and suggest training in technology be a 'sense-making' process by constructing the PD based on teachers' own pace and skill level and driven by their individual needs and interests to help increase their confidence to integrate technology in their future classrooms. The nature of the supportive PD offered various opportunities where Julie could receive one-on-one support and practice using the IWB enabled her to increase her technology skill level, gaining confidence in her abilities in technology. Furthermore, a focus on developing relevant science and technology-resources specific to Julie's classroom maintained her interest in learning to use the IWB throughout the PD, indirectly influencing her overall confidence when using the IWB to teach science.

5.4.3 Student support. Part of Julie's interest in learning to use and create science resources for the IWB was to get her students excited to learn science. Julie challenged herself to design lessons catered to her students' needs and presented her IWB lessons to a specific group of grade 5 students. Notably, the students in this class were patient and understanding as Julie

presented her IWB science lessons, which provided a supportive environment for her to practice her skills, ultimately influencing her confidence. Ertmer (2005) discussed components which could influence teachers' beliefs when learning to integrate technology into their practice, which included being provided with opportunities to practice in relevant contexts, learning technology uses consistent with teachers' pedagogical beliefs, and ongoing technical and pedagogical support. The assistance Julie received from her students (which provided her with opportunities to use the IWB in real context) contributed to a positive learning experience and allowed her to develop her confidence.

5.4.4 Attitude toward technology. Julie's attitude regarding technology integration also seemed to play a role in her confidence when using the IWB. She wanted to participate in the PD and to learn to use the IWB as teaching tool in the science and technology classroom. The link between attitude toward technology and self-efficacy has not been well-explored (Abbitt & Klett, 2007). Factors such as perceived usability and ease of use have been identified as important influences on developing TSE. Perceived usability is defined as users' perceptions toward technologies and there is reasonable assumption that usability is connected to acceptance; therefore, technology that is considered highly usable and useful to teachers will most likely be accepted by them, and eventually integrated into their classroom (Holden & Rada, 2011). This, they argue, along with the technology's perceived ease of use can influence a teacher's attitude toward technology. Julie's positive attitude toward technology enabled her to remain open to developing her IWB skills with the researcher and discover the IWB's potential as a science resource, ultimately contributing to her feelings of TSE.

5.4.5 Familiarity with the setting. Familiarity with the setting was also a factor determined to influence Julie's TSE, but not fully explored because of the time limitations of this study. Throughout most of her PD, Julie's practiced using an IWB on a permanent setup of computer-IWB in the library, but presented her IWB lessons using a non-permanent IWB setup in another classroom. Unforeseen interruptions led to Julie presenting the start of the same IWB lesson twice – once in the classroom and again in the library. Julie remarked she was significantly more comfortable presenting in the library because of the familiarity of the setting and the board. Although it was important in how Julie felt when teaching IWB science and

technology lessons, more evidence is needed to support the importance of setting familiarity on TSE.

5.5 PD Needs When Learning to Use Technology to Teach Science

As teachers' response to technology integration is influenced by the extent to which they develop technology proficiency skills and feel confident in their own use of technology, it is critical to examine their specific needs as they learn to use technology in the classroom (Williams *et al.*, 2000). This thesis examined Julie's needs when learning to use the IWB to teach elementary science. These were classified according to teacher, contextual and IWB-level needs based on an adapted technology integration model by Zhao et al. (2002).

5.5.1 Practical Learning Opportunities. At the teacher level, it was helpful for Julie to be provided with opportunities to develop her technology proficiency and with practical learning experiences. As Julie had never used technology as a teaching tool, it was essential for the PD to be supportive and cater to her level of technology proficiency and that she is provided with multiple hands-on opportunities to use the IWB. Aduwa-Ogiegbaen (2009) asserts PD needs should focus on developing a variety of technological skills in order for educators to assemble them to find ways to integrate it into their curriculum. As Julie worked with the researcher, she gradually developed a variety of skills and applied them in the lesson design and classroom implementation phases of the PD. Schnittka and Bell (2009) found using digital resources that elicit discussion and lead to interactive science lessons using the IWB requires practice. Julie designed interactive science lessons with as many opportunities as possible for her students to participate to aid in increasing student motivation to learn science. Enabling teachers to experiment with different instructional approaches, reflect on their lessons, and receive feedback from students, and other teachers regarding their IWB lessons are important aspects when learning to use the IWB (Schnittka & Bell, 2009). Furthermore, Desantis (2012) argues technology's introduction into schools has created a 'revolutionized classroom environment' and teachers may have to modify their pedagogical practices and approaches when using the IWB. Specifically, teachers learning to integrate technology in their classroom should seek advice from other teachers and students to see if learning outcomes are being met. Given a common challenge

for teachers to integrate technologies in the classroom is the lack of preparation in using the technology itself (Aduwa-Ogiegbaen, 2009), it was also helpful for Julie to take part in supportive PD which gave her the opportunity to experiment with the IWB in a relevant context. Julie was able to experiment with teaching a variety of lessons using a variety of IWB setups, giving her the practical experience she needed to determine what worked best for her and her students. The one-on-one supportive format of Julie's PD sessions where she could practice using the board and develop skills which catered to her level of technology proficiency, as well as the observational feedback she received from the researcher could have been key steps in facilitating the development of the skill set required to teach science using the IWB.

5.5.2 Experience with troubleshooting. Another need specific to Julie was to gain experience with troubleshooting as she encountered a variety of difficulties during her PD sessions and IWB lessons. The researcher and students often assisted with poor network and internet connections, random scans which slowed the computer, and realignment and display option complications. Klieger, Ben-Hur and Bar-Yossef (2010) examined attitudes of science teachers to the integration of laptop computers and toward technology PD and found having a professional support system in place to assist teachers with technical difficulties, such as dysfunctional internet connection and computer malfunctions, to be an essential part of PD involving technology use in the classroom. Additionally, they noted as teachers gain more experience with the technology, it is likely they will become more proficient in using it in their classroom through the reciprocal effect (i.e., trial and error). Specific to teaching with the IWB, Smith et al. (2005) surveyed the literature and found teachers can often become overwhelmed and frustrated because of their inexperience with managing the equipment (e.g., board set up) and manipulating the features on the board, as well as networking problems which can lead to lesson disruption. Consistent with Julie's experience, other concerns expressed by teachers when using the IWB were safety concerns because of the multitude of wires required for the IWB and its associated equipment, difficulties with reaching the board and projectors, as well as calibration issues requiring frequent realignment throughout lessons (especially if the board was not permanently fixed). Although Julie improved in her ability to solve reoccurring troubleshooting problems as she encountered them, she seemed to encounter fewer

troubleshooting problems when using a computer, projector and IWB with which she was familiar and experimented on during the PD. It should be noted, however, that Julie's limited experience with technology may have led to an increase in reported troubleshooting difficulties compared to teachers with more advanced levels of technology proficiency.

5.5.3 Subject-specific content. Julie also expressed learning relevant resources catered to her subject specific needs to be an important PD consideration to encourage IWB integration. Julie required assistance with basic technology skills and creating grade five IWB science lessons. By examining the attitudes of science teachers to the integration of laptop computers and the associated technology PD, Klieger et al. (2010) found creating meaningful experiences by integrating the laptop computer in teachers' content field to be important in affecting technology use and integration in the classroom. They also specified PD must be relevant in terms of content suited to the age groups they teach and in terms of instruction, curriculum and classroom management as integrating computers can change the dynamics of the classroom by placing teachers in new situations. Teachers have reported the introduction of IWBs into classrooms modified their classroom and time management style as lessons often occurred at a faster pace and increased involvement of students in the lesson (Türel & Johnson, 2012). Beauchamp and Parkinson (2005) found a similar reaction in science classroom, where teachers reported the support of an IWB to be helpful in transitioning between different parts of the lesson, while they were able to focus on their students' rather than taking up lesson time to draw diagrams on the chalk board.

Flick and Bell (2000) also outline the importance of introducing technology in the context of science content and taking advantage of specific technology features which cater to science instruction when preparing science teachers to use technology. Consistent with findings from this thesis research, preparing teachers to use educational technologies in appropriate ways should be subject-specific, with multiple relevant examples and resource exposure, relevant to the subject matter and group of students they are teaching. Notably, Julie was able to access several IWB science lessons online using websites such as SMART Exchange; however, teachers should take note of the quality of the digital education material and its relation to their curriculum expectations and students' needs (Somyürek, Atasoy & Özdemir, 2009). Thus, it

seems if technology PD is made relevant for teachers by incorporating materials and technological skills they are most likely to use in their classroom, teachers could be likely to use technology to teach in the classroom.

5.5.4 Support. Julie also expressed contextual needs when learning to use the IWB. Her lack of experience with using technology made it sometimes difficult to overcome hardware and troubleshooting issues associated with using an IWB in the classroom and support from the researcher and students was often required during PD sessions and in the classroom. The need for adequate support was found to be one of the most frequent issues raised by teachers when learning to use the IWB in the classroom (Klieger et al., 2010; Smith et al., 2005). Somyürek et al. (2009) found teachers were hesitant to use the IWB in the classroom primarily because of a lack of support on IWBs in their schools for resolving technical difficulties such as hardware and network issues. Klieger et al. (2010) also found having a professional support system in place for classroom and areas relating to technological management to be one of the main factors affecting technology PD for science teachers. An important finding in this thesis was not only can support from the researcher be beneficial when learning to use the IWB, but support from students (who often assisted with troubleshooting) and fellow teachers. Williams et al. (2000) found PD which allowed teachers to have ongoing access to technology to develop technological proficiency as well as a supportive organisational culture (e.g., sharing of resources and IWB lessons) are important needs for catering to teachers' technology PD accessibility needs. As learning communities were not within the breadth of this study, the role of learning communities as a support system should be further explored in the context of learning to teach science with the IWB.

5.5.5 PD focused on a teacher's needs. Another relevant contextual need expressed by Julie was the overall design of the supportive PD. The PD's emergent design with a focus on Julie's specific IWB needs enabled technology skills to be acquired based on her initial level of technology proficiency and explored IWB uses at Julie's preferred pace based on her science teaching needs. Other studies have examined teachers' needs as an essential consideration when designing PD in technology integration. Donovan et al. (2007) designed PD in integrating laptop computers and found teachers' initial situation (e.g., concerns, teaching routines, level of

computer proficiency, etc.) must be examined when planning their PD. UNESCO (2005) also developed four basic strategies for PD to help teachers integrate technology into education: (1) having the PD focus on teaching rather than on hardware or software-specific training; (2) providing access to technology resources; (3) be an ongoing process and not a one-time thing; and (4) working with a small group of teaching staff who can then show their colleagues (Aduwa-Ogiegbaen, 2009). Julie worked alongside the researcher for three consecutive months over multiple sessions, which provided an opportunity for the researcher to check in with Julie if her needs were being met. Donovan et al. (2007) suggest PD should be reassessed periodically throughout to it is in accordance with teachers' needs. In addition, Julie stated she would continue to use the IWB should she have access to one in her classroom. This is likely if she continues to use an IWB and practices what she has learned from the PD, as she could lose her IWB skills and knowledge as well as her confidence over time (Slay, Siebörger, & Hodgison-Williams, 2008). As Hall and Higgins (2005) explain, teachers need continuous training sessions to improve and also maintain such skills, while learning effective instructional strategies for using the IWB in order to transform their pedagogy into student-centered, social and interactive learning. Even though aspects of the PD design used for this thesis project may be difficult for schools to justify (e.g., one-on-one guidance, multiple and ongoing PD sessions), placing teachers' needs and level of technology proficiency at the forefront of technology PD design could be significant when designing PD for long-term technology integration.

5.5.6 IWB setup and accessibility. Julie also expressed IWB-specific needs in terms of the board itself and its accessibility. She practiced on both portable (classroom) and permanent (library) types of IWB during her PD sessions and when presenting her IWB lessons. Consistent with Smith et al. (2005), Julie preferred using the permanently-setup IWB as there were fewer technical challenges (e.g., calibration, setup and troubleshooting issues). This was supported by Julie's final IWB lesson, where the same IWB lesson was presented using both a portable and permanent IWB. Julie did not experience any troubleshooting issues when presenting the lesson with the permanent board in the library, but had several challenges when using the portable one in the classroom. A permanent setup can also save time during the setup, as fewer adjustments, if any, are needed (Gage, 2005).

Given there were only three IWBs shared between teachers at the school and Julie did not have her own classroom, limited accessibility on a daily basis could have negatively influenced her progress throughout the PD. Williams et al. (2000) surveyed primary and secondary teachers' needs in terms of developing their ICT skills and listed accessibility, such as presence of ICT in schools and the availability and sharing and management of ICT resources, as a main category. As accessibility is essential to integrating the IWB into any classroom, Julie will most likely need ongoing access to an IWB in order to continue to develop her IWB skills.

5.6 The Influence of the IWB on Science Pedagogical Strategies

After participating in PD, Julie was able to use the IWB to teach three science lessons for her grade 5 class: Renewable vs. Non-Renewable Resources; The Digestive System; and Recycling and Composting. Observations showed Julie took on a facilitator role by promoting whole-group discussion, managing students at the board during games, and using the board to cue lead-ins into new concepts on upcoming slides. Hennessy et al. (2007a) argue the IWB to change the science classroom dynamic because of teachers having to manage student interaction with the technology (a hands-on and student-centered approach) and to balance whole-class teaching with teacher-student and student-student interactions. The main reason why Julie enjoyed using the IWB to teach science is that it changed the classroom dynamic and added aspects of interactivity, which resulted in an observed increase in student participation and motivation during the science lesson.

Kennewell & Beauchamp (2007) found teachers' initial use of the IWB to often replicate traditional teaching methods, such as "direct teaching and questioning", enabling teacher-centric pedagogies, which also includes 'surface interactivity'. This can lead to IWB capabilities being underutilized by teachers who are new to IWB integration, resulting in its use as a non-interactive display surface for a data projector (Murcia, 2008). Teaching methods can range from didactic (i.e., teacher-centered) to methods that include greater student involvement (i.e., student-centered) and can be compared to a "progression of interactivity" when integrating the IWB in the science classroom (Beauchamp & Parkinson, 2005). Some of Julie's lessons consisted of presenting information to students, facilitating class discussion, annotating and

modifying by writing on the IWB, and labelling diagrams reflecting a didactic approach even though they included interactive components; however, jointly drawing graphs and co-constructing arguments with the class, or having students use the IWB software to prepare a presentation would be considered to promote higher-levels of interactivity. Although Julie incorporated games and a variety of online resources that added interactivity to her science lessons, examining the student perspective would better determine if higher-levels of interactivity were achieved. As the IWB has been shown to aid students in reasoning and relating to scientific explanations, incorporating the cognitive interactivity as part of future research could provide insight into the use of the IWB in promoting scientific literacy (Beauchamp & Parkinson, 2005; Murcia, 2008). Furthermore, the size and visual capacity of the IWB can enhance “traditional” teaching as they display a large colourful and technological visual for the entire class to see (Schuck & Kearny, 2007). In Julie’s case, she designed her science lessons by using strategies that were familiar to her such as prompting whole-group discussion with questions; however the IWB enabled her to add visual content and online resources that would not have been possible without an IWB.

5.6.1 Using the IWB to foster student participation and interactivity in science.

Using the IWB as a teaching tool, Julie was able to foster participation in science by creating an “active” learning environment, where learners are encouraged to actively engage in the learning process, rather than passively absorb instruction (Hennessy et al., 2007a). This reflects a “hands-on, minds-on” approach to science teaching can build science skills and positive attitudes toward science, actively engaging students in developing conceptual understandings of key science concepts (Knox & Schmidt, 2006). This type of instruction “places greater emphasis on approaches that foster active learning and emphasize understanding in response to individual students’ interests and needs, while giving students the opportunities to work cooperatively, and to discuss and debate scientific ideas” (Schnittka & Bell, 2009, p. 152).

The use of the IWB as a science teaching tool can promote student participation on a cognitive (e.g., getting students to acquire scientific knowledge), social (e.g., contributing to whole-group discussion) and physical (e.g., approaching the board) level, which can all have positive influences on student motivation and science learning (Hennessy et al., 2007a). Julie’s

comments and the researcher's observations confirm that students were more fully participating in the lessons as they showed excitement to approach the board and students who usually did not participate in whole-group discussions were eager to add to the discussion with the incentive to write their ideas on the board. Julie designed her lessons to provide as many physically-interactive opportunities as possible in order to give several students the opportunity to approach the board. Other teachers have reported doing the same in science, as this hands-on approach can enhance learning when carefully orchestrated (Hennessy et al., 2007a). Although the environment created by Julie was interactive on physical and social levels, the idea of developing changes in students' learning is a process of change from traditional teaching methods and takes time (Beauchamp & Parkinson, 2005). Julie reported increased interactivity in her science classroom, but this is likely surface interactivity, specifically technical interactivity, as students were encouraged to approach the board to manipulate objects in simple classification games and annotate their answers (Kennewell & Beauchamp, 2007; Smith et al., 2005). The level of interactivity Julie incorporated into her science lessons often reflected basic levels not reflect the quality of teacher-student and student-student interactions defined by Smith et al. (2005) or advanced interactivity in science teaching such as co-constructing scientific explanations and experiment planning and data logging (Beauchamp & Parkinson, 2005; Hennessy et al., 2007a).

Part of creating an active learning environment involves integrating the IWB with other resources. One of the most interesting features of the IWB for Julie was the visual display of the board to which the students could relate and the availability of online science resources to enhance the lessons. Murcia (2008) examined ways of using the IWB to teach science by incorporating visually appealing interactive displays, accessing online information and activities, and creating opportunities for interaction. Julie incorporated a variety of resources (e.g., media, pictures, links, videos) as part of her lesson to provide a visual for students learning about renewable vs non-renewable resources, and gained a deeper understanding of the human digestive system. These digital resources are commonly used in science teaching, especially to illustrate concepts and ideas that may be unfamiliar to students (Schnittka & Bell, 2009). In terms of lesson design, Schnittka & Bell state that adding visuals such as images, photos and animations can be a means for teaching creatively by supplementing instructional goals and

supporting such process skills as making observations and inferences, analyzing data, and supporting conclusions. Smith et al. (2005) cautions, however, that over time the novelty of a new technology in the classroom could wear off as students grow accustomed to the IWB features.

5.6.2 Illustrating and explaining science. Julie made scientific content relevant to students by linking the lesson to current images and videos and engaging her students by having them observe and make inferences about the digital images displayed on the IWB. The most notable examples of Julie's use of visuals was during the lesson on human digestion, where students could manipulate various parts of the digestive system into the correct sequence. Using the IWB to "show how things work" can be very helpful as a strategy for capturing student attention for greater student involvement, which is especially important in science where the concepts can be somewhat abstract (Hennessy et al., 2007a).

Along with active engagement, Hackling and Prain (2005) identified one of the dominant characteristics of effective science teaching to be life and community relevant science learning experiences. Julie found the IWB as being a great science resource and addition to the classroom as it could be linked to a variety of other scientific online resources. Julie added relevant real-life pictures (e.g., pictures from her trip to India to explain biodiversity), while connecting science to every-day contexts by adding hyperlinks to videos of the workings of recycling facilities. Her addition of links to real-life illustrations and online resources can promote authenticity and connectedness, adding richness to lessons that may not have been possible using the traditional chalkboard (Schuck & Kearny, 2007). This is consistent with other elementary science teachers who found it a useable teaching tool in facilitating science instruction because of its versatility in providing access to a variety of resources, while helping students to visualize abstract knowledge (Hennessy et al., 2007b; Murcia, 2008). In terms of lesson planning and design, the IWB is also an organizational tool to prepare, organize and store lessons, which can lead to highly-structured, well-sequenced lessons with access to useful (online) resources (Schuck & Kearney, 2007). This is especially pertinent for science teaching, as presenting relevant online and up-to-date information in meaningful and real-life contexts can help students make sense of challenging scientific concepts (Murcia, 2008).

Julie also found the visual nature of the IWB to accommodate a variety of learning preferences as it could be used as a tool illustrate complex scientific concepts. She was able to use the IWB as a tool to connect with students who had difficulties with fine motor skills (e.g., writing), allowing them to better showcase their abilities. She also mentioned she could use student feedback to assess the progress of her students' prior knowledge and skills. Teachers have reported using the IWB as a tool to support learning for students and an important aspect of the IWB is its ability to give immediate feedback as students move closer to attaining their learning goals set by themselves and the teacher (Harper & Dzaldov, 2011). This can lead to increase student interest as the lesson becomes suited to various types of learners through the use of a variety of teaching styles and resources (Gage, 2005).

5.6.3 Creating a scientific story. In science, dialogic, interactive communication allows teacher and students to explore ideas together, pose questions and combine scientific and informal ideas in order to increase accessibility by creating a “scientific story” (Hennessy et al., 2007a). This is how Julie approached two of her three science lessons, as students were guided slide by slide to form the complete story of the human digestive system (i.e., digestive pathway) and the elaboration of classification of everyday items into a discussion of community waste programs and community involvement, building on the earlier topics covered during the lesson. This can be paralleled with knowledge scaffolding, where the sequence of IWB screens can provide information that acts as a stimulus for classroom discussion, leading to the production of new information that can be stored and ready for use during the next phase of the lesson. The digestive pathway traced by the students and the recycling initiatives were saved by Julie, and she could refer to them at a later date when revisiting the material or as means of starting another lesson. Julie also used step-by-step discussion as part of her science lessons. This is part of scaffolding strategy, where students are motivated to carry out a task, learning is broken down into manageable chunks, students stay motivated throughout the lesson while critical features can be highlighted (e.g., animated, highlighted) (Beauchamp & Parkinson, 2005).

5.6.4 Using IWB tools to support science teaching. Various IWB features along with sound instructional strategies can lead to successful instruction (Glover & Miller, 2009) and teachers who use IWB features to support a variety of instructional strategies can have a positive

effect on student learning (Gage, 2005; Türel and Johnson, 2012). Beauchamp and Parkinson (2005) suggest the IWB can foster interactivity when information is presented using a variety of IWB features. Julie used IWB tools such as capturing, emphasizing, storing, annotating, modifying and linking in nearly every science lesson.

Capturing. Julie created engaging and appealing interactive displays by capturing pictures, diagrams and animations, which encouraged the students to manipulate words and images on the IWB, a first step in using the board interactively (Beauchamp and Parkinson, 2005). This enabled the lesson to have a dynamic and visual nature, not possible with a chalk board. Furthermore, gradually highlighting important concepts from slide to slide and using a variety of captured visuals supported the development of the “scientific story” and step-by-step knowledge building through the use of images as teacher-led discussion prompts.

Emphasizing. The IWB also has tools to help emphasizing important scientific information that can focus students’ attention and activities such as the spotlight feature or concealing part of the board can prompt students to ask questions, which can promote critical thinking in science (Beauchamp & Parkinson, 2005) and also help students to better remember the lesson (Damcott, Landato, Marsh, & Rainey, 2000). The hide and reveal (e.g., pull-tab), drag and drop and classification activities, as well as the use of diagrams catered to a variety of student abilities and enabled students to not only focus on important scientific concepts, but also support sequential knowledge building by emphasizing important concepts to be revisited later in the lesson.

Storing. Julie used the “save as” feature of the IWB to keep a record of student annotations and modifications to the lesson that could serve as a mean to review or revisit the lesson at a later date. Julie had commented on the use of this feature as an alternative means to assess students, such as those with learning difficulties or with difficulties writing by recording students’ answers on the board such as during a classification activity or their written answers. This feature also showed promise for assessment, as students could not only receive immediate feedback (i.e., assessment as learning), but it could also be used for formative assessment for revisiting concepts or determining next steps). Using the storing tools, Julie was also able to

rapidly build a collection of detailed science-related electronic resources, as saving a copy of a lesson in *Notebook* format keeps everything in one file, including links to other sources (if embedded) and any other imported material, or by collecting additional lessons from online sources such as *SMART Exchange*.

Annotating and modifying. When designing lessons, Julie highlighted important concepts by using large letters, highlighting an annotating important content using the IWB pens. This can help to increase student attention, especially when creating opportunities for students to manipulate objects at the board as it supports “active” learning. Glover & Miller (2009) report certain IWB tools to promote manipulation of objects at the board that facilitate interactivity. These include drag and drop, hide and reveal and other immediate feedback activities. Julie was able to use these features as well as interactive multimedia activities from the embedded gallery in *Notebook* (e.g., vortex game) to teach scientific concepts in an interactive manner. These commonly-used IWB techniques should be further explored and adapted for science teaching in order to encourage interactivity in science lessons, which seems to be the reason behind the IWB’s popularity with students (Beauchamp and Parkinson, 2005).

Linking. Finally, Julie incorporated a variety of links to other online resources and media to show students real-life connections to the material being presented to them, which supports effective science instruction (Orpwood et al., 2012). This can not only accommodate a variety of student needs and interests, but also increase relevancy and science awareness (Hennessy et al., 2007). The IWB supports the integration of a variety of online resources (e.g., websites, media) and other software (e.g., *PowerPoint*, *Paint*), which can not only assist teachers easily sharing various resources, but ultimately provide multiple perspectives for their students to make connections that support learning (Gage, 2005).

Chapter 6: Article

An Elementary Teacher's Feelings of Technology Self-Efficacy and Needs When Learning to Use the Interactive Whiteboard

By Francine Hart and Liliane Dionne

Abstract

Studies have shown elementary teachers may not be well prepared to use technology in their classrooms. This study examines one elementary teacher's feelings of technology self-efficacy (TSE) and needs when using the interactive whiteboard (IWB). This study employed a single case study design, where the researcher and participant worked together during supportive professional development (PD) sessions. Data sources are twelve PD sessions, the Computer Technology Integration Survey (adapted for IWB use in the classroom), and two interviews, three in-class observations of IWB science lessons, and three lesson debriefs. Results show the participant's TSE was positively influenced by the PD. Five factors were determined to influence TSE: the participant's level of interest, attitude, experience with technology, student assistance, and familiarity with the setting. Teacher, contextual and IWB- level needs were explained. Findings could contribute to current trends in teacher PD, continuing education, and preservice teaching programs related to science teaching.

Key Words: Interactive Whiteboard (IWB); Science Education; Technology Self-Efficacy (TSE); Technological Needs; Professional Development (PD); Technology Integration; Elementary Science Teaching.

Résumé

Plusieurs enseignants ne sont pas bien préparés pour utiliser la technologie en classe. En particulier, le tableau blanc interactif (TBI) n'est pas utilisé de façon optimale par les enseignants lorsqu'ils enseignent les sciences et la technologie à l'élémentaire. Cette thèse présente l'étude de cas unique d'une enseignante de l'élémentaire ayant cheminé dans un processus de développement professionnel (DP) pour l'aider à intégrer le TBI en sciences et technologie. Douze sessions de DP, un questionnaire sur l'efficacité avec le TBI (CTIS adapté), deux entrevues, trois sessions d'observation en classe et trois discussions sur les leçons constituent les sources de données. La participante est devenue plus confiante pour utiliser le TBI suite au DP. Elle a rehaussé son sentiment d'autoefficacité et accru son intérêt et sa connaissance du TBI. Elle a acquis des compétences techniques et une connaissance des contenus d'enseignement adaptés au TBI, bien que plusieurs besoins perdurent. Certaines stratégies pédagogiques avec le TBI expérimentées en classe par l'enseignante sont discutées. Cette thèse peut contribuer à fournir des pistes pour assister les enseignants de l'élémentaire à mieux intégrer le TBI en sciences et technologie, que ce soit lors de leur formation à l'enseignement ou en cours d'emploi.

Mots clés : Tableau blanc interactif (TBI); sciences et technologie; sentiment d'autoefficacité avec la technologie; besoins technologiques des enseignants; développement professionnel (DP); l'intégration des technologies en salle de classe; l'enseignement des sciences à l'élémentaire.

Introduction

Technology is one of the major focuses in developing school infrastructure, policy and curriculum as it can be used as a powerful tool in the teaching and learning process (Roblyer, 2006). Teachers are encouraged to use information communication technologies (ICTs), any traditional computer-based and digital communication technologies, to enhance the teaching and learning process. “Educational” technologies, those that can be used in the classroom to aid in the advancement of student learning such as computers, interactive whiteboards (IWBs) such as the SMART Board, tablets, android phones, internet access, and online resources, have also been shown to play a significant role in enhancing student learning (Hennessy, Deaney, Ruthven, & Winterbottom, 2007; Murcia, 2008).

The actual body of knowledge demonstrates many teachers are not well prepared to use the technology in their classroom (Coates, 2006; Kumar et al., 2008). Studies have also shown that teachers should be provided with adequate PD in order to make better use of technology such as the IWB (Murcia, 2008). Research has shown a link between high levels of teaching self-efficacy and increased student achievement (Dionne & Couture, 2010; 2013). Given educational practices and PD can have a significant effect on a person’s self-efficacy (Milbrath & Kinzie, 2000), examining feelings of TSE is central to understanding teachers’ predisposition to using technology in the classroom. Furthermore, intrapersonal factors, like self-efficacy, can play an essential role in whether teachers choose to integrate technology into their instructional practices (Niederhauser & Perkmen, 2008). Little research focuses on teachers’ needs and confidence when using the IWB (Duran, Brunvand & Fossum, 2009; Taylor & Corrigan, 2007). The purpose of this study is to examine one teacher’s feelings of TSE and needs when using the IWB to teach at the elementary level with the assistance of supportive PD. It is predicted PD may contribute to an increase in confidence when teaching with the IWB. This teacher’s experiences could serve as a basis for future studies in IWB PD in teaching for elementary teachers.

Literature Review

The Use of Technology to Support Elementary Teaching

ICTs have been shown to assist teachers in gaining a better understanding of what they are teaching, establishing various strategies for teaching a variety of subjects and locating meaningful resources for their classroom (Duran, Brunvand, & Fossum, 2009). With ICTs being integrated into curriculum, teachers are challenged to reshape the way they present concepts to their students as part of an incentive to motivate and relate to the new technologically-savvy generation of students (Abduwa-Ogiebaen, 2009; Murcia, 2008). IWBs are reported to be an effective way for teachers to interact and integrate digital content and multimedia learning resources in the classroom (Murcia & Sheffield, 2010). It enables students and teachers to interact with all functions of a desktop computer through a large surface, providing a space for interactive communication and exploration of ideas between teacher and student (Murcia, 2008).

The Use of the IWB to Support Science Teaching

The IWB is part of an interactive display system (IDS), which consists of a computer, digital projector, and Internet connection to support teaching and learning (Schnittka & Bell, 2009). It enables teachers and students to interact with a desktop computer through the board's large touch sensitive surface, with the IWB acting as a port through which any computer run ICT function can be displayed and interacted with (Murcia & Sheffield, 2010). This means that the IWB can enhance the benefits of computer-based learning, such as the use of interactive websites and ICT, by sharing this experience with the whole class, or small-group learning, without being hidden behind a desktop screen or isolating learners at a computer. As the use of technology for instruction can vary depending on its classroom purpose and the inherent challenges each one may present, the IWB, its use in elementary teaching can be considered distinct from using other technologies for instructional purposes (Schnittka & Bell, 2009). It can be distinguished from other technologies for teaching because of its interactive nature, and its ability to link to internet sites and online activities and supports a range of learning styles (Murcia, 2008). It has also been shown to influence the classroom dynamics, as it encourages IWB-specific strategies fostering interactivity (Beauchamp & Parkinson, 2005; Hennessy et al., 2007). Thus, the IWB will be

examined as a subset of the umbrella of ‘educational technologies’ as it presents unique opportunities for teaching in terms of online access and pedagogical strategies.

Technology Self-Efficacy (TSE) and Science Teaching

Several factors are considered to be crucial for successful integration and development of technologies in educational practice. Factors including the teacher’s personality, self-concept, attitudes, motivation and needs have been shown to influence technology integration in classrooms (Paraskeva, Bouta, & Papagianni, 2008). Research has shown there is a link between high levels of teacher self-efficacy and increased student achievement (Ross, Hogaboam-Gray & Hannay (2001) in Watson, 2006). Given the potential benefits IWBs have to offer teachers and students, it is imperative that known barriers such as low self-efficacy when using technology be addressed in order to find ways to encourage teachers to effectively integrate the IWB in classrooms.

Self-efficacy may be defined as the belief in one’s own abilities to perform an action or activity necessary to achieve a goal or task (Watson, 2006). An important question for educators is how self-efficacy and outcome expectancy beliefs are related to teaching performance (Bleicher & Lindgren, 2005). Based on Bandura’s definition, people with low self-efficacy tend to dislike being in situations where they feel they have little control or ability to handle a task; low self-efficacy toward technology integration is likely to lead to high levels of anxiety, possibly leading to some resistance when asked to incorporate technology in the classroom (Kovalchick, Milman and Elizabeth, 1998). More specifically, technological self-efficacy (TSE) can be defined as the judgement of one’s capability to successfully perform a technologically-sophisticated task (Farah 2011). ‘Teacher self-efficacy’ and ‘technology self-efficacy’ are further discussed as part of the conceptual framework.

Recent studies have focused on determining which factors affect teachers’ feelings of self-efficacy when integrating general technologies in the classroom. Paraskeva et al. (2008) examined the relationship between individual characteristics of secondary school teachers and computer self-efficacy, general feelings of self-efficacy compared to computer self-efficacy, as well as teacher prospects with regard to technologies. Multiple factors influence teachers’ TSE

on personal, behavioural and environmental levels (Farah, 2011). Personal factors, including subject matter, gender, and teaching experience are also strongly associated with teachers' attitudes and perceptions toward classroom technology usage (Jimoyiannis & Komis, 2007). Frequency of technology use and teachers' beliefs were also found to be important in influencing technology self-efficacy. Furthermore, studies have shown that technology must become personally meaningful to teachers before they use it in a way that is helpful for students when learning (Holden & Rada, 2011).

PD Needs When Learning to Use Technology to Teach Science

As teachers' response to technology integration is influenced by the extent to which they develop technology proficiency skills and feel confident in their own use of technology, studies have focused on determining their needs as they learn to use technology in their classroom (Williams, Coles, Richardson, Wilson, & Tuson, 2000). Aduwa-Ogiegbaen (2009) assessed Nigerian inservice teachers' technological skills and competencies to determine their needs in key areas of ICT. Their findings indicate PD should focus on developing a variety of technological skills in order for educators to assemble them to find ways to integrate into their curriculum. Williams et al. (2000) surveyed primary and secondary teachers' needs in terms of developing their ICT skills and suggested PD in technology should provide teachers with ongoing access to technology to develop technological proficiency as well as a supportive organisational culture (e.g., sharing of resources and IWB lessons). Hartley and Strudler (2007) designed PD in integrating laptop computers with teachers' needs in mind and found teachers' initial situation (e.g., concerns, teaching routines, level of computer proficiency, etc.) must be considered when planning their PD and reassessed periodically throughout to ensure it is in accordance with teachers' needs. Others studies acknowledge teachers' needs when learning to use technology for teaching science (Flick and Bell, 2000; Klieger et al., 2010; Taylor & Corrigan, 2006)

Science Learning and Teaching with the IWB

The use of the IWB as an instructional tool has been found to have several benefits for student learning. Morgan (2008) reported a positive change in student response as students are

better engaged and motivated throughout the lesson. The use of an IWB in a classroom can also be an opportunity for teachers to create shared dialogue space between students as students are encouraged to co-construct knowledge (Warwick, Mercer, Kershner, & Staarman, 2010). It is also a means by which the teacher is encouraged to use rich resources, appropriate pacing, and multimodal presentation throughout a lesson (Rivers 2009). Also, it can be a means to increase interactivity between teacher and students through digital culture (Schuck & Kearney, 2007). Although several benefits have been recorded, Warwick et al. (2010) caution the most important contributor to the IWB as part of an effective learning environment is the teacher who becomes the facilitator of the collaborative environment and who outlines learning objectives and devises tasks which use board affordances to promote active learning. Similarly, whether technology can improve student learning and impact student success depends on many factors such as the teacher's 'effectiveness' and teaching ability (Zhao, Pugh, Sheldon, & Byers, 2002).

The IWB can be a useful tool to assist teachers in developing teaching resources for their elementary science classroom. It has been shown to facilitate science lesson planning by enabling teachers to access to real life science contexts and support a wide range of learning styles, ultimately placing the students at the centre of the learning by encouraging interactivity in the classroom (Beauchamp & Parkinson, 2005; Murcia, 2008). Hackling and Prain (2005) argue the IWB to be conducive to effective science teaching, which they define as creating life and community relevant science learning experiences, promoting active engagement and inquiry-based learning and focusing on outcomes that contribute to scientific literacy. In their study, teachers used the IWB during science lessons as a means of presenting online science resources, organizing hands-on experiments, facilitating minds-on discussion questions, and providing interactive experiences for their students.

Research Questions

This study is guided by the following research questions:

- 1) Can supportive PD influence a teacher's TSE when using the IWB to teach science?
If so, what factors contributed to the change in TSE?

- 2) What teacher's needs are expressed when learning to use the IWB to teach science?

Conceptual Framework

Teacher Self-Efficacy

Teacher efficacy has been shown to account for individual differences in teaching effectiveness and has become an important construct in teacher education (Gibson & Dembo, 1984). The construct is grounded in Bandura's social cognitive theory (1977; 1997), where self-efficacy is defined as a belief in one's own abilities to perform an action or activity necessary to achieve a goal or task (Gibson & Dembo, 1984). Bandura's theory posits that people are motivated to perform an action if they believe that the action will have a favourable result (i.e., outcome expectation) and if they are confident that we can perform that action successfully (i.e., self-efficacy). Niederhauser and Perkmen (2008) describe self-efficacy as 'an individual's level of confidence that he or she can accomplish a given goal' (p. 100). As confidence is an inherent part of self-efficacy, both terms are used synonymously in this study.

Technology Self-Efficacy (TSE)

Technology Self-Efficacy or technology integration self-efficacy evolved from the concept of 'self-efficacy' suggested by Bandura (1981). Teachers' computer and internet self-efficacy, two of its related constructs, have been the subject of numerous studies which provide some evidence that a correlation exists between a teacher's confidence in the use of computers and the effective integration of them in the classroom (Compeau & Higgins, 1995, Holden & Rada, 2011; Morales, Knezek, & Christensen, 2011; Paraskeva et al., 2008; Watson, 2006). As Karsenti, Raby and Villeneuve (2008) explain, however, although using technologies in the classroom has shown advantages for student learning, factors such as technological familiarity and skills directly influences teachers' ease in incorporating technologies in the classroom. Nolan (2009) distinguishes between computer self-efficacy, referring to an individual's belief or confidence in his or her ability to perform computer-related tasks and TSE, which essentially has the same meaning, but referring to technology use in general. In tracing the evolution of these constructs, Nolan (2009) argues both computer and TSE have been used interchangeably and, for

the purposes of this study, will both relate to teachers' confidence levels with technology use (including the IWB) in the modern classroom.

Self-Efficacy and PD

Learning to using technology as a teaching tool is a process that could require a change on behalf of the teacher, especially if they are new to the process. Teacher learning is an “active, experiential process, through which knowledge is enacted, constructed and revised” (Fisher, Higgins, & Loveless, 2006, p. 2). Fullan and Stiegelbauer (1991) allege that when teachers are asked to use technology to facilitate learning, some degree of change is required along one or all of the following dimensions: (1) beliefs, attitudes, or pedagogical ideologies; (2) content knowledge; (3) pedagogical knowledge of instructional practices, strategies, methods, or approaches; and (4) novel or altered instructional resources, technology or materials. As PD can present opportunities for teachers to become learners in further developing their skills and practice while being agents of change to leverage information acquired with its application and effective use in the classroom, this model can be applied to technology PD. Ertmer and Ottenbreit-Leftwich (2010) elaborate on the Fullan and Stiegelbauer (1991) model by discussing the literature surrounding four key variables facilitating teacher change: (1) knowledge and skills; (2) self-efficacy; (3) pedagogical beliefs; and (4) school/subject culture. PD contributes to an increase in teachers' confidence in their ability to transfer learning into the classroom, which establishes a connection between educational change and teacher self-efficacy.

<INSERT FIGURE I HERE>

Teachers' Needs When Learning to Use the IWB

In order to understand a teacher's needs learning to use the IWB in science teaching, the needs must be defined. Zhao et al. (2002) developed a model for successful implementation of technology projects in the classroom by defining conditions for classroom technology innovation. The model consists of three interactive domains that outline conditions for integrating innovative technologies in the classroom: (1) The Innovator (Teacher); (2) The Context (School); and (3) The Innovation (Project). Zhao et al. (2002) discuss each domain and its related factors associated with technology integration. As the IWB can act as a port through

which any computer run ICT function can be displayed, it can be considered as a subset of technology integration (Murcia & Sheffield, 2010) (Fig. II).

<INSERT FIGURE II HERE>

Methods

Research Design: A Unique Case Study

The research design of this study is a qualitative single case study, an intensive, holistic description and analysis of a single entity, phenomenon, or social unit (Merriam, 1988). Specifically, this case study is descriptive in nature as it presents innovative information as a basis for future comparison and theory building (Merriam, 1988). As Merriam (1988) explains, educational processes such as teacher PD can be examined using a case study design because of its strengths which include a means of gaining detailed insights and real-life accounts of a phenomenon, bringing about an understanding that can ultimately improve practice.

Case Details

The unique case is a grade 5/6 elementary teacher, “Julie”, who has taught a variety of subjects from kindergarten to grade 6 periodically over the last 20 years. At the time of data collection, this was her second year of teaching music and science from kindergarten to grade 6 students. Of main relevance to this research project, she taught two 45 minute periods of grade 5 science weekly. As she was a subject-specific teacher (i.e., teaching only science and music), she travelled between classrooms and did not have her own classroom.

Context

Data collection took place where the participant taught, an Early Immersion (K-6) school in the Upper Canada District School Board, located in the Stormont, Dundas and Glengarry County with a student population of approximately 200. There were 4 IWBs within the school: a small portable one, a large portable one setup in a classroom, and two large permanent ones in the library and the kindergarten classroom. Most PD sessions took place in the library because of availability.

PD Design

The researcher worked with one participant during twelve (12) PD sessions that occurred over the first two months of a three-month data collection period at the end of the 2013 school year. The participant expressed specific needs related learning to use the IWB to teach science, which formed the basis of the PD's design. Needs expressed during the initial interview and during subsequent PD sessions on a weekly and/or bi-weekly basis guided the researcher to determine next steps in the planning of the PD. The flexible nature of the PD reflects an emergent and supportive design, where the initial plan for research and other phases of the research process changed further along the PD, or as the participant's needs shifted from technological needs through to more complex lesson design questions (Creswell, 2007).

Data Sources

Qualitative data were collected from the Computer Technology Integration Survey (adapted for IWB use in the classroom), two interviews (pre and post PD), three in-class observations of IWB science lessons, and three lesson debriefs.

The Computer Technology Integration Survey (CTIS) by Wang et al. (2004) measures the influence of vicarious learning experiences and goal setting on the self-efficacy beliefs for technology integration. The extended Skoretz (2011) version for practising teachers was used for this study (adapted for IWB use by the researcher) was the instrument of choice. It is a 21-item Likert scale survey in which respondents are asked to rate how confident they are in integrating technology in their classroom teaching. As this study was short-term in duration, the survey was used to predict technology use in a science classroom, with an ultimate future goal of integrating technology such as the IWB in the classroom.

Two semi-structured interviews were held with the participant during the first and final PD sessions. The purpose of the interviews was for the researcher to gain a deeper level of understanding of the participant's feelings, needs and comfort level when using the IWB in the classroom to teach science.

Researcher Observations and Lesson Debriefs

During the final month of PD (third phase), the researcher observed the participant teaching three grade 5 science lessons using the IWB. A researcher logbook served as a note-taking guide during classroom observations, which were used by the researcher as discussion prompts during the debriefs. Each lesson was followed by a semi-structured lesson debrief between the researcher and participant, where the researcher would ask questions related to previous themes from the PD and from observational feedback from the researcher during lesson.

Data Analyses

Qualitative research can have several benefits in context-driven case-based research. The data was analyzed using two methods: (1) a descriptive analysis of the CTIS-IWB survey; and (2) a thematic content analysis of the interviews, lesson debriefs and researcher logbook. The CTIS-IWB survey was descriptively analyzed by identifying statements in which a notable change was recorded and grouping according to their relevancy to the topics covered during PD sessions. The text from interview transcripts, lesson debriefs and researcher logbook was imported into *NVivo10* and manually coded using thematic analysis, a qualitative descriptive approach for identifying, analysing and reporting patterns (themes) within data (Braun & Clarke, 2006). The use of four data collection instruments enabled cross-referencing between multiple sources and ensured the necessary approaches with respect to credibility, dependability and confirmability (Shenton, 2004).

Results and Discussion

Julie's Feelings of TSE with Using the IWB

The CTIS-IWB survey measured the participants' feelings of TSE when integrating technology, and specifically the IWB, into classroom teaching. Notable changes were recorded in fourteen of the twenty-one of statements (67%) (Table 1). A notable change occurred if the participant indicated a different response from an initial position of disagreement to neutrality, disagreement to agreement, and neutrality to agreement with a particular statement.

<INSERT TABLE 1 HERE>

Although there were notable increases recorded in fourteen of the twenty-one CTIS-IWS survey statements, Julie did not report the highest levels of TSE. Aduwa-Ogiegbaen (2009) argues as long as the technology PD is relevant to teachers (which they explain to be designed based on teachers' technological skill level and the appropriate grade level), they may not have to have a high-level of TSE in order to implement the technology into their classroom practice. Contrasting with her initial fear of using an IWB in her classroom, Julie's change in TSE by the end of the PD enabled her to have the confidence to use the IWB to teach elementary science.

According to Julie's responses on the CTIS-IWB survey, her most notable changes in TSE are in the development of her IWB skills, the use of the IWB, and her overall confidence with using the IWB. A lesser, though notable increase in TSE concerned advanced topics, such as using the IWB software for student evaluation, data analysis, student-led projects as well as her ability to resolve technical difficulties associated with the IWB. This is consistent with findings from Kovalchick, et al. (1998), who found (preservice) teachers to work at their present skill-level and complete technology-related tasks consistent with their level of expertise when participating in a technology integration course. Reasonably, Julie did not feel the same increased confidence with advanced IWB techniques as the PD emphasized basic IWB skill development and considered her specific needs.

Julie's TSE increased in advanced IWB techniques despite the fact they were less emphasized during the PD and she did not use these features in her science and technology lessons. This finding is consistent when working with low-level technology users, as teachers are more likely to fully change their practices and incorporate high-level of technology integration over a five to six year period (Ertmer, 2005). Furthermore, even though many teachers may report knowing basic computer skills (e.g., getting information from the Internet, sending emails), most do not know how to use high-tech tools such as spreadsheets and presentation software to enhance their lessons and engage their students in basic computer-related activities such as internet research or using computers as a reward system or practice drills (Ertmer, 2005).

The change in Julie's TSE was significant as she was able to develop basic IWB skills relevant to her classroom needs, which enabled her to use the IWB to teach three science lessons.

It has been suggested self-efficacy may be more important than skills and knowledge among teachers who implement technology in their classroom (Piper, 2003). Positively influencing teachers' self-efficacy during PD has been shown to facilitate teachers' experimentation with technologies in their classroom, regardless of their level of technological proficiency. Desantis (2012) points out the importance of building TSE as part of a series of guiding principles he believes lay the groundwork for designing effective PD for IWB integration in the classroom. He argues successful adoption of IWB technology requires teachers to possess a combination of technology skills, self-efficacy, and a school environment that encourages teachers to utilize the IWB. Teachers who were already confident ICT users tended to become enthusiastic 'early adopters' after initial training with the IWB. Teachers with less confidence, however, were less able to be self-reliant and preferred to have sustained and individual guidance on a 'need-to-know' basis or more structured continuing support such as working alongside more experienced users Levy (2002).

From the beginning to the end of the PD, Julie gained confidence in her ability to use the IWB to teach science (Fig. III).

<INSERT FIGURE III HERE>

Individual factors related to the teacher's personality, such as self-efficacy, have been shown to affect the use, integration and development of modern technologies in education (Paraskeva et al., 2008). Teachers with a strong sense of self-efficacy are more open to new ideas and new methods of presenting new learning opportunities and experiences for their students (Tschannen-Moran & Woolfolk Hoy, 2001). Gaining a better understanding of what factors influence self-efficacy beliefs is essential as TSE can have a direct impact on how technology is used in teaching and learning (Abbitt & Klett, 2007).

Julie's feelings of TSE were positively influenced after participating in supportive PD on learning to use the IWB to teach elementary science. This is consistent with other studies, such as Dean (2001); Koul and Rubba (1999); and Sottile, Watson and Iddings (1998), where PD for inservice teachers led to an increase in TSE (Watson, 2006). In addition, Gonzales, Pickett,

Hupert and Martin (2003) found teachers who participated in technology PD to be more confident about using technology in their classrooms.

Factors Influencing TSE

The five most influential factors were Julie's (1) level of interest; (2) attitude toward technology; (3) experience with technology; (4) student support; and (5) familiarity with the setting (Fig. IV).

<INSERT FIGURE IV HERE>

Factors such as interest, experience with technology, student support, attitude toward technology, and familiarity with the setting were found to influence Julie's TSE when learning to use an IWB. Factors such as these are not mutually exclusive, but often interconnected and hierarchical in nature, which contributes to the complexities of the technology integration process (Inan & Lowther, 2010).

Interest. One of the reasons Julie participated in the PD was because of her interest using the IWB to acquiring more science and technology resources for her classroom to help motivate her students to learn science. Studies have shown the IWB to offer several potential benefits, such as versatility and flexibility in lesson planning, multimedia/multimodal presentations, interactivity and participation in lessons, and motivation from both teacher and student perspectives (e.g., Bell, 2002; Beauchamp & Parkinson, 2005; Murcia, 2008). As Julie was in need of science resources, the IWB was a means by which she could introduce new and interactive science resources into her classroom, complement her already-existing science lessons, while motivating her students to learn.

Experience with technology. Interest and experience with technology are important considerations when helping teaching to gain confidence during technology PD, ultimately influencing their TSE. Ertmer and Ottenbreit-Leftwich (2010) present a variety of strategies found in the literature for helping teachers to develop confidence when learning to use technology in their classroom. These include providing meaningful personal experiences to help with personal mastery (Ertmer and Ottenbreit-Leftwich, 2010), giving time to play with the

technology (Somekh, 2008), focusing on teachers' immediate needs (Kanaya, Light, and Culp, 2005), starting with small successful experiences (Ottenbreit-Leftwich, 2007) and situating the PD within the context of teachers' ongoing work (Cole, Simkins and Penul, 2002). Kovalchick et al. (1998) also outline ways of facilitating self-efficacy during technology education courses with novice technology users and suggest training in technology be a 'sense-making' process by constructing the PD based on teachers' own pace and skill level and driven by their individual needs and interests to help increase their confidence to integrate technology in their future classrooms. It is likely creating various opportunities where Julie could receive one-on-one support and practice using the IWB enabled her to increase her technology skill level, gaining confidence in her abilities in technology. Furthermore, a focus on developing relevant science and technology-resources specific to Julie's classroom maintained her interest in learning to use the IWB throughout the PD, indirectly influencing her overall confidence when using the IWB to teach science.

Student support. Part of Julie's interest in learning to use and create science resources for the IWB was to get her students excited to learn science. Julie challenged herself to design lessons catered to her students' needs and presented her IWB lessons to a specific group of grade 5 students. The students in this class were patient and understanding as Julie presented her IWB science lessons, which provided a supportive environment for her to practice her skills, ultimately influencing her confidence. Ertmer (2005) discussed components which could influence teachers' beliefs when learning to integrate technology into their practice, which included being provided with opportunities to practice in relevant contexts, learning technology uses that support teachers' pedagogical beliefs, and ongoing technical and pedagogical support.

Attitude toward technology. Julie's attitude regarding technology integration also seemed to play a role in her confidence when using the IWB. She wanted to participate in the PD and to learn to use the IWB as teaching tool in the science and technology classroom. The link between attitude toward technology and self-efficacy has not been well-explored (Abbitt & Klett, 2007). Factors such as perceived usability and ease of use have been identified as important influences on developing TSE. Perceived usability is defined as users' perceptions toward technologies and there is reasonable assumption that usability is connected to acceptance;

therefore, technology that is considered highly usable and useful to teachers will most likely be accepted by them, and eventually integrated into their classroom (Holden & Rada, 2011). This, they argue, along with the technology's perceived ease of use can influence a teacher's attitude toward technology. Julie's positive attitude toward technology enabled her to remain open to developing her IWB skills and discover the IWB's potential as a science resource, ultimately contributing to her feelings of TSE.

Familiarity with the setting. Familiarity with the setting was also a factor determined to influence Julie's TSE, but not fully explored because of the time limitations of this study. Throughout most of her PD, Julie's practiced using an IWB on a permanent setup of computer-IWB in the library, but presented her IWB lessons using a non-permanent IWB setup in another classroom. Unforeseen interruptions led to Julie presenting the start of the same IWB lesson twice – once in the classroom and again in the library. Julie remarked she was significantly more comfortable presenting in the library because of the familiarity of the setting and the board.

Julie's PD Needs when Using the IWB to Teach Science and Technology

Julie's needs when learning to use the IWB to teach based on communications during the interviews and lesson debriefs, as well as observations by the researcher. They are classified using a modified version of the Zhao et al. (2002) model (see conceptual) based on three interactive domains: (1) The Teacher; (2) The Context; and (3) The IWB (Fig. V).

<INSERT FIGURE V HERE>

PD Needs When Learning to Use Technology to Teach Science

As teachers' response to technology integration is influenced by the extent to which they develop technology proficiency skills and feel confident in their own use of technology, it is critical to examine their specific needs as they learn to use technology in the classroom (Williams et al., 2000).

Practical Learning Opportunities. It was helpful for Julie to be provided with opportunities to develop her technology proficiency and with practical learning experiences. As

Julie had never used technology as a teaching tool, it was essential for the PD to be catered to her level of technology proficiency and that she is provided with multiple hands-on opportunities to use the IWB. Aduwa-Ogiegbaen (2009) asserts PD needs should focus on developing a variety of technological skills in order for educators to assemble them to find ways to integrate in into their curriculum. Schnittka and Bell (2009) found using digital resources that elicit discussion and lead to interactive science lessons using the IWB requires practice. Enabling teachers to experiment with different instructional approaches, reflect on their lesson and receive feedback from students, and other teachers regarding their IWB lessons are important aspects when learning to use the IWB (Schnittka & Bell, 2009). Furthermore, Desantis (2012) argues technology's introduction into schools has created a 'revolutionized classroom environment' and teachers may have to modify their pedagogical practices and approaches when using the IWB.

Experience with troubleshooting. Another need specific to Julie was to gain experience with troubleshooting as she encountered a variety of difficulties during her PD sessions and IWB lessons. The researcher and students often assisted with poor network and internet connections, random scans which slowed the computer, and realignment and display option complications. Klieger, Ben-Hur and Bar-Yossef (2010) examined attitudes of science teachers to the integration of laptop computers and toward technology PD and found having a professional support system in place to assist teachers with technical difficulties, such as dysfunctional internet connection and computer malfunctions, to be an essential part of PD involving technology use in the classroom. Additionally, they noted as teachers gain more experience with the technology, it is likely they will become more proficient in using it in their classroom through the reciprocal effect (i.e., trial and error). Specific to teaching with the IWB, Smith et al. (2005) found teachers can often become overwhelmed and frustrated because of their inexperience with managing the equipment (e.g., board set up) and manipulating the features on the board, as well as networking problems which can lead to lesson disruption. Consistent with Julie's experience, other concerns expressed by teachers when using the IWB were safety concerns because of the multitude of wires required for the IWB and its associated equipment, difficulties with reaching the board and projectors, as well as calibration issues requiring frequent realignment throughout lessons (especially if the board was not permanently fixed).

Subject-specific content. Julie also expressed learning relevant resources catered to her subject specific needs to be an important PD consideration to encourage IWB integration Julie required assistance with basic technology skills and creating grade five IWB science lessons. Klieger et al. (2010) found creating meaningful experiences by integrating the laptop computer in teachers' content field to be important in affecting technology use and integration in the classroom. They also specified PD must be relevant in terms of content suited to the age groups they teach and in terms of instruction, curriculum and classroom management as integrating computers can change the dynamics of the classroom by placing teachers in new situations.

Consistent with this study's findings, preparing teachers to use educational technologies in appropriate ways should be subject-specific, with multiple relevant examples and resource exposure, relevant to the subject matter and group of students they are teaching (Flick and Bell, 2000). Notably, Julie was able to access several IWB science lessons online using websites such as SMART Exchange; however, teachers should take note of the quality of the digital education material and its relation to their curriculum expectations and students' needs (Somyürek, Atasoy & Özdemir, 2009).

Support. Julie's lack of experience with using technology made it sometimes difficult to overcome hardware and troubleshooting issues associated with using an IWB in the classroom and support from the researcher and students was often required during PD sessions and in the classroom. The need for adequate support was found to be one of the most frequent issues raised by teachers when learning to use the IWB in the classroom (Klieger et al., 2010; Smith et al., 2005). Somyürek et al. (2009) found teachers were hesitant to use the IWB in the classroom primarily because of a lack of support on IWBs in their schools for resolving technical difficulties such as hardware and network issues. Klieger et al. (2010) also found having a professional support system in place for classroom and areas relating to technological management to be one of the main factors affecting technology PD for science teachers. An important finding in this thesis was not only can support from the researcher be beneficial when learning to use the IWB, but support from students (who often assisted with troubleshooting) and fellow teachers.

Design. Another relevant contextual need expressed by Julie was the overall design of the PD. The PD's emergent design with a focus on Julie's specific IWB needs enabled technology skills to be acquired based on her initial level of technology proficiency and explored IWB uses at Julie's preferred pace based on her science teaching needs. Designing technology PD with teachers' initial situation (e.g., concerns, teaching routines, level of computer proficiency, etc.) in mind are an important part of PD planning (Donovan, Hartley and Strudler, 2007). Even though aspects of the PD design used for this thesis project may be difficult for schools to justify (e.g., one-on-one guidance, multiple and ongoing PD sessions), placing teachers' needs and level of technology proficiency at the forefront of technology PD design could be significant when designing PD for long-term technology integration.

IWB setup. Julie practiced on both portable (classroom) and permanent (library) types of IWB during her PD sessions and when presenting her IWB lessons. Consistent with Smith et al. (2005), Julie preferred using the permanently-setup IWB as there were fewer technical challenges (e.g., calibration, setup and troubleshooting issues). Julie did not experience any troubleshooting issues when presenting the lesson with the permanent board in the library, but had several challenges when using the portable one in the classroom.

Accessibility. Given there were only three IWBs shared between teachers at the school and Julie did not have her own classroom, limited accessibility on a daily basis could have negatively influenced her progress throughout the PD. Williams et al. (2000) surveyed primary and secondary teachers' needs in terms of developing their ICT skills and listed accessibility, such as presence of ICT in schools and the availability and sharing and management of ICT resources, as a main category. As accessibility is essential to integrating the IWB into any classroom, Julie will most likely need ongoing access to an IWB in order to continue to develop her IWB skills.

Conclusion

The focus of this study was to reveal factors influencing TSE and PD needs when learning to use the IWB in the elementary classroom. TSE when using the IWB increased after the PD, most evidently on statements concerning the topics more-emphasized during the PD.

Interest, attitude toward technology, experience with technology, student assistance and familiarity with the setting were found to be important factors influencing Julie's TSE. Technology proficiency, practical learning experiences, experience with troubleshooting, integration potential and resource relevance were determined to be an important consideration when learning to use the IWB. On contextual and IWB-levels, support, PD design, the type of IWB and its accessibility were important considerations when designing PD based on a teacher's needs. Findings from this study can serve as a precursor to future research in technology use and integration in the science classroom.

Limitations

The focus of this study is on one teacher's use of the IWB in an educational context. Student perspectives and impact on student learning and interest in science are not part of the breadth of this study, but these issues would be interesting to consider in future studies. The principal limitation of this research is its unique case study design as it is context-specific and the participant's experiences may not apply to other teachers' experiences when learning to use of the IWB in their science classroom, limiting the transferability and replicability of the results (Merriam, 1988). In addition, this study considers a teacher's needs and practices when using the IWB to teach science, which may not apply in the teaching of other subjects. The nature of the PD was one-on-one, while group instruction is the norm (Duran et al., 2009b; Kliger et al., 2010). Although factors influencing TSE were discussed, additional factors and their relationships should be further explored to gain a better picture of TSE and its influences. Results from this study may also not reflect how teachers feel about all educational technologies, as only the use of the IWB in the classroom is considered. Final limitations are the use of a survey as a data collection instrument and a unique researcher-coder; however triangulation of multiple data sources improved the validity and dependability of the evaluation of the findings and controlled for bias during theme validation (Golafshani, 2003).

Anticipated Contributions

Results of this thesis will help to better understand the needs and importance of TSE when learning to use the IWB to teach science at the elementary level. It may also influence the

design of teachers' PD on the integration of educational technologies such as the IWB in their science teaching. This could lead to an increase in technologically-literate teachers, eventually increasing student engagement in science (Linn, 2003). As teachers are exposed to educational technology PD and its complementary accredited online resources such as those offered for the IWB, the use of technology and use of curriculum-based software could be encouraged, ultimately changing the way students are learning science. When catering directly to teachers' technological needs, PD can lead teachers to have increased confidence in using technology in the classroom, enabling them to become more effective facilitators of technical and scientific literacy. Results of this study could also influence current trends in teacher PD, continuing education, preservice teaching programs, in addition to technology training using IWB in science and technology teaching.

Figures

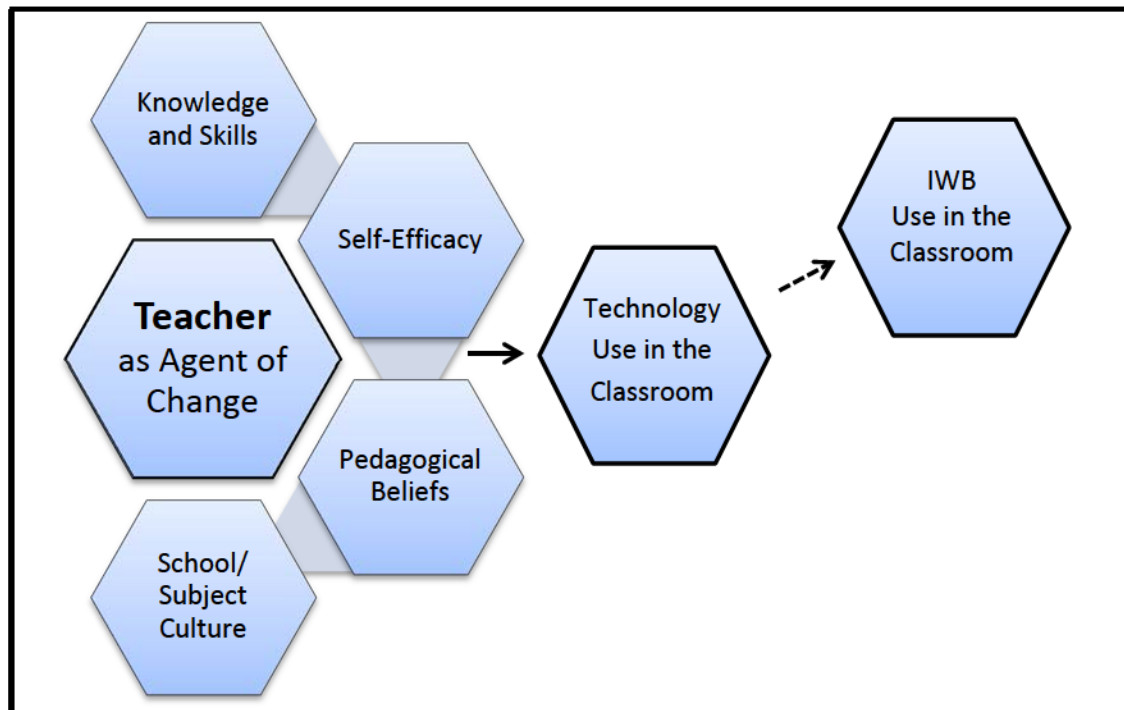


Figure I: Key variables facilitating teacher change when learning to use the IWB in the classroom (adapted by the researcher to illustrate concepts from Fullan and Stiegelbauer (1991) and Ertmer and Ottenbreit-Leftwich (2010)).

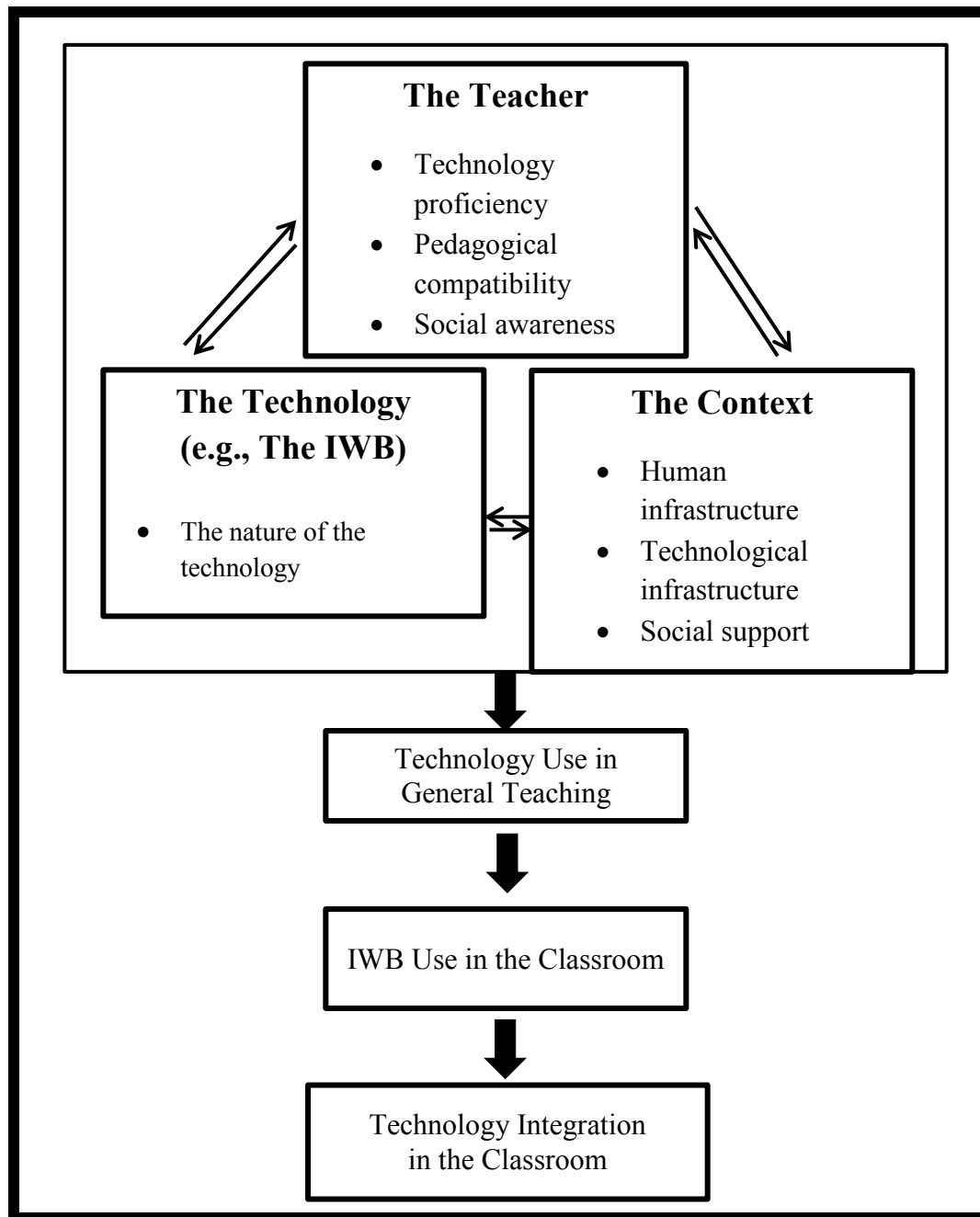


Figure II: Model for PD needs for the use and eventual integration of the IWB in the elementary classroom (adapted from Zhao et al. (2002)). Teachers' needs are categorized into three interactive domains: (1) The Teacher; (2) The Context; and (3) The IWB. IWB use to teach science is a step toward technology integration in the classroom.

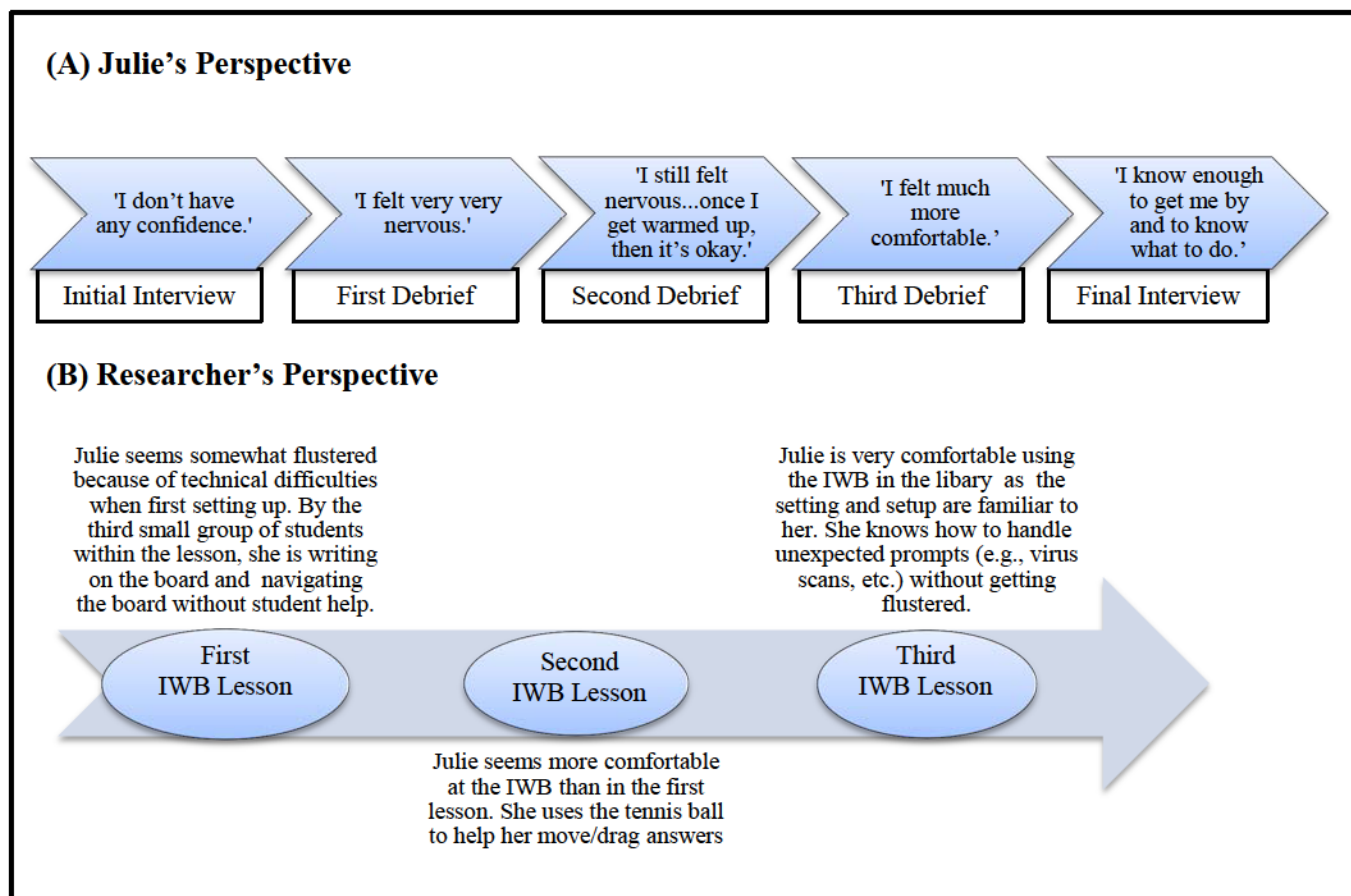


Figure III: Julie's confidence level over time with teaching using the IWB from (a) Julie's perspective, supported by selected excerpts articulated during the initial interview, first, second and third lesson debriefs, and final interview, and, (b) the researcher's perspective, supported by observations of each IWB science lesson recorded in the researcher logbook.

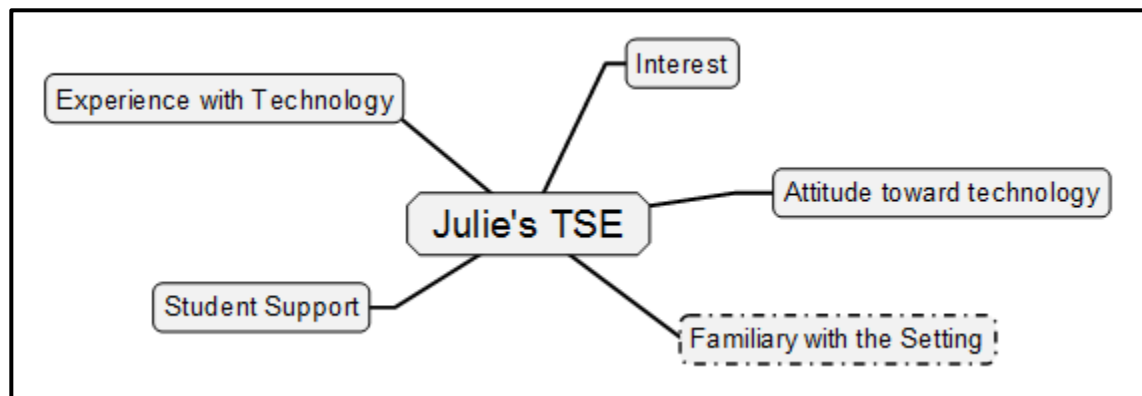


Figure IV: Map of factors that influenced Julie's TSE when using the IWB.

Note: There was less evidence for the familiarity with the setting factor as Julie taught in the library only once; however, a noticeable change in TSE was articulated by Julie and observed by the participant between the classroom and library (where the PD took place).

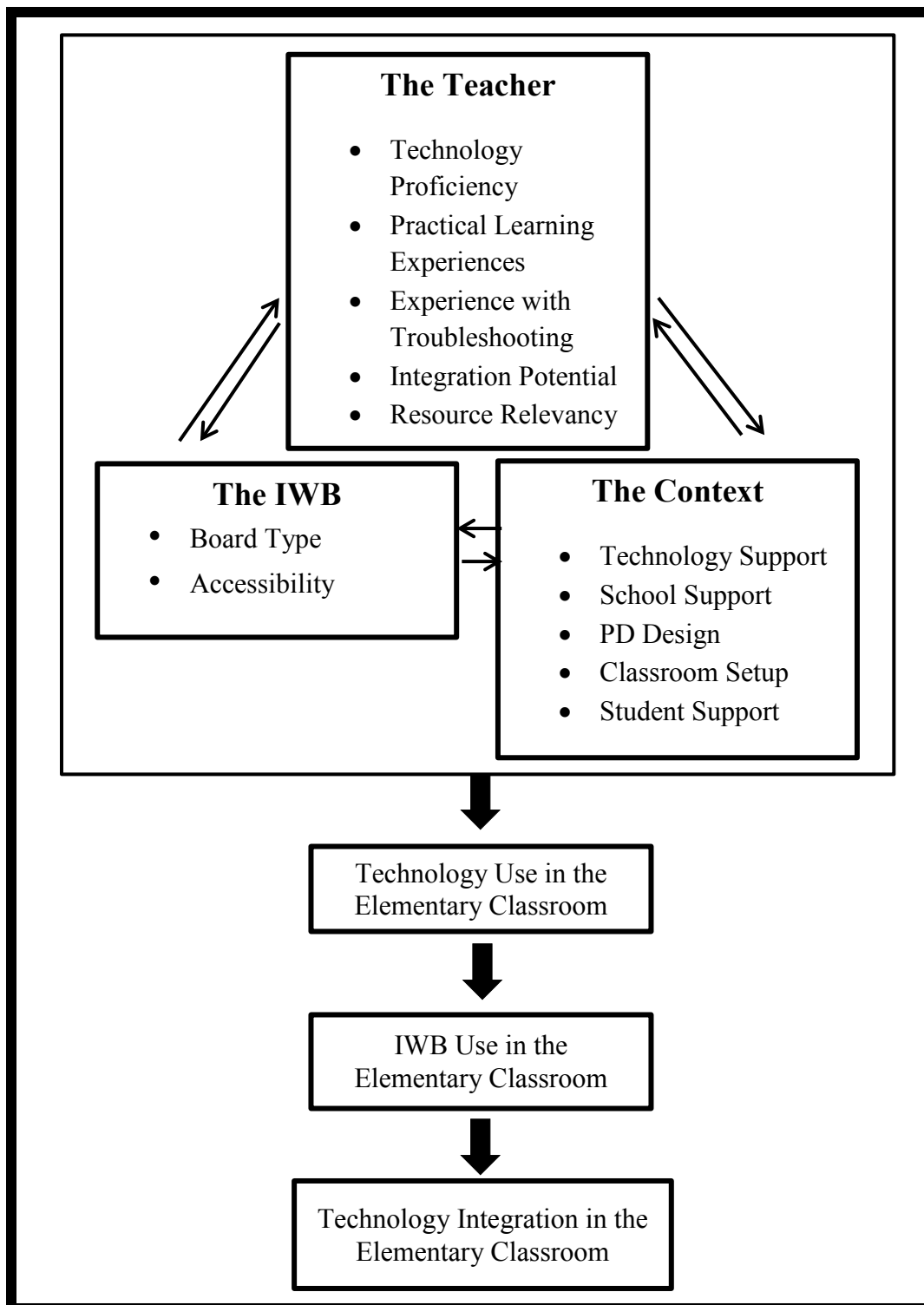


Figure V: Julie's needs when learning to use the IWB classified into three interactive domains: (1) The Teacher, (2) The Context, and (3) The IWB, based on the Zhao et al. (2002) model.

Tables

Table 1

CTIS-IWB Statements with a Notable Change in Julie's Response Before and After PD*

Statement: 'I feel confident that I [can]...'	Before PD	After PD
<u>Topics More Emphasized During PD</u>		
<i>Have IWB Instructive Skills</i>	SD	A
<i>Teach Relevant Content Using the IWB</i>	SD	A
<i>Monitor Student Computer Development for Projects</i>	SD	A
<i>Regularly Incorporate IWB in Lessons</i>	SD	A
<i>Select Appropriate Technology for Instruction Based on Curriculum Standards</i>	SD	A
<i>Keep Curriculum and IWB in Mind for Student Assessment</i>	SD	A
<i>Be Comfortable Teaching While Using the IWB</i>	SD	A
<i>Develop Creative Ways to Cope with System Constraints and Continue to Teach effectively with IWB</i>	ND/A	A
<i>Carry Out IWB-Based Projects when Opposed by Skeptical Colleagues</i>	SD	A
<u>Topics Less-Emphasized During PD</u>		
<i>Evaluate IWB Software for Teaching and Learning</i>	SD	ND/A
<i>Mentor Students in Appropriate Uses of Technology</i>	SD	ND/A
<i>Consistently Use the IWB in Effective Ways</i>	SD	ND/A
<i>Provide Students with Feedback During Technology Use</i>	SD	ND/A
<i>Use Technology to Collect/Analyze Data from Formative Assessment</i>	SD	ND/A
*A notable change occurred if the participant indicated a different response from an initial position of disagreement to neutrality, disagreement to agreement, and neutrality to agreement with a particular statement. SD = strongly disagree; ND/A = neither disagree/agree; and A = agree.		

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Conclusion

The focus of this study was to reveal factors influencing TSE, PD needs and pedagogical strategies when learning to use the IWB to teach science at the elementary level. TSE when using the IWB increased after the PD, most evidently on statements concerning the topics more-emphasized during the PD. Interest, attitude toward technology, experience with technology, student assistance and familiarity with the setting were found to be important factors influencing Julie's TSE. Technology proficiency, practical learning experiences, experience with troubleshooting, integration potential and resource relevance were determined to be important considerations when learning to use the IWB. On contextual and IWB-levels, support, PD design, the type of IWB and its accessibility were significant when designing PD based on a teacher's needs. A variety of pedagogical strategies when using the IWB to teach science were incorporated, such as emphasizing important scientific concepts and processes, strategic questioning, step-by-step discussion as well as the promotion of interactive learning environments by creating opportunities for student participation and manipulation, while integrating the IWB with other resources, and obtaining immediate student feedback. Finally, IWB tools were found to be beneficial in the science classroom. This study can serve as a precursor to future research in technology use and integration in the science classroom as well recommendations for teacher education courses.

Limitations

The focus of this study is on one teacher's use of the IWB in an educational context. Student perspectives and impact on student learning and interest in science are not part of the breadth of this study, but these issues would be interesting to consider in future studies. The principal limitation of this research is its unique case study design as it is context-specific and the participant's experiences may not apply to other teachers' experiences when learning to use of the IWB in their science classroom, limiting the transferability and replicability of the results (Anfara et al., 2002; Merriam, 1988). In addition, this study considers a teacher's needs and

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Anticipated Contributions

Results of this thesis will help to better understand the needs and importance of TSE when learning to use the IWB to teach science at the elementary level. It may also influence the design of teachers' PD on the integration of educational technologies such as the IWB in their science teaching. This could lead to an increase in technologically-literate teachers, eventually increasing student engagement in science (Linn, 2003). As teachers are exposed to educational technology PD and its complementary accredited online resources such as those offered for the IWB, the use of technology and use of curriculum-based software could be encouraged, ultimately changing the way students are learning science. When catering directly to teachers' technological needs, PD can lead teachers to have increased confidence in using technology in the classroom, enabling them to become more effective facilitators of technical and scientific literacy. Examining IWB-specific pedagogical strategies for teaching science can encourage teachers to use them for effective science teaching, leading to increased interest in the sciences, ultimately promoting scientific literacy. Results of this study could also influence current trends in teacher PD, continuing education, preservice teaching programs, in addition to technology training using IWB in science and technology teaching.

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Appendix A: Computer Technology Integration Survey-Interactive White Board (CTIS-IWB Survey)

based on Skoretz (2011) adapted by Francine Hart for the integration of the
Interactive White Board (IWB) or ‘SMART Board’

Technology Integration is defined as using computer technology to support students as they construct their own knowledge through the completion of authentic, meaningful tasks. The purpose of this survey is to determine how confident you feel about integrating technology into classroom teaching.

Please circle one response for each of the **21** statements in the table.

For each statement, indicate the strength of your agreement or disagreement by circling one of the five choices.	Strongly Disagree	Disagree	Neither Disagree/Agree	Agree	Strongly Agree
I feel confident that I...					
1. understand Interactive White Board (IWB) capabilities well enough to maximize them in my classroom.	1	2	3	4	5
2. have the skills necessary to use the IWB for instruction.	1	2	3	4	5
3. can successfully teach relevant subject content with appropriate use of the IWB.	1	2	3	4	5
4. can evaluate software for teaching and learning.	1	2	3	4	5
5. can use correct computer terminology when directing students' computer use.	1	2	3	4	5
6. can help students when they have difficulty with the computer.	1	2	3	4	5
7. can effectively monitor students' computer use for project development in my classroom.	1	2	3	4	5
8. can motivate my students to participate in technology-based projects.	1	2	3	4	5
9. can mentor students in appropriate uses of technology.	1	2	3	4	5
10. can consistently use the IWB in effective ways.	1	2	3	4	5
11. can provide individual feedback to students during technology use.	1	2	3	4	5
12. can regularly incorporate the IWB in my lessons, when appropriate to student learning.	1	2	3	4	5

Please continue to the next page to complete the survey.

For each statement, indicate the strength of your agreement or disagreement by circling one of the five choices.	Strongly Disagree	Disagree	Neither Disagree/Agree	Agree	Strongly Agree
I feel confident that I...					
13. can select appropriate technology for instruction based on curriculum standards.	1	2	3	4	5
14. can assign and grade technology-based projects.	1	2	3	4	5
15. can keep curricular goals and IWB uses in mind when selecting an ideal way to assess student learning.	1	2	3	4	5
16. can use technology resources to collect and analyze data from student tests and products to improve instructional practice.	1	2	3	4	5
17. can be comfortable using IWB in my teaching.	1	2	3	4	5
18. can be responsive to students' needs during computer use.	1	2	3	4	5
19. can continue to improve in my ability to address my students' technology needs.	1	2	3	4	5
20. can develop creative ways to cope with system constraints (such as budget cuts on technology facilities) and continue to teach effectively with the IWB.	1	2	3	4	5
21. can carry out IWB-based projects when I am opposed by skeptical colleagues.	1	2	3	4	5

If you have any additional comments on technology integration, and/or the integration of the IWB specifically, you may write them in the space below.

--

Thank you for your time.

Appendix B: Initial and Final Interview Templates

Initial Interview Template:

Date of Interview: _____

Start Time of Interview: _____

End Time of Interview: _____

PART A: TEACHING EXPERIENCE

1. How many years of full-time teaching experience do you have at the elementary level (i.e. grades JK – 8 inclusive)? _____

2. Which subjects have you taught at the elementary level (grade JK-8 inclusive)?

Subject Taught at the Elementary Level	Grade(s)	Number of Years of Teaching Experience for that Subject

Additional Comments:

(continued on next page)

3. How many years of full-time teaching experience do you have at the secondary level (i.e. grades 9-12 inclusive)? _____

4. Which subjects have you taught at the secondary level (grades 9-12 inclusive)?

Subject Taught at the Secondary Level	Grade(s)	Number of Years of Teaching Experience for that Subject

Additional Comments:

PART B: TECHNOLOGY AND TEACHING

5. Do you use technology in your teaching? (Circle one) YES NO

(a) If yes, how often do you incorporate technology in your teaching (e.g. nearly everyday, sometimes, rarely)? _____

(b) If yes, which technologies you use in your classroom?

6. Do you use technology to assist you in teaching science? (Circle one) YES NO

(a) If yes, which technologies you use in your classroom?

(continued on next page)

7. Do you have any specific training in science teaching and/or a science background (e.g. science specialist, university science courses)? (Circle one) YES NO

(a) If yes, could you elaborate on your science training and/or science background?

PART C: THE USE OF THE INTERACTIVE WHITE BOARD TO TEACH SCIENCE

8. How do you use the IWB in your classroom to teach in general and/or in science (e.g. creating presentations, using interactive online resources, for whole-class discussion, watching videos, etc.)?

9. Do you have any concerns with using the IWB in science teaching (e.g. access to an IWB in school, lack of knowledge of IWB resources, lack of confidence, etc.)?

10. Please comment on your confidence level when first with using the IWB to teach in general, and then specifically to teach science?

11. Do you have any additional information you would like to add about the use of the IWB in your classroom to teach science and/or any other subject (e.g. complements teaching style, general comments and/or concerns)?

Researcher Comments:

Final Interview Template:

Date of Interview: _____

Start Time of Interview: _____

End Time of Interview: _____

Guiding Questions/Prompts

TSE:

In your opinion, have the professional development sessions affected your confidence level with using the IWB in your science teaching?

Has your confidence level changed over the course of the PD with using the IWB to teach science? If yes, how? If not, why?

PD:

What would you like to see addressed in technology professional development?

In your opinion, what are some key aspects of professional development sessions which can help to address these needs?

Do you believe professional development such as the one in which you are participating encourages teachers to use the IWB in their classroom?

Do you think technology professional development geared to a specific subject is helpful?

IWB Teaching Strategies/Tool Use:

Which tools could you use on your own to create science lessons?

How would you integrate the IWB to complement your classroom routine?

Appendix C: Researcher Logbook Template

Lesson: _____ Technical Observations (e.g., IWB set-up, ease of IWB navigation, troubleshooting, etc.)	Teaching Observations (i.e., What strategies are being used to teach the students?)	Date: _____ IWB Tool Use (i.e., Which IWB tools are being incorporated into the science lesson?)

Appendix D: Supportive Data Re: Factors Influencing Julie's TSE and Needs When Using the IWB to Teach Elementary Science

Influence or Need	Participant Quote	Researcher Interpretation
Interest: A desire to learn about the IWB.	"I was watching some YouTube videos about Smart boards, and one of the examples that they showed was a science lecture lesson on the planets. And I thought that would be really neat to use (i.i.p.5)." "I look forward to trying to use it, and learning...and getting more resources that I can use in my classroom (i.i.p.5)." R: "So you would talk to other teachers and notice they were using it, right?" J: "Yes. Moe [the principal] presented it to me and I said Moe, I'm pathetic with things like that' and then he said 'Well, you know it's an opportunity to learn'...and I said 'Yeah...okay.' (s.d.p.7)." "If you have no interest it's kind of hard to get someone to be interested in something, but you have to motivate them like you do with students by showing them something they are interested in(s.d.p.7)." "You can pay me all the money in the world, but if I don't care (...) (s.d.p.7)." R: "Deep down, I think you had a curiosity about (the Smart board)." J: "Yes, I wanted to learn about it (f.i.p.1)." " (...) you're not likely to invest any time in something unless you want to do it. (...) I wanted to learn about it (f.i.p.1)." "In my case, I have no one else to help me do it so I have to learn to do it (f.i.p.2)." "I (...) saw there were kind of some neat Smart board resources for science and music and even languages (f.i.p.2)."	The participant knew about the potential science resources which can be acquired from the IWB and demonstrated curiosity towards learning the IWB and IWB resources prior to using it with the researcher.

(table continues)

Influence or Need	Participant Quote	Researcher Interpretation
Attitude: A way of thinking or viewing technology and the IWB.	“I am not against technology (f.i.p.2).” “[Taking PD in IWB] (...) depends on (...) if they’re willing to do it. If they’re not willing and they’re set in their ways, then there’s no sense in doing it (f.i.p.2).” “It would require a change on their part as they wouldn’t be doing what they normally do and they’d have to be willing (f.i.p.2).” “(Teachers) have to have the right attitude. And it’s also whether or not they would volunteer to take the training (f.i.p.2).” “And sometimes [during the third lesson] I’d say ‘hey I want to do it. It’s my turn!’ because it’s fun (t.d.).”	The participant was receptive to more IWB PD despite her past (negative) experience. She recognizes her (basic) level of technological abilities and kept an open mind to further developing them as well as her IWB skills.
Technology Proficiency: the technological skill level of the participant and the way in which the participant views herself when using technologies such as the IWB	“I don’t have any confidence (i.i.p.5).” “If you don’t have the basic knowledge behind you then you don’t like it and then it becomes scary, like with me before we started working together (f.d.p.6).” “The more you encounter [technical difficulties], the more you start to solve them, and you might know what to do and you might not, but at least you won’t think ‘oh no, what do I do?’ (f.d.p.9).” R: “If you had access to a Smart board every day, would you consider doing that lesson again?” J: “Oh absolutely. Oh yeah (s.d.p.7).” “I don’t mind [the researcher being in the classroom]. It was more I wanted to show you I could do this (...) I know I could figure it out (s.d.p.7).”	As the participant encounters various ‘obstacles’ when working with technology and the IWB her confidence level increases. The participant did not have any confidence with using the IWB in the classroom. By the end of her second lesson, she could see herself using the IWB in her classroom and had the confidence to want to demonstrate her IWB skills to the researcher.

Influence or Need	Participant Quote	Researcher Interpretation
The PD Experience	“I thought [the lesson] was fun. I thought it was interesting (t.d.p.8).” R: “Would it have been different with advanced people instead of the one-on one format?” J: “I would have left (...) probably because I would have felt left out (f.i.p.2).” “ (...) it took me a while to get me to have it sink into my head, but all-in-all it’s not really difficult to get used to. I mean it was for me because [the researcher] had to really show me a lot of stuff, but if you have that basic already, then it’s fairly easy (f.d.p.5).” “It’s if you don’t have that basic knowledge behind you then you don’t like it and then it becomes scary, like with me before we started working together (f.d.p.5).” “The videos we were watching with the internet being so slow, it’s part of technology to learn to adapt to these glitches that might come up (t.d.p.9).”	The researcher considered the participant’s basic level of knowledge when teaching IWB skills and lesson development. This was different from her past IWB PD and helped in making her feel more comfortable and less overwhelmed, and give her the confidence to challenge herself to overcome some of the barriers associated with technology.
Student Support / Motivation	“[I’m looking forward] to having the kids interact with it too (...) I’ve seen the little ones (...) use it sometimes (...) and it’s just kind of neat watching [them] interact with it (i.i.p.17).” “I think I could add a lot to it, especially for kids who are hard to engage sometimes (f.d.p.5).” “I think it helped motivate the kids. And it’s nice not to have to do pencil and paper task with them (...) I just enjoyed it too (t.d.p.8).” “But this got them really excited to learn (s.d.p.7).” “I was talking to them about the lesson afterward and to them it was awesome (s.d.p.7).”	The students’ increased in motivation and reaction when the participant used the IWB in the classroom gave the participant incentive to further develop her IWB skills to be able to use it in her future classes.

(table continues)

Influence or Need	Participant Quote	Researcher Interpretation
Student Support / Motivation (continued)	“[The students] enjoyed it. They thought it was good, because I don’t do anything like that. I had never done anything like that with any students so it was a nice change for them. It was exciting for them and exciting for me at the same time (t.d.).” “I had never done anything like that with any students so it was a nice change for them. It was exciting for them and exciting for me at the same time (t.d.p.9).”	
Student Assistance	“[The students] were very helpful (...) I knew they were a nice group of kids to do something like this with (f.d.p.5).” “It depends on the dynamics of the group (...) I thought ‘there’s something I’m going to keep in mind for next year to do with them’ (s.d.p.7).” “I think I could teach with it. I definitely would use it again (...) like for next year (...) and the students are very helpful with it (s.d.p.7).” “[The students] have been raised on technology, which helps because I wasn’t at all. And they know a lot about it at such a young age (t.d.).” “And the students are good to help out too (f.i.p.2).”	The students were supportive while the participant practised using the IWB to teach their science lesson. They would offer their assistance with setting up the IWB and with troubleshooting.
Potential of new practices and resources for science teaching. The ease of the IWB into the participant’s teaching practices.	“There would be lots of resources to use. I could use it as a whole-lesson thing or again for activity stations (f.d.p.5).” “Yes I would [integrate it in the classroom] because it’s a different way of presenting material (...) (f.i.p.2).”	The participant enjoyed the practical applications of the IWB in her science lessons. “Quick and easy” games to insert into her lessons as well as accessible science resources were seen as useful and motivating to her.

Influence or Need	Participant Quote	Researcher Interpretation
Familiarity with the Setting and Board-Specific Needs	“I felt much more comfortable in the library (where we did the PD) than I did in the (classroom) because...I hadn’t been in that classroom that often. (...) and the library had fewer things to distract the students (t.d.p.8).” “ (...) because we actually used that one, we practised on it.’ It is the one we trained on (f.d.p.9).” “I wasn’t even worried about it. I felt it would work because we had done it before (f.i.p.14).” “I found [the students] were just too close together in the classroom...but when we put them farther away, they’re farther from learning in a sense. In the library, we had a smaller number of students and they were comfortable around the board (f.d.p.9).” “The library didn’t seem to upset [the students] as much [as changing them classrooms like we usually do] (...) The transition seemed easier for them (t.d.p.8).” “When we had the students [in small groups] that worked well because we had a small group at the Smart board, giving all students a chance to participate (...) chances to work in smaller groups. I can get everyone involved that way and have an idea of if they’re getting it or not (...)I kind of feel more comfortable doing things like that (t.d.p.9).” “The problem is the setup (...) I don’t have a classroom [to myself] (...) so it’s a bit different going into [another teacher’s] classroom (f.d.p.5).” “I found the physical setup wasn’t the way I would have liked it (s.d.p.7).”	The type of IWB as well as the familiarity of the classroom influenced the participant’s level of comfort when using the IWB in her science lesson. Using the projector, computer and IWB she had practiced on in a room she and the students were routinely in, decreased her level of nervousness when presenting the lesson.

Appendix E: Researcher Logbook Observations - Troubleshooting

Lesson	Type of IWB	Setting	Troubleshooting Observations
1	Portable	Classroom	- IWB was not plugged in, the projector had to be adjusted to fit the screen and the cables needed to be plugged in (overall setup took approx.. 7 minutes); - View page option needed to be changed to accommodate slide with larger table and word bank.
2	Portable	Classroom	- Julie remembers how to start the IWB and projector, but is still unsure because the projector light takes a few seconds to illuminate; - Participant needs help connecting the cables (there are several unused cables nearby for the connection of several laptops); - No speakers on the IWB so must use poor quality laptop speakers to listen to audio clips; - Must recalibrate the IWB as students move the board when touching it; - Julie and the students are tripping on the cords; - Julie and students use a tennis ball to manipulate the parts to complete the diagrams.
3	Portable	Classroom	- IWB must be realigned three times throughout the lesson; - Unable to log on to laptop because 'no network available' when entering username; - Introductory video would not work because there was no internet connection; - Delayed by extra password required for internet access; - Slow internet speed.
	Permanent	Library	- Julie is able to do the complete setup of the IWB and start the lesson without any delays (e.g., located projector remote, knew login passwords and 'pop ups' from running programs); - No realignment of IWB required throughout the lesson; - Use of tennis ball for manipulation.

Appendix F: Lesson Descriptions

Grade Five IWB Science Lessons Presented by Julie: (1) Renewable vs Non-Renewable Resources, (2) Human Body: Digestive System, and (3) Recycling and Compost

	Lesson Title	Description
1	Renewable vs. Non-Renewable Resources	The lesson consisted of three activity stations, where the class was divided into three groups of students who changed stations every 20 minutes. The three stations were: (1) at the IWB (teacher-led), (2) making an energy conservation poster (groupwork at desks); and (3) brainstorming conservation tips (individual at desk). The purpose of this lesson was to review renewable and non-renewable resource differences and practice classifying them accordingly. Julie presented the same lesson three times. The IWB lesson consisted of two parts: the first part was an interactive classification ‘vortex’ game where students were given a word bank made up of renewable and non-renewable resources and asked to click and drag them into the corresponding labeled vortex. The second part was a table the students completed using the IWB pens with the help of hints at the bottom of the screen as well as their own examples.
2	The Human Body: The Digestive System.	This IWB lesson was found on the SMART Exchange website and recommended for grade 5 and 6 science classes. The purpose of this lesson was to review the major organs and their respective functions that make up the human digestive system. The lesson consisted of a series of questions where the students could formulate their answer and verify using either the ‘erase-and-reveal’, ‘pull-tab’, ‘checker tool’, or ‘click-to-reveal’ features in <i>Notebook</i> . The final portion consisted of labelling a diagram of the human digestive system by dragging the corresponding labels to their designated location. These answers could be verified by the students using a ‘check answers’ button. As an additional activity, students were asked to ‘trace the pathway’ of the food through the digestive system from their mouth to expulsion.
3	Recycling and Compost	This lesson was divided into 2 parts: (1) three seven-minute videos from the television show <i>How it’s Made</i> followed by a sequence of activities involving recycling and composting including a sorting activity using images, a classification table where students could summarize their decisions from the previous slide followed by a brainstorming activity on waste management and its community applications. The purpose of this lesson was to review recycling and composting materials, as well as discuss recycling and composting issues related to students’ lives. Julie had a chance to present the beginning portions of this lesson twice, once in the classroom and once in the library, as there were unforeseen interruptions and technical difficulties which prevented the lesson from continuing.

Appendix G: IWB-Integrated Science Teaching Strategies Examples

IWB-Integrated Science Teaching Strategy Examples Used in Julie's Science Lessons

Teaching Strategy	Lesson 1: Renewable vs Non-Renewable Resources	Lesson 2: Human Body: Digestive System	Lesson 3: Recycling and Compost
The teacher fosters student participation and collaboration through interactivity and encourages scientific investigation.	Vortex sorting game; fill-in-the-blank using word bank related to renewable resources; energy conservation poster	Quiz format to reveal answers to role of each organ in the digestive system (e.g., checker tool, erase and reveal)	Recycling sorting activity using items students are familiar with and classification table
The teacher provides opportunities to assess learning informally and moves students' thinking through discussion of results or prompting them step by step.	Activity stations using teacher-led IWB discussions and small-group peer discussions at other stations	Student voting/discussion before revealing answer	Student discussion concerning multiple classifications for items
The teacher designs and uses science-related resources that respond to varying learning needs and focuses student attention on key underlying concepts, relationships and processes.	Visual display of the IWB and manipulation of objects for visual and tactile learners	Visual display of IWB and means of oral assessment	Visual display of the IWB and participation from students during discussion and for approaching the IWB
The teacher creates opportunities for student exploration, participation and manipulation in science.	Stimulating interest with games	Sharing of real-life examples and personal stories creating meaning; use of manipulative (e.g., mini-diagrams)	Stimulating interest with media and real-life examples
The teacher expands opportunities for learning by accessing science information and tools to share with students.	Use of the IWB to create an interactive science lesson for students	Use of <i>SMARTExchange</i> , an online IWB resource bank for teachers	Use of the IWB to present media, links and videos related to recycling and compost issues

(table continues)

Teaching Strategy	Lesson 1: Renewable vs Non- Renewable Resources	Lesson 2: Human Body: Digestive System	Lesson 3: Recycling and Compost
The teacher exploits the affordances of dynamic visual presentation, interactivity and immediate feedback to render underlying scientific concepts and processes more salient and accessible to learners.	Assessment option for students with trouble with fine motor skills (e.g., writing)	Immediate feedback for students	Generates teacher-student and student-student discussion

Appendix H: Specific Examples of Julie's Use of IWB Features

	Lesson 1: Renewable vs Non-renewable Resources	Lesson 2: Human Body: Digestive System	Lesson 3: Recycling and Compost
Capturing	Julie captured images from online sources and incorporated images from the Notebook gallery of renewable and non-renewable resource examples.	This lesson was taken from the SMART Exchange website and included diagrams related to human digestion as interactive online images.	Julie copied and pasted a variety of images related to recycling and compost from the Internet using the camera feature.
Emphasizing	Julie used an interactive vortex game to emphasize the distinction between renewable and non-renewable resources.	Various parts of the digestive system were discussed using 'erase-and-reveal', 'pull-tab', 'checker tool', and 'click-to-reveal' features, drawing students' attention to a particular organ and its function.	Students wrote on the board and completed the slide with ideas for community recycling and waste management initiatives.
Storing	Julie saved each small group's work from the first lesson to keep track of student answers to the vortex classification game and the fill-in-the-blank table.	The students traced the pathway of the digestive system by naming organs in order. This slide was saved and would be useful as a starting point for future lessons or as review.	As this lesson was discussion-based, Julie was able to save the lesson with students' responses for future lesson ideas and prompts.

(table continues)

	Lesson 1: Renewable vs Non-renewable Resources	Lesson 2: Human Body: Digestive System	Lesson 3: Recycling and Compost
Annotating and Modifying	Julie allowed students to complete the table using a word bank and/or the drag-and-drop feature to explain natural resources and environmental concerns if they are depleted.	Students placed labels on a diagram of the digestive system and were able to modify their placement by rearranging them.	Students modified the classification of each object by shifting its placement on the IWB as its justification came into question if it could be placed into more than one category.
Linking	Julie linked a worksheet of renewable and non-renewable resources students had worked on a few months prior to situate the students.	-	Julie inserted links to Youtube videos from the television show 'How It's Made' on topics related to recycling such as the making of plastic bottles and aluminum cans.