Science Teachers’ Experiences in Integrating Information and Communication Technology (ICT) into their Teaching Practices

By

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A research paper submitted in conformity with the requirements for the Degree of Master of Teaching

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TEACHERS’ EXPERIENCES WITH ICT INTEGRATION

ABSTRACT

In response to rapid social, economic and technological change, Canadian education authorities have recognized the importance of integrating ICT into teaching and learning. Despite the growing availability of technology in Canadian classrooms, there remain barriers to technology integration relating to teachers’ beliefs about technology and learning, aspects of pre-service training, professional development opportunities, accessibility of technology, and ongoing support. This research investigates two middle and secondary school science teachers’ experiences integrating technology into the classroom. Overall, technology was perceived as useful, although there were many barriers to its integration into the classroom, namely barriers relating to human, material, and time resources. Peer support was an important facilitator in understanding how to use different technologies. Finally, teachers’ increase in confidence occurred with increased familiarity with a new technology. Consistent with the literature, the findings from this study indicate that there exist key barriers and facilitators. Teachers’ experiences of these barriers and facilitators interact to shape their perceived usefulness of technology in teaching, and their comfort using it in their teaching practice. This research highlights the importance of content-based technology learning in order for transformative uses of technology to become more common among science teachers. The findings have implications for both professional development content, as well as pre-service training curricula.

Key Words: information and communication technology (ICT), technology, science, student learning, pre-service training, and professional development.
ACKNOWLEDGEMENTS

I wish to acknowledge and thank my research supervisor, Katherine B., for her unconditional support throughout this academic journey as this would have not been possible without her guidance. I am grateful to Louisa P. and Christine M. for their academic insight and support in the months leading to the final draft of this research paper. I especially want to thank my parents, Balkar and Sarbjeet M., without whom I would not have achieved this ladder of success. I also want to thank both of my sisters, Harmeet M., Pardeep D., and brother-in-law Amninder D., for their joint efforts in supporting my academic endeavors over the last two years. Last, I devote this original academic research paper to my niece Loveleen G., and nephews Gurbaj G., and Yuvraj D., so as to share with them my message regarding success and failure in life, remember kids true effort always yields great results.
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Chapter 1: INTRODUCTION

Introduction to the Research Study

What are some of the implications of rapid technological innovation and development for our education system? As stated by Ron Canuel, the CEO of the Canadian Education Association (Dunleavy & Willms, 2011), “if education is meant to prepare these children for their world, use of technology must become the norm in our classrooms and schools” (Canuel, 2011, p. 33). This puts the onus on teachers to create opportunities for students to acquire the information and communication technology (ICT) skills needed in order “to prepare them for today’s economy and to make the most of new learning tools” (Plante & Beattie, 2004, p. 6). In this context, “equipping students with computer skills has become an important goal of school systems across the country” (Plante & Beattie, 2004, p. 6).

Due to the innovative advancements in instructional technology, the significance and role of the teacher in accepting and integrating them has become the focus of attention when it comes to the learning and achievement of students in today’s technological classroom learning environments. There are different interpretations as to the benefits of integrating technology into the classroom, as there are many research studies that have focused on highlighting the benefits of technology integration by teachers into their teaching practices. For example, in a study by Keengwe, Schnellert, and Mills (2012), it was concluded that by integrating laptops into the classroom, there was a higher level of student motivation, engagement and learning, and ability to work individually, along with evidence that the integration of laptops in the classroom led to an
increased use of technology at home and in the classroom, by the students. In addition, Keengwe et al. (2012) found that “faculty believed that the integration of 1:1 computing improved traditional, at-risk, and high-achieving students’ learning experiences” (p. 144). The findings from the above research are significant when it comes to evaluating the roles of ICT in the classroom and the variations in the interpretations of the teachers’ beliefs regarding what their students have learned from the integration of such technology. Thus, to further address the variability or congruency in teachers’ interpretations, this study hopes to provide more insight into the role, influence, and potential benefits of ICT integration in the teaching practices of secondary and middle school science and mathematics teachers based on their experiences.

From the mid-twentieth century to present day, there has been a huge leap in computer innovation and use. When Konrad Zuse built the world’s first programmable automated computer in 1938, known as the Z1, the machine was a luxury possession, inaccessible to the general public (Rojas, 1997). This accessibility limitation decreased as advances in technology allowed more households to purchase computers during the 1990s, leading to a new digital era. Technology is increasingly becoming integral to many aspects of our daily lives and is a pervasive symbol of modern society (Plante & Beattie, 2004).

There is a distinction to be made between integrating and using ICT as the former acts as a supplement to the teaching practice whereas the latter is more in the line of a substitute for teaching in the classroom. In considering the importance of integrating technology in the classroom, we must not only focus on students’ preparedness for the technological world, but also on what educational technology can supplement and/or
enhance student learning. Technology is already readily available in the Canadian education system. In Canada, less than 1 % of elementary and secondary schools are without computers and 98 % have Internet connections (Plante & Beattie, 2004). In addition, Canadian schools also have high computer to student ratios. The Information, Communications and Technologies Student Survey (ICTSS) found a median ratio of one computer for five students in 2003-2004 (Plante & Beattie, 2004). Based on these statistics, access to internet-connected computers and technology in the major provinces of Canada is not a concern for the teaching profession. Having considered this, how much of the available technology is being integrated into teaching practices in order to enhance teaching and student learning?

**Background of the Researcher**

I was born in a small rural village in the state of Punjab, India and spent my early years growing up with my two older siblings. The highlight of our week was usually when all the village children gathered at our house to watch a movie, as my family was one of the few families in the village with a television at home. In 1993, my family and I immigrated to Montreal, Canada where we were introduced to a new culture, language, education system, and an abundance of new technology. My father had decided that Montreal would provide us with opportunities for education and to advance our lives, and improve our quality of life.

Throughout my elementary and secondary years, I did not appreciate the true value of technology as a means to help me, the learner, in the classroom. The primary reason for this was that most of my teachers did not either use or show technology to be a meaningful tool or resource during their teaching practices. I remember questioning
myself in my early adolescent years as to why I did not experience a lot of technology in
my elementary and high school classrooms, but as soon as I would exit the school
environment, technology was everywhere around me. It was a great culture shock for me,
coming from a home that cherished a cassette player, radio, and a television. In my native
Punjab, I had felt that we were privileged, but coming to Canada, I felt this sense of
privilege stripped away from me when I realized that these were common acquisitions of
the average individual. Nevertheless, during high school, I vividly remember the
excitement of nearing the lunch hour for the purpose of having access to the computer
room, where every student in the school had the opportunity to use the Internet. In the
context of technology for learning in the classroom, PowerPoint was not regularly used;
the main place technology was present was in the computer labs.

Upon high school graduation, I chose natural sciences (Health Sciences) for
CEGEP (pre-university) studies. I did not understand the scope of why teachers used
technology so scarcely by teachers. After graduating from CEGEP, I began to reflect on
my strengths and weaknesses in the subjects that I had completed over the two years.
Three subjects where I had greatest academic achievement were chemistry, mathematics,
and biology. During this period, I began to appreciate technology in the classrooms and
the lives of students and teachers as my three subjects were made more engaging by
virtue of having technology as a medium to help strengthen my understanding of science
and mathematics. I began to realize the potential of technology in the classroom through
the exemplary work of my teachers. Further, in my biology classroom, my teacher would
use PowerPoint to present diagrams or pictures in order to illustrate various concepts that
would otherwise have taken much longer if using traditional teaching methods (e.g., the
blackboard). Also, my mathematics teacher used scientific calculators on a daily basis for our pre-calculus and guided us through learning how to manipulate many functions on the calculator in order to have a graphical representation of the problem. Further, during our biology lab periods, the teacher would have the students use particular simulations such as using computer software for breeding fruit flies in order to deepen our understanding of associated biological processes and concepts. I do not want to neglect the importance of how technology, such as computers for presentations and reports, helped me throughout all of my courses in my CEGEP career. However, I gained more insight into the benefits of learning with technology through my sciences and mathematics courses.

By virtue of my health sciences stream, I chose to specialize in Biochemistry for my undergraduate studies. In university, technology played a significant role in my life as a student, whether it served as a communications tool between the professors and myself via student portals like Moodle, or when using highly sophisticated equipment and software in the biology and/or chemistry laboratories. I was overwhelmed by the innovative and highly precise technologies that I encountered on a daily basis, which I believe helped me in furthering my understanding of concepts related to mathematics and science. The ‘hands on’ experience during the laboratory experiments allowed me to acquire a set of technical skills, along with a greater appreciation of the wealth of applications made possible through different technology. During my final year of undergraduate studies, the fact that I felt technologically fluent provided me with a high level of confidence, which aided me in maintaining a work-life balance, as I was able to efficiently manage my academic courses and research, extra-curricular and teaching
commitments, as well as a part-time government job. Although my university experience was exemplary in terms of my professors’ efforts to make technology meaningful for student learning, I still believed that there were gaps between many teachers’ beliefs regarding technology and their actual practices. As a teaching assistant for a university-level Chemistry course, I was able to further consider this gap. I used these teaching opportunities to infuse my classrooms with technologies such as PowerPoint, clickers, social media, graphing programs, application software, and real-time simulation software, to help my students enhance their understanding of a concept and increase their appreciation for the usefulness of technology for learning.

In my view, some of my teachers, through technology integration, helped to enrich my understanding of various phenomena in the world. I am interested in understanding more about teachers’ experiences associated with using technology in their teaching practices. My research question is therefore influenced by my past life and academic experiences. I believe that this qualitative research study will provide insight into the experience of teachers with technology integration.

**The Purpose of this study**

Rather than looking at the correlations between integrating ICT and students’ academic achievements, this study aims to explore how middle and secondary school science teachers integrate ICT to supplement their teaching practice(s) in order to enhance student learning. Thus, the purpose of this study is to explore the commonalities or variations in teachers’ experiences teaching the Ontario middle and secondary school science curriculum.
Research Questions

The main research question guiding this study is: (1) what are middle and secondary school science teachers’ experiences in trying to integrate technology into their teaching practices? For the purpose of this study, technology integration will be defined as “the use of computing devices, such as desktop computers, laptops, handheld computers, software, or Internet in K-12 schools for instructional purposes” (Hew & Brush, 2007, p. 225). As different factors are responsible for teachers’ level of technology integration, one sub-question will be: what particular elements of prior experiences help to prepare teachers to integrate technology? Specifically, it will be helpful to consider which participant integrated technology more, and how a teacher’s extent of technological integration is related to her/his past experiences with technology.

A second sub-question addresses the teaching of science specifically: what specific experiences are associated with integrating technology into the science classroom? This question will aim to explore the different strategies employed by the participants to integrate technology into their science classrooms. By comparing the findings from this study to those of studies investigating technology integration, experiences specific to the sciences can be explored.

Overview

The introduction and purpose of this study, the research questions, as well as my personal experiences and background that brought me to this study have been presented in Chapter 1. Chapter 2 contains a brief review of the literature on teachers’ integration of technology. Chapter 3 describes data collection and analysis methods, including
information about the study participants and data collection instruments. Chapter 4 will highlight the key themes based on the findings from the collected data. Chapter 5 will provide an in-depth analysis of the findings, implications for the education community, limitations of this study, as well as suggestions for future research.
Chapter 2: LITERATURE REVIEW

Today’s young generations face an “unprecedented pace of social, economic and technological change” (Action Canada, 2013, p. 2). In response to this rapid change in the social, economic and technological environment, Canadian education authorities have recognized the importance of integrating ICT into teaching and learning (Plante & Beattie, 2004). A recent survey by the Canadian Education Association (Dunleavy & Willms, 2011) found that students’ intellectual engagement in Canada is relatively high up until Grade 7, with 82 and 76 percent of students intellectually engaged in Grades 5 and 6, respectively (Dunleavy & Willms, 2011). However, starting with Grade 7 these levels drop dramatically, and by Grade 9, less than 50 percent of students are intellectually engaged (Dunleavy & Willms, 2011). It is important to note that students’ efforts to do well remain high; what falls is their level of interest and motivation (Dunleavy & Willms, 2011). As suggested by the organization C21 Canada, these observed drops in Canadian students’ intellectual engagement may denote the public education system’s struggle to engage “today’s digital generation” (C21 Canada, 2012, p. 4).

A conversation has started in Canada surrounding a new vision of learning, referred to as 21st century learning (Action Canada, 2013). A move towards 21st century learning represents a shift in education strategies, from a focus on the instruction of facts, to a model where additional competencies such as critical-thinking, character and creativity are emphasized (Action Canada, 2013). In their report Shifting Minds, C21 Canada (2012) proposes a new learning framework for Canada’s public education system. This report includes a description of seven important 21st Century Competencies: (1) creativity, innovation and entrepreneurship, (2) critical thinking, (3) collaboration, (4)
communication, (5) character, (6) culture and ethical citizenship and (7) computer and digital technologies. This last competency targets the capacity to use computers and digital resources to access information and create knowledge, solutions, products and services, as well as the capacity to use social media for learning (C21 Canada, 2012). The character competency is described as becoming a life-long learner, a leader, responsible, accountable, self-directed, adaptable, and resilient (C21 Canada, 2012). In addition to including computer and digital technologies as a competency of its own, technology is integrated into the targeted outcomes of other competencies, namely communication, collaboration and critical thinking (C21 Canada, 2012). This view on learning thus emphasizes an interdisciplinary approach, where technology is integrated across domains (Action Canada, 2013).

Information at the national level on the degree to which technology is integrated into Canadian classrooms is limited. The Information and Communications Technologies in Schools Survey (ICTSS), which surveyed 15,500 Canadian elementary and secondary schools provided insight on the availability of technology in classrooms in 2003-2004. Results from this survey showed that over 99% of the schools had computers during the 2003-2004 school year (Plante & Beattie, 2004). Further, the national student-to-computer ratio was slightly above 5 students for every computer (Plante & Beattie, 2004). About 45% of the computers in elementary and secondary schools in Canada were located in computer labs, 41% were placed in the classroom, and the remaining were located in libraries or other locations (Plante & Beattie, 2004). The survey also showed that word processing software was the application most often incorporated into teaching practices, with 78% of principals reporting that it was used either most of the time or
always. Internet/Intranet was the second most used technology (34%), followed by software for special needs students and/or remedial programs providing individualized learning (29%) (Plante & Beattie, 2004). With regards to connectivity, less than 1% of principals reported not having Internet connections (Plante & Beattie, 2004).

Despite the seeming accessibility of technology in schools, a plethora of barriers to integrating technology in classrooms have been identified (Hew & Brush, 2007; Ertmer, 1999, 2005; Ertmer, Ottenbreit-Leftwich, Sadik & Sendurur, 2012; Liu, 2011). In order to better understand the factors that influence the integration of technology into Canadian classrooms, the present study aims to explore middle and secondary school science teachers’ experiences in trying to integrate information and communication technology (ICT) in their teaching practices. There is a vast body of literature on technology, and teaching and learning, with research focusing on various aspects and levels of technology integration in classrooms. This literature review aims to provide a brief overview of the literature relating specifically to the impact of technology integration on learning and the different factors that aid or impede this integration. Before describing this literature, it will be important to first discuss what is meant by technology integration.

**A Definition of Technology Integration**

The National Council for Education Statistics (NCES), in agreement with the International Society for Technology in Education (ISTE), two leading bodies responsible for establishing standards for students, teachers, and administrators in K-12 classrooms, offers the following definition of technology integration:
Technology integration is the incorporation of technology resources and technology-based practices into the daily routines, work, and management of schools. Technology resources are computers and specialized software, network-based communication systems, and other equipment and infrastructure. Practices include collaborative work and communication, Internet-based research, remote access to instrumentation, network-based transmission and retrieval of data, and other methods. This definition is not in itself sufficient to describe successful integration: it is important that integration be routine, seamless, and both efficient and effective in supporting school goals and purposes. (U.S. Department of Education, 2002, p. 75)

As discussed by Milton (2003), “ICT in schools and classrooms is a complex proposition” and involves the design of new learning environments (Milton, 2003, p. 3). Viewed from this lens, successful integration of technology in schools and classrooms would include, amongst others, the following elements: a culture of innovation, clearly defined educational goals that include deeper understanding and problem solving, teachers and students using technology as a tool for their own learning, teachers selecting pedagogical strategies appropriate to both learning goals and individual needs of students, learners engaging in authentic investigations using a variety of resources, teachers and students working in collaboration creating professional as well as learner communities, learners becoming more skillful in choosing their own goals, computer and network standards sufficient for the pursuit of educational goals, and teachers having appropriate access to expertise in curriculum and pedagogy (Milton, 2003). Following this view, full integration of technology in the classroom is evidenced through many different facets of
teaching systems—through the learning environment, professional networks, student directed learning and access to technology.

As the present research seeks to address more narrowly the issue of teachers’ experiences using technology in their daily instruction, I will refer to technology integration as “the use of computing devices such as desktop computers, laptops, handheld computers, software, or Internet in K-12 schools for instructional purposes” (Hew & Brush, 2007, p. 225). This definition allows for the exploration of teachers’ experiences using different technologies in their teaching practices. This of course does not exclude the possibility of exploring various aspects of technology integration that are more broadly defined aspects of technology integration such as professional learning environments and access to technology in schools. Two different aspects of technology use in the classroom are explored in the following sections: (1) the impact of technology integration on teaching and learning, and (2) the different factors that affect teachers’ integration of technology into the classroom. For the purposes of this research study, ICT and technology will be used synonymously.

The Impact of Technology Integration on Learning

One important area of research with regards to technology integration is whether it enhances academic achievement (Hutinger, 1996; Wenglinski, 1998; Sandholtz, Ringstaff, & Dwyer, 1997; Keengwe et al., 2012). An early study conducted by Apple Computers called Apple Classrooms of Tomorrow (ACOT) aimed to explore the impact of computer saturation on teaching and learning in K-12 classrooms (Sandholtz, et al., 1997). This collaboration project involved several school districts and was conducted
over a ten-year period. The researchers were interested in examining the impact of “universal access” to computers on learning and teaching (Sandholtz et al., 1997). All students in the project were provided with computers both at home and at school (Sandholtz et al., 1997). The integration of technology radically transformed the physical environment, making it technology-rich, but the impact on student learning was only observed after two years. The researchers noted a positive enduring impact on student engagement, motivation, higher-order thinking, and in successfully completing complex tasks that emphasized interdisciplinary and project-based instruction (Sandholtz et al., 1997).

Similar to the ACOT project, the Tomorrow-98 program aimed to observe and understand the short-term implications of increased computer technology. Over a five-year period (1994-98), 35,000 computers were installed in 905 schools, and computer-aided instruction (CAI) training was provided to primary school mathematics teachers (Angrist & Lavy, 2002). Some examples of CAI applications include: computer visualization of complex objects, guided drill and practice exercises, and computer-facilitated communications between teachers and students (Arnold, 2008). Overall, this study failed to demonstrate technology having a positive impact on student achievement (Angrist & Lavy, 2002). Tamim (2009) conducted an extensive meta-analysis of 1253 different primary-studies related to technology integration and student achievement. Tamim (2009) attempted to answer whether technology enhanced the “student achievement in formal face-to-face settings as compared to traditional (no/low technology) settings” (p. 5). He found that, relative to the average student in a traditional setting where technology is not used to enhance the learning process, the average student
would perform at a higher level (Tamim, 2009). Most importantly, Tamim (2009) highlights that the positive impact of technology is observed when it is used to supplement face-to-face instruction, rather than when it is used merely as a substitute (Tamim, 2009). A significant amount of educational technology research has been centered on comparing student achievement in technology-rich environments to student achievement with traditional instruction (Tamim, 2009). However, as was suggested by Berger, Lu, Beltzer, and Voss (1994), the more appropriate question should be to ask what are the most effective means by which educators can positively affect student learning through the use of technology. For example, technology integration has been found to improve students’ self-concept and motivation (Bialo & Sivin-Kachala, 2000). Additional benefits to using technology have also been noted such as the fact that technology provides opportunities for teaching and learning that may otherwise be difficult or nearly impossible to attain (Hew & Brush, 2007). One example of this is using computer-mediated communication tools to help students from various geographical locations easily connect and speak to one another and to experts, which enhances the learning process (Hew & Brush, 2007). Technology can also help students build their “conceptual understanding through the process of interactivity, simulation, and visualization” (Subramaniam, 2007, p. 1065). Finally, meaningful technology integration can enhance learning by supporting a student-centered and student-directed curriculum (Ertmer et al., 2012).

It is also important to note the importance of technology integration in the context of special education. For example, Schneps, Thomson, Chen, Sonnert, and Pomplun (2013) proposed a reading method called Span Limited Tactile Reinforcement (SLTR),
which allows for text to be displayed on a handheld device in a continuous fashion using large fonts and only a few words per line. The target group for this study was high school students living with dyslexia. The findings from Schneps et al. (2013) suggested that this device-facilitated reading method improved both speed and comprehension in students with dyslexia. A key point highlighted by this research is that the integration of technology such as handheld devices, allows teachers to supplement their lesson delivery by improving comprehension. In this sense, technology is not a substitute for teaching practice, but rather, it helps teachers better accommodate student needs. Another example is found in the use of technology with autistic students. Price (2011) investigated the use of iPads and comprehension levels with students living with autism from grades 6-12 and ages 18-22, who were enrolled in state mandated special education classes. The research found that all 30 children improved in their information acquisition area of disability when using the iPads and interactive e-books (Price, 2011). Teachers from this group of students reported that the students “found the iPads motivating and that use of the iPad reduced off-task behaviour” (Price, 2011, p. 32). The author stated that although “no two individuals affected are the same”, not a single student reported a decrease in her/his information acquisition (Price, 2011, p. 34).

**Factors that Affect Technology Integration**

Ertmer (1999) provides a way of conceptualizing the different factors that influence technology integration, distinguishing between first-order (external) barriers and second-order (internal) barriers. First-order barriers refer to obstacles extrinsic to teachers, for example equipment, time, training, and support (Ertmer, 1999). Second-order barriers include those that interfere with or impede mental change, including teachers’
confidence, beliefs about how students learn and the perceived value of technology to the teaching and learning process (Ertmer, 1999; Ertmer et al., 2012). Studies looking at the progression of teachers’ integration and use of technology from 1991 to 2004 revealed that while in 1991 few teachers were able to successfully integrate technology due to fundamental issues such as lack of accessibility and technical support, the “majority of teachers in 2004 appeared to have achieved basic levels of computer integration into their daily professional activities” (Shi & Bichelmeyer, 2007, p. 188). This can partially be explained by the increase in access to resources in the early 2000s, reducing first-order barriers (Ertmer et al., 2012). Despite this apparent progress however, the literature still points to certain factors, such as resources and institutional structure, as problematic for technology integration. The following provides an overview of first-and second-order barriers, followed by a consideration of their relative importance.

**First-Order Barriers**

Many factors have been documented to influence teachers’ integration of technology into the classroom. In an analysis of 48 empirical studies conducted from 1995 to 2006, Hew and Brush (2007) documented technology integration barriers and divided them into six different categories namely (1) resources, (2) institution, (3) subject culture, (4) assessment (5) teachers attitudes and beliefs, and (6) knowledge and skills. Amongst these six categories, the first four fall under first-order barriers (Ertmer et al., 2012). Lack of technology (insufficient computers, peripherals and software), difficult access to available technology, lack of time and technical support are all factors that present barriers to technology integration (Hew & Brush, 2007). Importantly, the lack of access to technology does not merely refer to technology availability of technology, but also to
the number of technologies, the types of technologies and the location of technologies (Zhao, Pugh, Sheldon & Byers, 2002; Hew & Brush, 2007). For example, when computers are located in classrooms and are Internet-connected, teachers are more successful in carrying-out innovative and technology-rich projects (Zhao et al., 2002). In addition, lack of on-site support for teachers using technology, lack of help supervising children when using computers, lack of ICT specialist teachers, and lack of financial support have also been documented as problematic to technology integration (Mumtaz, 2000). Time is also an important constraint to technology integration (Mumtaz, 2000). Lack of time can be understood in the context of the large amount of preparation needed for using unfamiliar technologies (Zhao et al., 2002). In a related vein, the pressure of testing can be a major barrier to technology integration, as teachers can feel that they have limited time to try new instructional methods involving technology (Fox & Henri, 2005; Hew & Brush, 2007).

Lack of school leadership, inflexible school time-tableing structure and the lack of school planning with regard to technology use are all institutional factors that can impede teachers’ integration of technology (Hew & Brush, 2007; Fox & Henri, 2005; Becker, 2000; Lawson & Comber, 1999). Finally, subject culture, which refers to the institutionalized practices and expectations that exist surrounding a school subject can become a barrier for technology integration when teachers are hesitant to adopt a technology that is not perceived as compatible with the norms and practices of their subject (Goodson & Mangan, 1995; Henessy, Ruthven & Brindley, 2005; Hew & Brush, 2007). For example Henessy et al., (2005) found that many English teachers perceived ICT to be incongruent with their subject culture.
Second-Order Barriers

One of the most common reasons teachers give for not using technology is a lack of knowledge and skills (Hew & Brush, 2007). Becker (2000) surveyed over 4,100 teachers in order to understand the relationship between teachers’ educational philosophies and characteristic teaching practices, how they used computers in their teaching, and different aspects of their teaching environments. Results showed that teachers’ technical expertise influenced the level of integration of technology into their teaching practices (Becker, 2000). Similarly, in a study investigating the use of ICT by academic and non-academic staff, O’Mahony (2003) found that the provision of relevant and supportive training for staff was a major obstacle. It is also important that teachers possess technology-supported-pedagogy knowledge (Hew & Brush, 2007). This is knowledge about the different ways that technology can be used for teaching, which can be divided into three categories: (a) replacement, (b) amplification, or (c) transformation (Hughes, 2005). As described by Hughes (2005), technology as replacement means that technology is not changing instructional practices, but merely replacing other forms of instruction. In technology as amplification, technology is used merely to make instruction more efficient and effective (Hughes, 2005). Finally, when technology is used as transformative, it can change how learning occurs, including cognitive processes and problem solving (Hughes, 2005; Pea, 1985). Hughes (2005) found that when teachers’ learning experiences and knowledge was focused uniquely on technology with no connections to education or their content areas, they used less innovative technology-supported pedagogy.

Teacher attitudes and beliefs surrounding technology can present another major obstacle to technology integration (Hew & Brush, 2007). An attitude is “a readiness to
become motivated with respect to an object”, for example how much a teacher likes or dislikes technology (Sartain, North, Strange, Chapman & Martin, 1958, p. 1). A belief is “an acceptance or rejection of a proposition about reality” and in the context of technology integration, it can be understood as educational beliefs about teaching and learning as well as beliefs about technology (Sartain et al., 1958, p. 1). Beliefs generally are found to determine attitudes (Onur Bodur, Brinberg, & Coupey, 2000; Hew & Brush, 2007). It has been argued that ultimately, the decision about whether and how to use technology is dependent on teachers’ beliefs surrounding technology (Ertmer, 2005). Similarly, Becker (2000) found that teachers’ pedagogical philosophies could influence a teacher’s level of technology integration into their teaching practice. Further support for the association between what a teacher believes and her/his technology use is provided by Inan and Lowther’s (2010) research-based path model for causal relationships between factors affecting individual characteristics of teachers and perceptions of environmental factors that influence their technology integration in the classroom. Furthermore, teachers with constructivist beliefs tend to use technology to support student-centered curricula, while those with traditional beliefs use computers to support more teacher-directed curricula (Tondeur, Hermans, Braak, & Valcke, 2008).

_Weighing the Relative Influence of First- and Second-Order Barriers_

As found by Hew and Brush (2007), the three most frequently cited barriers that impact technology integration are resources, followed by teachers’ knowledge and skills and teachers’ attitudes and beliefs (Hew & Brush, 2007). Considering the evidence reviewed above, it is apparent that resources remain an important challenge, despite the increased availability of technology in schools. Ertmer et al., (2012) conducted multiple case
studies to assess whether external constraints exert the same influence over teachers’ technology practices as was the case 10 years ago, as well as to determine the extent to which first-order barriers constrain teachers’ efforts to integrate technology, leading to possible misalignments between beliefs and practices. The authors found that teacher beliefs surrounding technology differed, however, on average, each teacher’s belief was linked to their practice (Ertmer et al., 2012). For example, those teachers who believed that technology was useful to deliver content or reinforce skills, used technology in their practice to keep students busy interacting with the content through the use of math stations (Ertmer et al., 2012). Importantly, this link between teachers’ beliefs and teaching practices was observed despite technological, administrative or assessment barriers (Ertmer et al., 2012). Thus, while technological, administrative or assessment barriers remain important, teachers’ beliefs surrounding technology are highly associated with teaching practices. This is consistent with Pelgrum’s (2001) findings from a multi-country study showing that both material and non-material conditions figure among the top 10 obstacles to ICT integration in education. As summarized by Bingimlas (2009), there are many important components to successful technology integration, including ICT resources, effective professional development, sufficient time, confidence, competence, and accessibility. While no one factor is sufficient to provide good teaching, “the presence of all components increases the possibility of excellent integration of ICT in learning and teaching opportunities” (Bingimlas, 2009, p. 1).

This research study aims to answer the following research question: *What are middle and secondary school science teachers’ experiences in trying to integrate technology into their teaching practices?* In the following two chapters, the research
findings are presented based on my interpretation of the each participant’s point of view followed by an examination of these findings along with connections to literature and implications for the teaching profession.
Chapter 3: METHODOLOGY

The interpretive paradigm was chose to investigate middle and secondary school science teachers’ experiences in integrating technology into their teaching practices. This theoretical paradigm seeks to understand how people interpret and create meaning of their world (Willis, Jost, & Nilakanta, 2007). This paradigm was chosen, as it is well suited for understanding how teachers perceive technology, and what their experiences are using technology in their classrooms. As each teacher’s experience is unique and subjectively understood, I chose to follow the phenomenological methodology, according to which the truth of an event can only be discovered through embodied perception (Starks & Trinidad, 2007). My study was thus concerned with understanding the lived experience of participants, and highlighting the commonalities and differences of their accounts. Through the interviews conducted, it was possible to better understand what kinds of experiences shape and influence these two teachers’ technology integration practices in their teaching. By providing opportunities for participants to answer reflectively and retrospectively, the interviews sought to explore the following themes: the usefulness of technology; barriers and facilitators to integrating technology into the classroom; and familiarity and comfort with using technology while teaching science.

Participants

Two participants with different experience in technology integration were chosen. Both purposive and convenience sampling was used to recruit participants. As the sample size consisted of only two participants, purposive sampling was important in order to recruit participants who were likely to provide useful data for the research question.
(Green & Thorogood, 2009). In addition, in order to reflect the experiences of teachers in different teaching divisions, (i.e., junior/intermediate and intermediate/senior), one middle school and one high school teacher were selected. Both participants were recruited on the basis of professional relationships that I had formed during my pre-service training experiences. Convenience sampling was therefore used to complement the purposive sampling (Green & Thorogood, 2009). Based on my observations during this pre-service training, I believe that both research participants integrated technology into their teaching practices.

In order to protect anonymity, each participant has been assigned a pseudonym. The first research participant, John Stanford, is currently teaching intermediate and senior science courses. He is in his 27th year of teaching in an urban secondary school in Toronto. John holds a Bachelor of Science from Ryerson University and completed his teaching degree at the University of Toronto with Environmental Science and Sciences (general) as his two teachable subjects. He teaches mainly secondary science courses, both in the academic and applied streams. John holds an additional qualification in special education (Part 1) and his honours specialist in chemistry. The second participant, Russell Brown, teaches mathematics, language and rotary science to primary/junior and junior/intermediate students. Russell has a Bachelor’s degree in Anthropology and a teaching degree from Lakehead University. His qualifications are for Junior/Intermediate divisions. Russell has been teaching for 14 years at an urban middle school in Toronto. Both participants have a significant amount of teaching experience. They offered insight, largely based on their educational backgrounds and experience in the teaching profession.
Data Collection

Data was collected through semi-structured interviews that were approximately an hour in duration and were conducted by the researcher. Interviews as a data collection method are appropriate for the interpretive paradigm as they allow participants to describe their perceptions and experiences with integrating technology into their classrooms (Willis, Jost, & Nilakanta, 2007). Through my own interpretation of each participant’s point of view regarding their experiences in integrating technology, it is possible to provide insight into how participants create meaning of the world around them (Willis, Jost, & Nilakanta, 2007). An interview guide was first developed with a graduate student at the University of Toronto. The process of formulating questions was informed by the literature review conducted at the outset of the research process. The interview guide was piloted and adapted based on the interviewee’s response. The final interview guide can be found in Appendix B. The interviews were held at each participant’s respective school classroom at a time most convenient for them. The participants in this study did not receive any financial compensation. The interviews were digitally recorded using the Apple software application “Supernote”. I subsequently transcribed each of the interviews by listening to the recording and manually typing the text of each conversation strictly verbatim into a Word document (Creswell, 2013).

Data Analysis

Data collected through the semi-structured interviews were analyzed using the thematic content analysis method (Braun & Clarke, 2006). This method aims to identify common or recurrent themes in the data and to describe the important elements of
participants’ accounts (Braun & Clarke, 2006). This approach to data analysis was chosen, as it is consistent with a phenomenological methodology focused on reporting the experiences and realities of participants. In addition, to support “what the participants in the study experienced” with the phenomenon (i.e., technology), textural descriptions of the experience are provided and supported through verbatim examples (Creswell, 2013, p. 159). Further, structural descriptions are provided in order to explain how the experience happened, in which I reflect on the “setting and context in which the phenomenon was experienced” (Creswell, 2013, p. 159). The data analysis method used includes six steps, as outlined by Braun and Clarke (2006): I first familiarized myself with the data by reading the interview scripts over several times. Based on this initial review, I generated a list of codes that were data-driven and consistent with the interpretive approach. I then considered how commonly considered codes combined to form over-arching themes. I reviewed these themes to ensure that they accurately reflected the data set. Finally, I defined and named the themes, and reflected on how best to report them (Braun and Clark, 2006).

**Ethical Review Procedures**

Informed consent was obtained from all research participants. The consent letter used can be found in Appendix A. A copy of the consent form signed by each participant was kept with the researcher. Participants were informed that there was no known risk(s) associated with participation in this study, and were informed that they could withdraw from the study at any time. Participants were also informed that their anonymity would be ensured and that no identifiable references would be made in the final paper. Lastly, the University of Toronto had provided the research study with an ethical waiver that
allowed for the collection of data through semi-structured interviews without requiring an ethical review procedure.
Chapter 4: FINDINGS

Introduction

The findings from the study interviews underscore the challenges faced by participants in learning and integrating technology into the classroom. I begin by sharing participants’ perceptions of the usefulness of technology in their teaching practices. I then recount the barriers and facilitators to integrating technology into the classroom. I conclude with an emphasis on how participants begin to feel more comfortable using technology in their day-to-day practices. I use verbatim quotations in order to support each theme.

Usefulness of technology

In order to better understand teachers’ experiences integrating technology into the classroom, it is important to first understand why they choose to use technology and how they perceive it to be useful. Both participants expressed the view that technology was an important tool for enhancing lesson delivery and student learning, but emphasized that technology remains an assistive tool and is not a substitute for the instructor.

Technology as Assistive

One way in which participants perceived technology to be an assistive tool for lesson delivery was through the possibility of multiple modes of representation that it offers. Russell explicitly expressed the view that technology offered many different ways of teaching a concept, and that he considered this when planning his lesson. For example, he talks about deciding whether or not to use technology to teach the concept of density:
I look at a concept or topic that needs to be covered and sort of think about what is required…how is the best way to deliver this piece of information? Well, let’s say we’re doing science, if we’re doing density. I can draw diagrams on the board, I can talk about it, I can have them read, or I can have them do research, which is sometimes better. Last year, when you were in my class, we found those simulations and I look at that and say “will using technology, whether it’s a data projector or any kind of technology, benefit my lesson and give me another option to present the concept to the students?” (R. Brown, interview 2, January 10th, 2014)

For Russell, technology is a way to constantly change the ways in which material is presented, and he perceived this as having a positive impact on student understanding. For example, Russell explains:

With science, it’s actually quite easy because I can go find visuals on stuff like laminar flow versus turbulent flow. It’s easier for me to integrate technology that way and say “ok let’s go to YouTube or look at simulations from the University of Colorado”. It is beneficial for a lot of the kids because you can explain concepts to them in four or five different ways or you can show them once and see them have their “aha moment”. (R. Brown, interview 2, January 10th, 2014)

For Russell therefore, when technology is used to present concepts and ideas to students in engaging ways, the use of technology becomes more meaningful for both the teacher and the learner. Whereas Russell emphasizes the use of technology to deliver content in many different ways, which is perceived by him as enhancing student understanding,
John’s experiences highlight how technology offers the possibility of demonstrating scientific concepts in a more interactive and visual manner. For example, he describes his experience using computer software technology in teaching genetics:

If we’re talking about fruit fly breeding, you’re talking a couple of months because they mature at their own rate, whereas in a computer they mature instantly, so it’s a good time saver, and also a lot of the graphics are simplified so that you see what you need to see, which is clear, so there’s no blending in with the surroundings which can happen if you have the real thing, like if you’re watching a video of the real thing in progress…The message may get lost in the surroundings, whereas when you have an animated simulation, everything stands out. (J. Stanford, interview 1, September 27th, 2013)

For John therefore, technology offers the opportunity of simulating scientific experiments that cannot be easily undertaken in the classroom. John also stresses the importance of presenting complex concepts in a timely and accessible manner:

Even if its time-lapse photography, you can do that with a video, there’s lots of good time-lapse videos with that done. You can find it on the net if you don’t have access to, if students don’t have access to the video, they can go on the net and see some time-lapse photography of that happening, that’s a good thing! And, also they can do a lot of simulations in a decent amount of time for things that would normally take a considerable amount of time. (J. Stanford, interview 1, September 27th, 2013)
Although both participants viewed technology as an assistive tool in their teaching practices, it is important to highlight that neither viewed technology as integral to their lesson. As indicated above by John through his genetics lesson example, he cites that he saves time and the graphics are clearer, but does not say that the lesson would have been impossible without technology. Furthermore, Russell highlights that even though he was able to teach concepts such as density using the blackboard and diagrams, he felt that technology allowed him to present the information in a more engaging way that would help the students more easily understand the concepts.

*Technology does not replace the Instructor*

While both participants explained how they regarded technology as useful for content delivery and student learning, they both specified that technology is a tool, and does not replace the instructor. When asked about his beliefs surrounding technology and student learning, Russell explains:

> Technology is meant to assist! It’s not meant to be the instruction. I know technologies have become such a major part of everyone’s lives. Everyone has their phones; everyone has their iPods, and tablets. I have my laptop, but that isn’t all, and that’s not how we’re learning, it’s helping us learn! (R. Brown, interview 2, January 10th, 2014)

John echoes this perspective that technology should not be viewed as the primary means of delivering content:
It’s just another tool and it’s not a replacement or anything. It’s just another tool for the kids to use to learn and as well as for the teachers…(pause) to teach. I think especially with the computers, they can see things. It’s one thing to talk about say (pause) mitosis, and another thing to actually see it happening. (J. Stanford, interview 1, September 27th, 2013)

Thus both participants shared an understanding of technology as an assistive tool for teaching and learning. Furthermore, John expressed the concern that he might be becoming too reliant on technology:

Sometimes, I wonder, am I too reliant to using PowerPoint, it’s great, but there are some lessons where it’s actually more useful if I do it on the chalkboard…because you have absolute control with the chalkboard, whereas for PowerPoint, you have a lot of control, but as far as what you’re going put into the with the chalkboard, you’re not. You’re only limited by the amount of space you have and of course you can always erase old stuff. And, also the good thing with the chalkboard is that this stuff is up there the whole time and through the whole process starting from your known information to arriving at your final answer, it’s all there! So, this way the kids can digest it as you go along, that’s why for some things I think the chalkboard is better, but I’d be the first to admit that I use PowerPoint a lot! (J. Stanford, interview 1, September 27th, 2013)

Russell emphasizes that technology should not be the primary delivery method as he perceives that this would eliminate the need for a teacher. In Russell’s view therefore technology and the instructor cannot both have a primary role in teaching. In his view,
TEACHERS’ EXPERIENCES WITH ICT INTEGRATION

Technology remains a tool that should augment what the teacher delivers, not replace him. Both participants therefore seemed to share a concern that technology could, in one way or another, become too present in the classroom. This notion of technology being too present in the classroom was expressed by the participants through the ideas of teachers becoming too reliant on technology, and technology becoming the single mode of lesson delivery.

To conclude, both teachers recognized that technology as an assistive tool in teaching could enhance the instruction and learning process, while making both teaching and learning more time efficient. Both however implied that there are limits to the usefulness of technology. These limits are (1) the extent to which teachers are reliant on technology and (2) the centrality that technology should play in instruction; technology should not be viewed as a primary source of instruction.

**Barriers and facilitators**

The participants referred to certain factors that either facilitated or impeded their integration of technology into the classroom. The key factors associated with difficulty integrating technology were: unreliability, dated pre-service training, and inadequate professional development. The key perceived facilitator was support received from other teachers.

**Unreliability of Technology**

John expressed a great deal of frustration related primarily to hardware and software compatibility issues and receiving technical support. Although this participant had used more complex technology, such as chemical probes, the difficulties he had experienced
led him to shy away from less user-friendly technologies such as probes and interactive whiteboards. For example, when asked about the different kinds of technologies that John had used in his teaching practices, he replied:

Ah, I have used probes. I just find that a lot of the times the programming just has a mind of its own…Not very cooperative, I tend to stay away from them as much as I can. The chemistry department uses them a lot. They do have a lot of activities where that would be useful. In my experience, when we were dealing with stuff like pressure readings and that, the programming was very uncooperative. (J. Stanford, interview 1, September 27th, 2013)

John’s definition of higher technology refers to any technology that may require a greater amount of technical attention, precision or calibration. John’s reluctance to use such higher technology seemed to stem from his experiences with having such technology fail while teaching. For example, John reiterated:

Higher technology tends to break down more easily and if it does breakdown, it’s beyond me to fix it…And this is the thing, the slide projector; I don’t think we have anymore, but the overhead projector, very simple technology. If it breaks down, it’s usually because you need to replace the light bulb, it’s not a problem, and you just have to have a replacement bulb handy. Ah if the computer breaks down, its probably a big problem and you’re probably going have to have an expert intervene on your behalf…So you’re just going to have to resort to plan B until you get that expert to help you. So, to me it’s great and technology just
enables us to do so much more, but it’s more of a double-edged sword! (J. Stanford, interview 1, September 27th, 2013)

Russell did not appear to be concerned with hardware/software communication, but did emphasize the need for improved Internet connectivity offered by the Toronto District School Board. He described how his teaching was interrupted due to connectivity issues:

This year the TDSB has had issues with wireless service. I’m in the middle of doing my PowerPoint project and my Internet goes down for three days! Ah, annoyed, aggravating and the kids are quaking at me “well the internet isn’t working” there’s nothing I can do about it so that’s why I say, “that technology is meant to assist, it’s not meant to be the instruction”. (R. Brown, interview 2, January 10th, 2014)

Lack of Administrative and Technical Support, and Resource Constraints

When he experienced technology difficulties, John did not feel that there was adequate administrative and technical support within the school system. John described the protocol that is to be followed when confronted with a technical issue. Based on the description of this experience below, John perceived the procedure of seeking help from administrative school staff as an unnecessary burden that left him feeling frustrated at the way technological disruptions were dealt with:

We do have a help desk in the TDSB… I find that a lot of times I’m hearing about stuff and then they say, “oh it’s just on the web”. We have the TDSB website, and they [administrative staff] say “oh it’s on the website”. Well, you’re going to have to do better than that! So, I find that the administration from the principal to
Russell associated unreliability with a lack of access to Internet-connected computers rather than hardware/software concerns. He suggested that greater access to computers would allow him to teach his students useful computer skills such as a more in-depth understanding of Microsoft Office software, which would enable his students to have a more in-depth understanding of the different functions of such technologies:

For the most part, technology is pretty reliable, but we have our floating labs with 20 laptops on this floor for all the classrooms to use them. The entire grade 7s and 8s use the 20 computers and they take a beating, but if every class had their own set of computers, there would not be an issue. If I had more access to computers, more access to technology, I would show them how to do PowerPoint and show them what is proper and show them how to do Excel and how to create spreadsheets and how to do online resumes. (R. Brown, interview 2, January 10th, 2014)

It is worth noting that both participants referred to technology in the context of the definition provided for this study (i.e., using computing devices for instructional purposes). Therefore, both participants use technology such as computers, the Internet, and computer software programs interchangeably, when appropriate.

*Inadequate Pre-Service Training*

John perceived his pre-service training to be good, but as he received it in 1984-85, he did not think that it was relevant to today’s technology. He explained that “computers
were just starting to get into schools, back then it was the commodore 64s that were starting to get into schools” (J. Stanford, interview 1, September 27th, 2013). Similarly, Russell also expressed the feeling that he did not receive adequate preparation regarding the integration of technology in classroom teaching due to the fact that he received his training 14 years ago. In this sense, he did not view his training as inadequate for teaching 14 years ago, but in the context of technological advances made over the past decade, it is no longer relevant:

Teachers college, yeah didn’t prepare me at all. That was 1999 so there was very much “hey it’s the Internet kind of thing”. The Y2K was about to happen. Yeah, they talked about integrating technology minimally. We were still like chalk boards, pens and paper kind of thing. It’s hard to believe it was only 14 years ago. (R. Brown, interview 2, January 10th, 2014)

*Lack of Professional Development (PD)*

Both participants did not perceive their professional development experiences to have helped them integrate technology into the classroom. Whereas John’s professional development (PD) event was irrelevant in the context of today’s technology, Russell’s experiences left him frustrated, as he did not have access to new technologies covered during his trainings. John described how his first PD session that was technology-focused had provided him with “some rudimentary understanding of how you go about searching for your answers on the Internet” (R. Brown, interview 2, January 10th, 2014). Despite the various opportunities to attend PD courses offered by the Toronto District School Board, John expressed a desire for more learning opportunities led by teacher experts:
And, I think we need more in the way of workshops where we can have someone like a staff-member who knows what they are doing to take the time out or we get release time like maybe shorten the day by maybe 40 minutes or something like that so that we can have a session and at least get started. (J. Stanford, interview 1, September 27th, 2013)

Russell’s experiences with PD opportunities were also unhelpful. He believed that much of the PD that he received in the past did not prove to be of use, as the schools where he was teaching lacked the technology he was trained on:

Well any PD experience that I’ve had has been…spotty and it’s always been right near the front end of technology, like “we’re going to be using Smart Boards”. I went for Smart Board training when they first introduced them, they were like “you’ll be able to do all these things” and then no school I was at had a Smartboard. So, any PD that I’ve had has not been super useful. (R. Brown, interview 2, January 10th, 2014)

Although Russell expressed dissatisfaction with his PD opportunities, he did highlight the fact that he did not use technology in every lesson, while indicating that he had taken some knowledge from his PD experiences and adapted the technology to his own needs for teaching and learning:

So, I’ve had some PD and I’ve just really taken to using what they’re giving in these PDs and saying “this is the way you should use it” and just sort of modifying it, tailoring it to my own needs…while I don’t use it for every single class or every single day. I use it so that it has an impact because if you’re using it
all the time it becomes sort of commonplace. (R. Brown, interview 2, January 10th, 2014)

In conclusion, unreliability of hardware/software communication as well as Internet connectivity was perceived by participants to be a barrier to integrating technology into the classroom. Moreover, one participant expressed frustration with technical and administrative support for using technology, and the other with resource constraints regarding access to Internet connected computers. As summed up by John, “it boils down to two things: having the technology in your hands, and when you do, does it work, and when it works, does it work continuously or does it break down all the time?” (J. Stanford, interview 1, September 27th, 2013).

Teacher-to-Teacher Support

Teacher support was described as an important facilitating factor for both participants in their efforts to integrate technology into their teaching practices. John highlighted how one former departmental colleague provided him with initial support when he first began using Internet technology:

I had a friend get me started, I had just bought my first Internet capable computer and got everything hooked up. That was easy. And then he showed me how to get on the Internet and you know a few functions and after that it was just playing around and figuring it out. (J. Stanford, interview 1, September 27th, 2013)

John also mentioned that this former departmental colleague provided him with ongoing support through the form of informal meetings outside of school in order for him to understand the basics of how to use the Internet for information retrieval:
So, I’d arranged with him to come to my place after supper and he was guiding me with the basics. From there I was able to figure it out. You know, it’s always cracking that nut from the first place. (J. Stanford, interview 1, September 27th, 2013)

Russell also emphasized the importance of peer support within his school setting. He associated the small size of his school and the middle school setting with increased support amongst teachers and greater collaboration:

I don’t know whether it’s because of the smaller building or the smaller group of kids, but I think there’s more of a collegial feeling, I can go and lean on another teacher and say “hey I’m having trouble with this so can you help me out with this sort of thing?” (R. Brown, interview 2, January 10th, 2014)

Based on Russell’s experience, open communication and teachers’ willingness to help each other was seen as a key driver to facilitating successful integration of technology within his classroom. Both participants highlighted that they each had technology experts amongst their departmental staff. For John, learning from expert teachers was perceived as valuable, and he expressed the desire for more formal learning opportunities, for example short workshops. John described his positive experience getting started with Moodle through the assistance of an expert teacher:

As far as integrating the technology, well again it’s like afterschool workshops with expert teachers. For instance, one of our science teachers is a resident expert on the use of Moodle and he’s been conducting workshops for the last couple of weeks like one day a week. So he’d take a few of us and show us how to use the
Moodle, how to get set up. So that’s good, so in that sense, we’re integrating the Moodle into our classroom practice. Not so much to instruct the kids, but I use it as a message board for the kids. (J. Stanford, interview 1, September 27th, 2013)

Russell appeared to be less convinced about the usefulness of technological advice that he had received from other teachers at his school. As with the professional development sessions, he tailored the advice to fit the needs of his classroom:

We do have regular meetings with other staff. We share ideas in terms of instruction, not technologically per se, but we do have our tech person that would often say, “here you can do this, I found this, you can do these things”. Some of it I find incredibly useful, some of it I don’t. (R. Brown, interview 2, January 10th, 2014)

Both participants described how the collaboration that they had received was largely informal. Whereas Russell did not think the advice he received had always been helpful, John relied on other teachers’ technological expertise as an avenue to overcome the amount of information he must process to learn a particular technology:

And I’ll be learning or picking Jason’s brain to learn like another little bit at a time, maybe I’m getting old, but to have it all thrown at me at once is information overload and I’m not going to remember any of it. (J. Stanford, interview 1, September 27th, 2013)
Becoming comfortable and confident with integrating technology

In learning to use new technologies, Russell spoke about self-directed learning, whereas John preferred receiving more instruction. Moreover, both participants’ level of confidence with integrating technology in the classroom seemed to be related to their degree of familiarity with a technology in particular.

And then there is the unfamiliarity with it; some people just seem to be in the know. For instance, with the Moodle, I’ve heard about it and the good thing is that the fella who knows most about the Moodle in the schools happens to share the office with me. (J. Stanford, interview 1, September 27th, 2013)

When working with unfamiliar technology, John felt reassured by the fact that his office mate could help him when he needed help managing Moodle. By contrast, Russell preferred to familiarize himself with a new technology by practicing at home. For example, Russell described practicing using simulation software found through the University of Colorado’s website at home. For this participant “becoming fluent” in a technology was important and was perceived as necessary in order to properly integrate it into his instruction:

Much more, much more confident as with anytime you try anything new. There’s either immediate success or there’s catastrophe. I think now it’s become part of. You become more adept at planning the use of technology within your classroom the more experience you have, the more fluent you get. I feel now it is much more natural to be using those things. (R. Brown, interview 2, January 10th, 2014)
Both participants’ self-perceived capacity to use various technologies seemed to vary. John believed himself to be more of an ongoing learner who acknowledged his shortcomings when using technologies that were alien to him, whereas Russell perceived himself to be quite “tech savvy”, as indicated when he says:

For me, I consider myself pretty tech savvy, but if there are issues there are people on staff that I can go to, but I know other teachers who are nearly not tech savvy, and it tends to be a huge barrier because if something goes wrong with a piece of technology, they don’t know how to fix it. I’m pretty adept with doing that, so it’s not a huge concern for me. There’s support within the building and it’s fairly useful. (R. Brown, interview 2, January 10th, 2014)

In short, unfamiliarity with technology was a shared concern amongst both participants, and was a motivation for further learning in order to enhance instruction and student learning. Although participant’s self-perceived capacity with using technology varied, both acknowledged that support from other colleagues was a resource they could bank on. Furthermore, there was strong agreement between both participants’ views on technology as assistive to their teaching practices, but not integral to their lessons.
Chapter 5: DISCUSSION

Relation to the Literature

Technology integration is becoming an increasingly important area in the professional practice of educators, putting the onus on teachers to prepare today’s students with the core competencies that they will require as 21st century learners. Considering, the wide availability of technology across Canadian classrooms, educational research is still lacking in the understanding of how much teachers are integrating technology in their classrooms. This is partly due to the fact that technology integration is a relatively new phenomenon and a common understanding among the teaching community is still lacking. Teachers vary in their definition of technology integration depending on their pedagogical beliefs and the value they place in technology for teaching and learning. Teachers also face different barriers in integrating technology. These beliefs and barriers act to influence how teachers are able to integrate technology, which may have an impact on student learning. Before starting this research, I was aware of my own beliefs regarding the impact that technology could have on teaching and student learning, but was unclear as to what a technology integrationist might look like in a classroom setting. After having collected and analyzed the data from this research study, I have reified my understanding of the different components need in order to prepare teachers to be technology integrationists equipped with an understanding of how to apply their knowledge and skills in technology to support their teaching subjects.

The main purpose of this research project was to explore and understand the impact of middle and secondary school science teachers’ experiences in trying to
integrate technology into their science teaching practices. Following an analysis of the data collected, the results were organized according to three themes: the usefulness of technology in teaching and learning; the major barriers and facilitators faced by both participants in their efforts to integrate technology into their classroom practices; and how both participants’ confidence and comfort levels impacted their teaching practices in a science classroom.

A consideration of participants’ views on technology and its usefulness for teaching suggested that both participants perceived technology to be an assistive tool in teaching, but that it should not replace the instructor. This shared meaning of how technology was perceived to be an assistive tool in teaching was supported through the various examples each participant provided on how technology enhances the lesson and/or the student learning process. For example, on multiple occasions during the interview process, John mentioned how technology had allowed him to demonstrate more abstract concepts like fruit fly breeding on a much smaller timescale. Russell echoed a similar example of how technology had allowed him to enhance his lessons by providing him with opportunities to present various concepts, such as density, in varying and more interesting ways that allowed his students to better grasp the general concept. Both participants emphasized that although technology was perceived to be an assistive tool in their day-to-day teaching practices, technology itself was not seen as the primary mode of content delivery or knowledge construction in their classrooms. In this sense, neither of the participants viewed technology as integral to their teaching practices. Based on Hughes’s (2005) categories of uses of technology in teaching, both participants viewed technology as a replacement or as amplification, but less so as transformative. When
Russell and John spoke of using PowerPoint, for example, this was seen as an alternative to using the blackboard. In this sense, PowerPoint could replace the blackboard. Both participants also described using technology to render their teaching more efficient and effective, for example using software to “grow” fruit flies rather than actually breeding them in the laboratory. Neither, however, used technology in innovative ways that changed how learning occurs, including cognitive processes and problem solving. Hughes (2005) gives several examples through case studies of such possibilities for transformative uses of technology. For example, one participant described by Hughes (2005) used the software “HyperStudio” to allow students to gather, organize and present information in their English classes. As perceived by this participant, “this allowed students to understand the structure of English language and composition, like no other strategy he had used before” (Hughes, 2005, p. 292). Although John and Russell spoke of some instances where technology really provided a means of teaching a concept in a novel way, for example, using time-lapse photography to illustrate mitosis occurring on an accelerated time scale, examples of transformative uses of technology were limited. As discussed by Hew and Brush (2007), in order for transformative uses of technology to occur, it is important that teachers possess the appropriate level of technology-supported pedagogy knowledge.

As different factors are responsible for teachers’ level of technology integration, one sub-question of this research was what particular elements of prior experiences help to prepare teachers to integrate technology and what specific experiences are associated with integrating technology into the science classroom. Both John and Russell were asked to discuss what they perceived to be the most common barriers or facilitators in
their efforts to integrate technology into their teaching practices. Based on the findings, there were many more barriers relative to facilitators. The most important barriers were: the unreliability of technology, the lack of administrative and technical support, and resource constraints, inadequate pre-service training, and lack of professional development (PD) opportunities. In terms of facilitators, both participants perceived support from other teachers to be the most helpful in their technology integration practices.

The unreliability of technology was perceived to be the greatest barrier for both participants. Over the course of John’s experiences, he describes multiple experiences involving hardware/software compatibility issues. Such experiences had a direct impact on John’s willingness to introduce particular types of technology that may involve more precision and/or calibration. John’s description of his experiences with such technology explains why he is now more reluctant to integrate them into his teaching practices. He appeared convinced that more sophisticated technology was highly uncooperative due to hardware and software compatibility issues. Russell’s main concern regarding unreliability of technology was rooted in the poor Internet connectivity issues, which disrupted his teaching operations. Further, John accentuated the lack of administrative and technical support when faced with a technical problem in his classroom. In addition, John describes his experiences to be offsetting as he was left with the impression that he was being “dumped on” when asking for help from administrative staff. John’s main concerns can be summarized as a lack of communication between teaching and administrative staff, as well as time delays in receiving technical support from the TDSB helpdesk. Both participants’ echoed each other regarding pre-service training,
highlighting that neither received adequate training on technology use during their teacher training. They perceived this as a disadvantage; such instruction would have better equipped them with skills around technology and its integration in the classroom setting. Although both participants perceived their pre-service training to be inadequate, both John and Russell’s teacher training experiences are far too dated to reflect the context of current pre-service curricula. Last, PD was yet another barrier that both participants perceived as having not provided them with sufficient knowledge on technology use in science classrooms in order to make both participants more effective in their teaching practices. These findings reflect first-order barriers documented in the literature (Ertmer, 1999; Ertmer et al., 2012). Most of the barriers mentioned by Russell and John were extrinsic barriers relating to time, equipment, training and support (Ertmer, 1999; Ertmer et al., 2012). Similarly to Hew and Brush (2007), technology availability, time and technical support were all resources that were described by both participants as lacking. It is interesting to consider these findings in the context of the latest statistics available on computer accessibility in Canadian schools. While there appears to be a high computer to student ratio, which is a requirement for technology integration, other important barriers exist, such as the reliability of connectivity, adequate support for teachers who are less familiar with technology, and providing teachers with the time to learn new technologies. Furthermore, participants indirectly mentioned the institution as a barrier (Hew & Brush, 2007). For example, Russell referred to the fact that the computer lab was in high demand and had to be booked well in advance. Participants did not discuss subject culture and the pressure of preparation for assessment as barriers, although they are described as important barriers by Hew and Brush (2007).
Teacher-to-teacher support was the most important perceived facilitator for both participants. John described how initial support from colleagues that were more familiarized with a particular technology had a meaningful impact on his technology integration by allowing him to become more comfortable and skilled at using the new technology. Russell also referred to expert colleagues in his school, but emphasized that he would usually tailor the advice to fit the needs of his classroom. Both participants mentioned how collaboration among staff was mostly informal. This is consistent with the finding that the presence of exemplary computer-using teachers in a school environment may lead to an increase in the number of teachers using computers, as expert teachers share their knowledge with colleagues (Becker, 2000).

Finally, participants described how their experiences with technology led them to be more comfortable and confident using it in the classroom. There was a disparity between the two participants with regards to their perceived abilities to learn new technologies and their capacities for applying newly acquired technological knowledge in their science classrooms. John perceived himself to be more dependent on others’ expertise such as staff, colleagues, and friends when confronted with unfamiliar technology. He relied on help from other teachers to learn how he could use certain technologies in his teaching. On the contrary, Russell perceived himself to be more of a self-directed learner when it came to familiarizing himself with a foreign technology, as he preferred to practice with the technology at home in order to overcome any shortcomings. In relation to each participants’ self-perceived capacity to use various technologies, John appeared to be more of an ongoing learner, who is cognizant of his own shortcomings when working with unfamiliar technology, whereas Russell perceives
himself to be “tech savvy”, hence making the task of learning an unfamiliar technology less difficult. As documented by Ertmer (1999) and Ertmer et al. (2012), second-order barriers to technology use include those that interfere with or impede mental change, and include teachers’ confidence. It was clear that, if he did not receive help from his colleagues, or administrative and technical staff, John’s confidence with technology could become a barrier to using it. Moreover, his experiences with the unreliability of technology contributed to his beliefs about its usefulness in teaching, influencing how valuable he regarded it in his teaching practice. Both beliefs about how students learn and the perceived value of technology are additional second-order barriers to technology integration (Ertmer et al., 2012). Thus, it is evident that different barriers and facilitators interact with each other to influence the extent of technology integration that a teacher will exercise.

Having considered these findings together, it is interesting to reflect upon the participants’ view of what technology integration means. It is arguable that participants in this study viewed “technology integration” as using computing devices for instructional purposes (Hew & Brush, 2007). However, contrary to the U.S. Department of Education’s definition of ICT (2002), technology was not described as being used, for example, for collaborative work and communication. The level of integration described by both John and Russell could not be characterized as “routine, seamless, and both efficient and effective in supporting school goals and purposes” (U.S. Department of Education, 2002, p. 75). I suggest that the lower level of technology integration described by the participants relates to both the barriers they face in using technology in their day-to-day practices, but also to their lack of experience and training on how to use
technology in effective, engaging, innovate, and creative ways that transforms learning and develops 21st century learning competencies.

**Implications**

As discussed by Hughes (2005) “the power to develop innovative technology-supported pedagogy lies in the teacher’s interpretation of the technology’s value for instruction and learning in the classroom” (p. 297). Moreover, this is mediated by both teachers’ past experiences and their accumulated knowledge (Hughes, 2005). In order to enable teachers to integrate innovative technology-supported pedagogy, they must have opportunities for content-based technology learning (Hughes, 2005). This has implications for PD sessions and pre-service training. PD opportunities must go beyond showing teachers how to use technologies, to include how different technologies can be applied in creative ways to different disciplines. As mentioned by Hughes (2005), teachers can acquire ideas for their lessons from other teachers who have used technology in innovative ways to enhance student learning. Pre-service training provides an opportunity for more in-depth opportunities for content-based learning and practice with technologies. Technology should therefore be offered as a core component course, but also be integrated into all teachable subjects in order to ensure that content-based technology learning can occur. Another implication of these findings is that informal teacher collaboration is a great asset for schools with regards to facilitating teachers’ capacity to integrate technology. Schools (administrators, staff, and colleagues) should facilitate this type of informal knowledge sharing among teachers. For example, professional learning communities could support teachers in their sharing of technology-related knowledge and successful integration experiences (DuFour, 2004). As a science
and mathematics pre-service teacher, this research has made be more aware of the different aspects involved in shaping teachers’ beliefs regarding the role of technology in teaching and how there exists an interaction between barriers and facilitators, which must be recognized in order to identify the types of environments that facilitate technology integration. I am also more aware of the interplay between a teachers’ pedagogical knowledge (PK), technological knowledge (TK), and content knowledge (CK), which must interact together for teachers to integrate technology in effective, engaging, and innovative ways (Mishra & Koehler, 2006). As I enter the teaching field, I am more cognizant of the importance of ongoing PD, and for more informal sharing of technology-related knowledge and resources among colleagues. I recognize the difficulty that transformative technology integration presents, but also the potential it holds for enhancing student learning, and the importance it represents in the context of 21st century learning.

Limitations

A major limitation of this study was the small sample size. As the experiences of only two participants were included in this study, the perceptions and expressions of the participants may not reflect those of all science teachers in Toronto, or even of those in their respective schools. The findings from this study therefore remain highly specific to the experiences of these two participants and are not generalizable or transferable. Another important characteristic of this study is the relationship that the researcher had with the participants. As I had previously been a pre-service teacher who taught in both Russell and John’s classrooms, I was well acquainted with them, their teaching styles and classroom dynamics. This presents both a strength and limitation of the study. As I knew
both Russell and John before interviewing them, I already had pre-conceived notions about them as teachers. For example, I already had an idea of what types of technology they used in their teaching practices. However, my relationship with the participants also presents a strength, as a rapport had already been established and participants felt more comfortable answering questions. This was particularly important considering the length of my interviews, which were fairly short. If I had not known the participants beforehand, it might have been necessary to include more “warm-up” questions before jumping into questions about their beliefs and practices. With regards to interview length, it is important to note that both interviews lasted between 30 and 45 minutes. Longer interviews would have most likely provided more details about their experiences and perceptions, which might have influenced the interpretation of results. In terms of the data analysis, I conducted the extraction of themes from the interview transcripts, however in order to increase reliability and validity of the findings, another graduate student participated in coding of the data. Moreover, a “member check” was conducted by sharing a draft of the findings with each participant in order to ensure “that the participants’ point of view is depicted as authentically as possible” (Falk & Blumenreich, 2005, p. 122). This study could be enhanced by increasing the sample size and length of interviews, as well as by having two or more researchers participate in the entire data analysis.
Conclusion

This research provides insight into science teachers’ perceptions of technology and their experiences integrating technology into the classroom. Overall, technology was perceived as useful, although there were many barriers to its integration into the classroom, namely barriers relating to human, material, and time resources. Peer support was an important facilitator in understanding how to use different technologies. Finally, teachers’ increase in confidence occurred with increased familiarity with a new technology. This research highlights the importance of content-based technology learning in order for transformative uses of technology to become more common among science teachers. This has implications for both professional development content, as well as pre-service training curricula. Future research is needed on how professional development and pre-service training can integrate more content-based technology learning. However, before thinking about changing professional development and pre-service training practices, we must further our understanding of transformative means of using technology, and how it applies to different disciplines.
REFERENCES


TEACHERS’ EXPERIENCES WITH ICT INTEGRATION


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Appendix A: Letter of Consent for Interview

Date: ___________________

Dear X,

I am a graduate student at OISE, University of Toronto, and am currently enrolled as a Master of Teaching candidate. I am studying the relationship between teachers’ experiences and integration of technology into the classrooms for the purposes of a graduate research project. I believe that your knowledge, background, and experience will provide insights into this topic.

I am writing a report on this study as a requirement of the Master of Teaching Program. My course instructor who is providing support for the process this year is Dr. Patrick Finnessy. My research supervisor is Katherine Bellomo. The purpose of this requirement is to allow us to become familiar with a variety of ways to do research. My data collection consists of approximately a 45-minute interview that will be digitally recorded. I would be grateful if you would allow me to interview you at a place and time convenient to you. I can conduct the interview at your office or workplace, in a public place, or anywhere else that you might prefer.

The contents of this interview will be used for my research, which will include a final paper, as well as informal presentations to my classmates and/or potentially at a conference or publication. I will not use your name or anything else that might identify you in my written work, oral presentations, or publications. This information remains confidential. The only people who will have access to my assignment work will be my research supervisor and my course instructor. You are free to change your mind at any time, and to withdraw even after you have consented to participate. You may decline to answer any specific questions. I will destroy the digital recording after the paper has been presented and/or published which may take up to five years after the data has been collected. There are minimal risks associated with you participating in this research, and if requested, I will share with you a copy of my transcript to ensure accuracy.

Please sign the attached form, if you agree to be interviewed. The second copy is for your records. Thank you very much for your help.

Yours sincerely,
Researcher name: Amandeep Mann

Phone number, email:  514-238-4200, amandeep.mann@mail.utoronto.ca

Instructor’s Name: Patrick Finnessy email address: pk.finnessy@utoronto.ca
Phone number: 416-978-0078

Research Supervisor’s Name: Katherine Bellomo

Phone #: 416-978-0078

Consent Form

I acknowledge that the topic of this interview has been explained to me and that any questions that I have asked have been answered to my satisfaction. I understand that I can withdraw at any time without penalty.

I have read the letter provided to me by ______________________(name of researcher) and agree to participate in an interview for the purposes described.

Signature: ________________________________

Name (printed): ______________________________________

Date: ______________________
Appendix B: Interview Questions

1. Where did you complete your teacher certification training and if applicable, with what teachable subjects?

2. Can you tell me about the first time you used technology in your teaching practice?

3. What factors influence your initial use of a technology?

4. Thinking back to this first experience, how confident do you now feel in your ability to integrate technology into your teaching?

5. Can you tell me about an experience of using technology that was particularly meaningful for you?

6. What forms of technology do you use and in which contexts?

7. In integrating technology, tell me about some barriers or support that you might have had?

8. Can you explain how your pre-service teacher training did or did not prepare you for integrating technology into the classroom?

9. How do you feel technology helps you in your teaching practice?

10. What is your belief surrounding technology and student learning?

11. What does the term “instructional technology” mean to you?

12. What do you wish to achieve by integrating a particular technology into your teaching?

13. Have you had professional development experiences, and if so, how have they influenced your integration of technology in your teaching?
14. Have you had opportunities to collaborate or exchange with teachers or other education professionals, such as councilors, meetings with other staff members, weekly meetings to set goals, and if so, do you feel this has influenced how you integrate technology?

15. Do you feel that as a science/math teacher, you face challenges associated with integrating technology into a science or math classroom?

16. Are there past experiences, which you have not already discussed that you feel relate strongly to your integration of technology?

17. If funding were not an issue, what types of technology would you have in your classroom and why?

18. Are there other stories you want to tell me regarding your successes or failures in integrating technology?