How Digital Technologies and Texts Impact Teachers' Pedagogy in High School Biology Classrooms

by

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Bachelor of Education, University of Alberta, 1984

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Supervisory Committee

Working Title: Impacts of Digital Technologies on Biology Teachers' Pedagogy

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Abstract

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This collective case study examines ways in which digital technologies and texts impact three selected teachers' pedagogy in high school Biology classrooms on southern Vancouver Island. Data from an anonymous online survey was used to compare and contextualize the case study data. Methodological triangulation for the three participants' case studies included lesson plans, on-site lesson observations with accompanying field notes, digital photos and audio recordings, and semi-structured interviews. The collected data was coded, analyzed for themes within cases, and then re-analyzed for themes across the three cases. The salient themes that emerged centered on: changes to pedagogical and learning practices resulting from the use of digital technologies and texts; how teachers live with contradictions within their changing educational environment; and the role traditional methods have within a digital classroom. While these considerations of integrating technology may be useful to many educators, this study has specific implications for the development of new science curricula in British Columbia, and teachers of Biology adapting their practice to engage contemporary Millennial Generation learners.

Keywords: collective case study, survey, biology, British Columbia, Millennial Generation

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I would like to acknowledge the three high school Biology teachers who so generously invited me into their classrooms, and their students who shared those spaces with me.

Dedication

To my family and advisors, for the support they provided me throughout this journey.

Chapter One: Context

Each Educational Researcher Has a Different Pathway that Leads to their Study

I begin my thesis by contextualizing my own journey to this inquiry; where I trained as a teacher, how long I have been teaching, and the various contexts in which I have taught. Following that, I describe how I integrated technology into my own teaching practice while noting some of the important events and milestones that occurred during this journey. I situate this information within the educational and technological movements of which I have been a part, for just as we are individuals, we are also part of (and co-creators) of larger historical, societal and educational trends. I conclude this chapter by stating my research question.

Teaching Background

I graduated from the University of Alberta's Faculty of Education in 1984 specializing in secondary education, with a major in biological sciences and a minor in physical sciences. During my university training, I was introduced to and influenced by the thinking of educational psychologist Benjamin Bloom, psychologist Jerome Bruner, and the use of discrepant events (i.e., a puzzling happening, surprising phenomena or unexpected event) in science education as articulated by Tik Liem (Liem, 1981).

At the time that I attended university, pre-service education for secondary school teachers included several rounds of student teaching where one was supervised by a university faculty member and mentored by a cooperating teacher. My practicum placements included: an eight-week observational round I spent in a rural kindergarten to Grade 9 community school; a four-week introductory session where I was assigned to a suburban Grade 10 – 12 composite high school; a four-week junior high placement for which I was assigned to an urban elementary – junior high school; and a four-week senior high term during which I taught in a large urban Grade 10 – 12 composite high school.

After graduation, my first job as a teacher was a full-time contract teaching primarily science to students attending Grades 8 – 12 in a small school located in a hamlet in rural Alberta. The following year, I accepted a temporary position as a science and computers teacher in an urban elementary – junior high school. After this, I moved to a new school division located just outside of a large, western Canadian city, where I spent 20 years employed as a teacher and department head in science. Fourteen of those years were spent teaching high school science (primarily biology) in two different public school contexts: one a rural centre that served as the central high school for a large farming community, and the other a small suburban city that served as a bedroom community to a larger urban centre. The student population in both of these high schools hovered around 1000 students from grades 10 to 12. Both of these schools were designated as "composite" high schools, which meant that the students had access to a wide variety of courses, including academic studies, sports, fine arts, languages, and career and technology studies programs.

Integration of Technology into My Teaching Practice

Having described my teacher training and experience, I now provide a background on how I became acquainted with and interested in digital technologies and texts. As a high school student in rural Alberta during the late 1970s, I had no contact with computers. I was taught to use a slide rule and data tables in the mathematics, physics, and chemistry courses that I took, although I did purchase a Texas Instruments TI-30 calculator (Woerner, 2001) when I started university. During my first year working as a classroom teacher in a very small school in rural Alberta, there were no computers in the school. A year later, I taught Computers 7 as an option to grade seven students in an “Academic Challenge” elementary – junior high public school (grades kindergarten to nine) located in a large urban centre. With one computer programming course under my belt from my time as an undergraduate university student, I was deemed expert enough to teach this course. In Computers 7, my students learned the names and functions of the parts of a computer, how to keyboard, simple programming using the Beginner’s All-purpose Symbolic Instruction Code (BASIC) programming language (Kemeny & Kurtz, 1968), and how to draw and move coloured, on-screen shapes using the Logo programming language (Logo Foundation, 2011).

I immediately saw the utility of using a computer, both for the students’ learning in the classroom and as a tool to support my teaching practice. For my students, the dedicated classroom of twenty computers allowed them the opportunity to pair-up to learn keyboarding skills using software programs such as Microsoft’s Typing Tutor® (v.II), to create reports and assignments using AppleWorks® (v.2.0), and to compose artwork and newspapers using The Print Shop® (v.2.0). For teachers, the computer was initially a shared resource located in the staff room. On this computer, we could use AppleWorks® (v.2.0) to create, organize, and store lesson plans, assignments, and tests, and enter and calculate student marks. It made modifying resources such as assignments and tests much easier than before when one had to re-type an assignment or test from scratch rather than simply modifying a portion of the text that already existed in a digital file. This flexibility and ease-of-use created efficiencies when editing work for re-use during any subsequent offering of a course.

The Internet became accessible for my use in 1995 via a dial-up community network based in the large urban centre that was close in proximity to where I lived and taught. I created an account, and started using it as a classroom support tool by posting class notes to my website. The site that I provided to my students eventually grew to include links to other websites that offered more detailed information on the content that I was teaching, supplements and enhancements to the standard curriculum, and interactive simulations that helped students engage with and extend their conceptual knowledge of the topics we were studying in class.

Consistent use of computers, digital probes, and the Internet led to my identification as a TELUS 2Learn (2Learn.ca Education Society, 2014) teacher-leader for my school division. To promote the use of technology in education, TELUS sponsored a program that allowed school divisions in Alberta to select up to four teachers to receive special training on how to effectively incorporate the Internet into their teaching practice, and then to share this knowledge with other teachers in the school division through a peer mentorship model. After receiving my training, I worked with three other teachers from my school division to support colleagues as they planned and delivered computer-based lessons to their students. Through this training, I received a much broader view of how a computer connected to the Internet could be used in my own classroom. I learned that it could be more than a tool for content delivery; students could use the computer in creative and constructivist ways to build their own knowledge, connect with others, and compare and contrast their understanding of a content area with that of other students.

This experience led to my being seconded by Alberta Education to work on the LearnAlberta.ca project (LearnAlberta.ca, 2014). LearnAlberta.ca started as a special project in the Learning Technologies Branch of Alberta Education, designed as a learning object repository to support all teachers and students in Alberta. My initial assignment was to conclude the Physics 20-30 project (LearnAlberta.ca, 2014), a multi-year undertaking designed to develop and deliver web-based simulations, streaming video, and animated tutorials to classrooms and homes throughout Alberta. Content licensed and developed for the Physics 20-30 project included all 52 programs in the California Institute of Technology's telecourse *The Mechanical Universe … And Beyond* (Annenberg Foundation, 2013), animated tutorials created in Adobe Authorware® (v.6.0) designed to present difficult-to-understand topics such as magnetic and electric fields within computer-based tutorials, and 61 simulations created using the Java Development Kit language (v.1.1) that allowed students to modify variables such as pendulum length and mass to study simple harmonic motion.

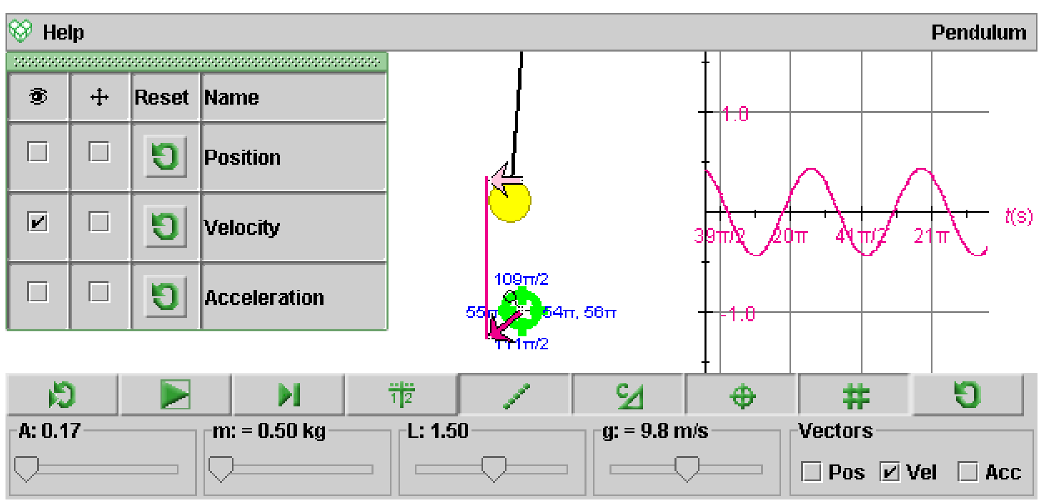


Figure 1. Java applet depicting simple harmonic motion. This figure illustrates the selection panel for variables to be graphed (left), pendulum illustration with vector diagram displayed (centre), active graph panel (right), and variable selection and modification control panel (bottom).

After a one-year return to the classroom, I was seconded a second time to Alberta Education. This time, my role was to oversee the design and development of digital learning resources to support classroom instruction of Biology 20-30. Content licensed and developed for this project included 43 instructional videos in the *BiologiX* series (Access Media Group, 1996), 117 of ExploreLearning's interactive online simulation *Gizmos* (ExploreLearning, 2008), six of Stanford University's *myVirtualBody* interactive simulations (Stanford University Medical Media and Information Technologies, 2008), 17 drag-and-drop anatomy quizzes (Alberta Education 2008), six 360°-rotatable images of actual human organs supported with anatomical labels and self-tests (Alberta Education & Ignition Industries Ltd., 2009), 50 digital microscope slides that can be scanned, magnified, measured and annotated (Alberta Education, 2007), and a virtual trip to the University of Calgary's Kananaskis Field Station that allows learners to compare various biotic and abiotic aspects of two different forest ecosystems (Alberta Education, 2009).

As evidenced by the integration of digital technologies into my teaching practice since 1985 as described above, I was a relatively early adopter of these technologies. I saw computers as an effective support for student learning in the subject areas in which I taught. Computers provided me with a vehicle through which I could develop and enhance students' understanding of complex molecular processes such as nerve impulse transmission and the light-dependent reactions of photosynthesis. Using a computer attached to the school's network, my students could access the Internet to view animations illustrating these processes. In comparison, the tools available to me before computers included a text-based description of the process in the textbook supported by a short series of cartoon images that I could project onto a screen using an overhead projector that I would sign out from the audio-visual storage area in the school library, and any additional oral description that I could provide based on my deeper understanding of the topic. If I planned my timing accurately and far enough in advance, I could also order a supporting video from the regional audio-visual consortium of which my school division was a member.

Arranging to have the video arrive at the exact time that I reached that part of the curriculum was not my only pedagogical challenge however. In Alberta, the science curriculum is clearly articulated by Alberta Education, the provincial government's department of education. As a high school teacher, it was my legal responsibility to deliver the curriculum as described in the Biology 20-30 Program of Studies. The level of detail used to describe the curriculum is precise and demanding in relation to available resources. As an example, Biology 30 Specific Outcome 30-A1.1k states that biology teachers are to ensure that their "students will describe the general structure and function of a neuron and myelin sheath, explaining the formation and transmission of an action potential, including all-or-none response and intensity of response; the transmission of a signal across a synapse; and the main chemicals and transmitters involved, i.e., norepinephrine, acetylcholine and cholinesterase" (Alberta Education, 2007).

Educational / Technological Movements

Alberta Education (along with other educational stakeholders including the superintendent of the school division for which I worked, the principal of my school, the parents of my students, and my students themselves) ensured that I followed the curriculum as stated in the Biology 20-30 Program of Studies by administering a diploma examination at the end of the semester in each grade 12 biology course taught. This examination was weighted heavily: 50% of each student's mark was based on the five months of classroom work they did with me, and 50% of their mark was based on the three-hour diploma exam they wrote at the conclusion of the course. Exam results had a huge impact on the students' university admissions, and provided an easy means for school-to-school and teacher-to-teacher comparisons. This placed a significant amount of pressure on me as a teacher to ensure that I taught all of the information evaluated by the diploma exam, and that my students understood that content well. As a result, my students needed a clear understanding of processes such as the transmission of an action potential as described above.

The combination of computer and Internet proved to be an excellent support to me and my students in this regard. It not only provided us with access to professionally-rendered animations of molecular processes such as the transmission of an action potential, but this resource also provided my students with some degree of control over the pace of their learning, as they could play, stop, rewind, and review the animation as many times as they wanted. Limitations on access to this information also changed over time; students could view the animation from school or home – even on their cell phones towards the end of the time that I was working in the classroom.

An additional benefit of using the Internet was the ability of Internet-based resources to provide up-to-date information to both me and my students. In 2005, the textbook that I was using as a classroom support, *Nelson Biology* (Coombs, Drysdale, Gardner, Lunn, & Ritter, 1993), was twelve years old. Teaching a scientific discipline in which active research continues means that new discoveries and clarifications to previous understandings occur on a regular basis. The twelve year-old textbook that we used was dated. It contained some content that was no longer relevant, some content that was now better understood or explained more completely, and some content that was no longer correct. It is an expensive and time-consuming process to create a new print version of a textbook. A digital text, on the other hand, can be updated much more efficiently.

I believe, then, that this is a very exciting time to be a science teacher. The seemingly ubiquitous availability of digital technology opens up a wide variety of learning opportunities for students, teachers and the general public alike. Digital technologies can communicate up-to-date information to learners through a variety of modalities: texts, diagrams, cartoons, photographs, audios, videos, and animations. Transmission of information can now occur either synchronously or asynchronously in many directions: from a teacher to his or her students, from the students to the teacher and/or their peers, from an expert in the field to the general public, or between students and practicing scientists. Classroom dialog has arguably become richer than the traditional one-way flow of information from teacher to student, supported by a single textbook.

Additionally, students now have tools available to them whereby they can assess their understanding of a topic through diagnostic, formative, and summative evaluation tools. Online questions are available whenever a student wishes to access them, 24 hours per day, seven days per week, 365 days per year, not just during scheduled class time. This provides students with tailored, individually-relevant, and easily-accessible ways to integrate learning into other aspects of their busy, complex lives.

However, this technology does come with a price. Anyone with a computer and Internet connection can upload content to the Internet. How can an interested learner make sure the information they have accessed is not only current, but also correct? Further, the nature of both gathering information and reading in an online environment is different than that used in a textbook-based learning environment. Quickly surfing from web page to web page, fast scanning of content and superficial rather than deep reading have implications for not only learners' understanding, but for brain development as well. As Carr (2010) argues, working within an online environment may promote "cursory reading, hurried and distracted thinking, and superficial learning" (p. 116). This contrast in how digital technologies are utilized in different ways by different populations of learners fascinates me.

Conclusion

In this first chapter of my thesis, I situated myself in terms of my teaching experiences and the time and place in which I practiced. Most of my 22-year teaching career was spent working in Alberta classrooms. Throughout my career I taught science, always biology, but also general science, chemistry, and physics. A consistent theme throughout my career has been a use of technology to support my teaching practice and as help for my students to better understand the content that they were learning. I described some of the experiences that I had using technology, and how digital technologies impacted and influenced my teaching practice. I was an early adopter of the Internet as a content-delivery channel. I had learners use electronic probes to measure a variety of variables in laboratory activities, and used computers extensively as a classroom tool. This led to my being seconded by Alberta Education to work on three projects: the LearnAlberta.ca Physics 20-30 project, Science 9 e-textbook, and Biology 20-30.

Due to my own experiences using digital technologies, I began to wonder about the impact digital technologies have from a broader perspective. I developed a keen desire to gain an empirical understanding of other teachers' experiences using digital technologies and texts. Honouring where I came from and looking at an environment with which I was quite familiar, I designed my study to investigate the impact digital technologies and texts had on high school Biology teachers working in public school classrooms in southern Vancouver Island. The research question that I arrived for this study is: "How do digital technologies and texts impact teachers' pedagogy in the high school biology classroom?"

In the next chapter, I will conduct a literature review to help define the terminology I will be referencing in my study, assess what is already known about this topic area, and identify a gap in which to position my research to make a unique contribution to what is known in this area.

Chapter Two: Literature Review

Introduction

This is an exciting, yet challenging time to be a secondary school biology teacher. Digital technologies such as laptops, tablets, and smart phones are now small enough to be truly portable, powerful enough to be useful as multi-purposed communication, composition and research tools, and priced low enough to be affordable to a majority of Canadians. For example, as of 2012, 83% of Canadian households had access to the Internet at home with 69% of those homes having more than one device such as laptops or wireless hand-held devices to go online (Statistics Canada, 2013). Such technologies are capable of ‘holding’ several textbooks-worth of content simultaneously, in addition to running a range of interactive applications, and providing connectivity to a wide variety of resources accessible via the Internet. As the tail end of the Millenial Generation – identified as those individuals who are born between 1980 and the early 2000s – enter middle years and high school classrooms, portable and other personal computing devices afford a wide variety of teaching and learning opportunities.

As is evident in my research question, I am interested in understanding how digital technologies and contemporary biology teachers in their classrooms are using texts; particularly how these digital technologies and texts are impacting their pedagogy. In this literature review I: describe how the prescribed learning outcomes in the British Columbia Biology 11 and 12 curricula are grounded in the *cognitive*, *affective* and *psychomotor domains*; describe four commonly-used instructional approaches used in British Columbia science classrooms; discuss the existing literature that examines the use of digital technologies in secondary and tertiary classrooms; and describe some of the challenges and affordances that the use of such technologies have for biology teachers' pedagogy. This fourth section includes considerations of traditional approaches and resources for science instruction, the professional and technical support required for the implementation of digital technology in the biology classroom or lab, and the provincial and curricular subject area context of my study.

The goal of this study is to answer the question: "How do digital technologies and texts impact teachers' pedagogy in the high school biology classroom?" For the purposes of this study, a high school biology classroom is defined as a Biology 11 or 12 public school classroom situated in southern Vancouver Island, British Columbia, Canada. Pedagogy includes the methods and activities used by secondary biology teachers taking part in the study to teach the Biology 11 and 12 curriculum as articulated in the *Biology 11 and 12 Integrated Resource Package* (British Columbia Ministry of Education, 2006). Digital texts refer to files created and made available digitally through software such as word processors, presentation programs and web page editors. These files include text, image, audio, video, animation and simulation content, all of which can be accessed via the Internet or delivered through a variety of digital technologies. Digital technologies are defined as all hardware devices used to access digital resources, including desktop, laptop and tablet computers, as well as digital projectors, photocopiers, SMART® Boards, cellular phones and smart phones.

Determining what is Taught in Biology Classrooms

The Ministry of Education. In British Columbia, the provincial Ministry of Education is responsible for determining who can do the teaching through the Teacher Regulation Branch, as well as what is taught to students through the design of subject area curricula. Although identifying who can teach is important, it is not within the scope of this study. Determining what is taught, however, is foundational to what I examine in my research inquiry.

The Ministry of Education in British Columbia determines what is taught to secondary Biology students, and has codified this information in the *Biology 11 and 12 Integrated Resource Package 2006* (British Columbia Ministry of Education, 2006). Specific details regarding what is to be taught to students are listed in this document as "*prescribed learning outcomes*, [which are] the legally required content standards for the provincial education system. The learning outcomes define the required knowledge, skills, and attitudes for each subject. They are statements of what students are expected to know and be able to do by the end of the course" (British Columbia Ministry of Education, 2006, p. V). An example of a prescribed learning outcome from Biology 12 is outcome C2, which is located in the curriculum organizer Human Biology, suborganizer Digestive System: "[It is expected that students will] describe the components, pH, and digestive actions of salivary, gastric, pancreatic, and intestinal juices" (British Columbia Ministry of Education, 2006, p. 20).

A *specific achievement indicator* supports each prescribed learning outcome. Specific achievement indicators "are statements that describe what students should be able to do in order to demonstrate that they fully meet the expectations set out by the prescribed learning outcomes. Achievement indicators are not mandatory; they are provided to assist in the assessment of how well students achieve the prescribed learning outcomes" (British Columbia Ministry of Education, 2006, p. V). For example, the specific achievement indicators that correspond with prescribed learning outcome C2 listed above are listed in Figure 2 below:

- relate the following digestive enzymes to their glandular sources and describe the digestive reactions they promote:
  - salivary amylase
  - pancreatic amylase
  - proteases (pepsinogen, pepsin, trypsin)
  - lipase
  - peptidase
  - maltase
  - nuclease
- describe the role of water as a component of digestive juices
- describe the role of sodium bicarbonate in pancreatic juice
- describe the role of hydrochloric acid (HCl) in gastric juice
- describe the role of mucus in gastric juice
- describe the importance of the pH level in various regions of the digestive tract

Figure 2. Example of specific achievement indicators.

The Ministry of Education states that "prescribed learning outcomes in BC curricula identify required learning in relation to one or more of the three domains of learning: cognitive, psychomotor, and affective" (2006, p. 17). Due to the important role each of these domains of learning play in determining what is taught to secondary Biology students, I will analyze the development of each domain of learning in more detail below.

Domains of learning. The first domain found in the provincial curriculum for British Columbia is the *cognitive domain*, which is defined in the *Biology 11 and 12 Integrated Resource Package 2006* as dealing "with the recall or recognition of knowledge and the development of intellectual abilities" (British Columbia Ministry of Education, 2006, p. 17). In 1948, Bloom was one of a number of "college examiners attending the American Psychological Association Convention in Boston … [who] expressed an interest in developing a theoretical framework that they could use to facilitate communication and to promote the exchange of test materials and ideas about testing with other examiners" (Moore, 2014). The group continued to meet, eventually "develop[ing] a classification system for thinking behaviours that were important in the learning process" (Moore, 2014). The classification system that they developed was published as taxonomy of educational objectives for the cognitive domain, organized "from the simple to the more complex behaviour and from the concrete or tangible to the abstract or intangible" (Bloom, Engelhart, Furst, Hill & Krathwohl, 1956, p. 30). These increasingly complex levels were identified as developmental categories within the cognitive domain. Not only do levels grow increasingly complex as learners advance from knowledge through to evaluation, the progression from a lower level to a higher level is often dependent upon a learner attaining competency at the lower level. The levels in this taxonomy with associated definitions/details are listed in Figure 3 below.

- 1.0 Knowledge
  - 1.1 Knowledge of specifics
    - 1.1.1 Knowledge of terminology
    - 1.1.2 Knowledge of specific facts
  - 1.2 Knowledge of ways and means of dealing with specifics
    - 1.2.1 Knowledge of conventions
    - 1.2.2 Knowledge of trends and sequences
    - 1.2.3 Knowledge of classifications and categories
    - 1.2.4 Knowledge of criteria
    - 1.2.5 Knowledge of methodology
  - 1.3 Knowledge of universals and abstractions in a field
    - 1.3.1 Knowledge of principles and generalizations
    - 1.3.2 Knowledge of theories and structures
- 2.0 Comprehension
  - 2.1 Translation
  - 2.2 Interpretation
  - 2.3 Extrapolation
- 3.0 Application

4.0 Analysis
  - 4.1 Analysis of elements
  - 4.2 Analysis of relationships
  - 4.3 Analysis of organizational principles

5.0 Synthesis
  - 5.1 Production of a unique communication
  - 5.2 Production of a plan, or proposed set of operations
  - 5.3 Derivation of a set of abstract relations

6.0 Evaluation
  - 6.1 Evaluation in terms of internal evidence
  - 6.2 Judgments in terms of external criteria

Figure 3. Bloom's taxonomy for the cognitive domain.

Although he did not work alone to develop the taxonomy for the cognitive domain, Bloom's name has since become synonymous with the taxonomy. It is this original conception of Bloom's taxonomy for the cognitive domain that is used by the Ministry of Education in British Columbia to frame learning outcomes in the cognitive domain.

The second domain listed in the provincial curriculum for British Columbia is the *affective domain*, which the ministry states "concerns attitudes, beliefs, and the spectrum of values and value systems" (British Columbia Ministry of Education, 2006, p. 17). In 1956, Krathwohl, Bloom, and Masia published their taxonomy for the affective domain. Their taxonomy included five categories, which, listed from simplest to most complex behaviours, are: receiving phenomena, responding to phenomena, valuing, organization, and internalizing values (characterization). Although neither as frequently nor as prominently featured in the *Biology 11 and 12 Integrated Resource Package 2006* as categories in the cognitive domain, affective categories are described in such outcomes as "[It is expected that students will] demonstrate ethical, responsible, co-operative behaviour" (Ministry of Education, Province of British Columbia, 2006, p. 30).

The third domain found in the provincial curriculum is the *psychomotor domain*, which is defined in the *Biology 11 and 12 Integrated Resource Package 2006* as including "those aspects of learning associated with movement and skill demonstration, and integrates the cognitive and affective consequences with physical performances" (British Columbia Ministry of Education, 2006, p. 17). Huitt (2003) notes that three taxonomies for the psychomotor domain have been developed: Dave (1967), Simpson (1972), and Harrow (1972). Simpson's taxonomy describes the progression of learning of a psychomotor skill from observation to mastery, Dave's taxonomy elucidates the training of workplace skills for adults, and Harrow's taxonomy focusses on psychomotor skills intended to express or evoke feelings. Of these, Simpson's taxonomy best matches the type of psychomotor learning that occurs in science classes.

In her taxonomy of the psychomotor domain, Simpson proposed the following seven categories, listed from simplest to most complex behaviour: perception, set, guided response, mechanism, complex overt response, adaptation, and origination (1972). An example of an outcome from the psychomotor domain listed in the *Biology 11 and 12 Integrated Resource Package 2006* is "[It is expected that students will] demonstrate safe and correct dissection technique" (British Columbia Ministry of Education, 2006, p.60).

In summary, the prescribed learning outcomes listed in the *Biology 11 and 12 Integrated Resource Package 2006* articulate the knowledge, skills, and attitudes students are expected to demonstrate upon successful completion of Biology 11 and 12. These learning outcomes are based on taxonomies derived from research into the cognitive (Bloom, Engelhart, Furst, Hill & Krathwohl), affective (Krathwohl, Bloom, and Masia), and psychomotor (Simpson) domains.

Four Approaches to Teaching

As detailed in the previous section, in British Columbia the provincial government determines what students are to be taught. In publicly-funded schools in British Columbia, individual classroom teachers are afforded the freedom to choose the approach that they take in teaching that curriculum to their students – essentially, the “how”. Although a variety of instructional approaches exist in secondary science, I will focus on four instructional approaches that are used in secondary classrooms: transmission, constructivism, social constructivism, and self-directed or personalized teaching. I outline the main features of each of these approaches below while acknowledging that the realization of each approach by a teacher is largely affected by previous, emergent, and varying personal, social, and educational experiences and contexts.

Transmission. The traditional method of teaching science at the secondary level within British Columbia is *transmission.* As with each instructional approach, transmission instruction assumes certain characteristics about the relationship between learner and teacher.

Transmission instruction is based on a theory of learning that suggests that students will learn facts, concepts, and understandings by absorbing the content of their teacher's explanations or by reading explanations from a text and answering related questions. Skills (procedural knowledge) are “mastered through guided and repetitive practice of each skill in sequence, in a systematic and highly prescribed fashion, and done largely independent of complex applications in which those skills might play some role” (Ravitz, Becker & Wong, 2000, p. 3).

This approach to teaching has been, and continues to be employed in many secondary school classrooms across British Columbia, especially for subject areas such as biology that have a large number of concepts and content to be addressed. Within this approach, the teacher remains as the main authority while the cognitive domain of learning is highly privileged.

Constructivism. Development of constructivist theory was initiated by the work of Jean Piaget. In *The Psychology of the Child* (1969), Piaget suggested that learners actively process novel information received from the world around them, and construct and internalize new knowledge through the mechanisms of assimilation and accommodation.

During assimilation, learners incorporate novel information about a topic into their already-existing framework of understanding about that topic, without changing their existing framework. In contrast, accommodation occurs when the learner realizes there is a discrepancy between novel information and their existing framework of understanding about a topic, and alters their framework of understanding to incorporate the novel experience, thereby broadening their understanding. It is through the processes of assimilation and accommodation that learners construct knowledge from their experiences of the world (Piaget & Inhelder, 1969).

Characteristics of constructivist learning include: (1) learning occurs when new ideas are integrated with already-existing ones through effort on the part of the learner; (2) students who have different interests, experiences, and understandings, and therefore require different supports for their learning; and (3) learning results from actively working with and applying ideas within a socially-mediated context (Ravitz, Becker &

Wong, 2000). A constructivist approach acknowledges the role of the learner and his or her previous experiences in creating content area understanding, and applying that understanding. This differs from the transmission approach that views learners as being empty vessels or blank slates into which knowledge is transmitted (Vacca, Vacca & Begoray, 2005).

Social Constructivism. Building upon constructivism is social constructivism which posits that meaning is constructed dynamically, through the interaction between individuals including students and their teacher. Grounded in the work of Lev Vygotsky, there has been a concerted effort to bring social constructivist approaches into science classrooms since the late 1980s (Vacca, Vacca & Begoray, 2005). Driver, Asoko, Leach, Mortimer and Scott (1994) note this need for teachers to model, guide and facilitate, students to be “initiated into scientific ways of knowing” (1994, p. 6). Through the interaction between science teacher and science student, students develop a culturally-acceptable knowledge of science (Driver, 1995). Further, “as learners collaborate, they internalize and transform the assistance they receive from others, connect new ideas to prior knowledge, and eventually use these same means of guidance to direct their future constructions” (Stage, Muller, Kinzie, & Simmons, 1998, p. 45).

Self-directed and personalized learning approaches. In the self-directed or personalized approach to teaching, learners are in charge of their own learning, and determine what and how they learn. Knowles (1975) described self-directed learning as “a process by which individuals take the initiative, with our without the assistance of others, in diagnosing their learning needs, formulating learning goals, identify human and material resources for learning, choosing and implement appropriate learning strategies, and evaluating learning outcomes" (p. 18). A notable proponent of this approach is Hargreaves (2006) who identified and described nine interconnected gateways through which personalizing learning is realized: (1) student voice; (2) assessment for learning; (3) learning to learn; (4) new technologies; (5) curriculum; (6) advice and guidance; (7) mentoring and coaching; (8) workforce development; and (9) school design and organization. This approach is becoming increasingly popular in Canadian educational contexts, as evidenced by its inclusion as a strategy to support the first goal of Alberta Education's 2010-2013 business plan: [to] "support a flexible approach to enable learning any time, any place and at any pace, facilitated by increased access to learning technologies" (Alberta Education, 2010, p. 70).

The British Columbia Ministry of Education has also focused on this approach, listing "Personalized Learning for Every Student" as the first of five key elements in BC's Education Plan (2012). The Ministry describes personalized learning for every student as "teachers, students and parents …work[ing] together to make sure every student's needs are met, passions are explored and goals are achieved" (British Columbia Ministry of Education, 2012, p. 5). This potentially means that student-centered learning is to be "focused on the needs, strengths and aspirations of each individual young person. Students will play an active role in designing their own education and will be increasingly accountable for their own learning success" (British Columbia Ministry of Education, 2012, p. 5). This plan is currently in development, and likely will supersede the existing Integrated Resource Packages.

Curricular Change

Based on the draft curriculum document for K-9 science, it appears that the direction the Ministry is taking with their rewrite of the Biology 11-12 curriculum is to organize content into key concepts represented by "big ideas" such as "Humans live in constant interaction with micro-organisms" (British Columbia Ministry of Education, 2013a, p. 14), define learning standards along lines of inquiry based on scientific process skills, for example "formulate multiple hypotheses and predict multiple outcomes" (British Columbia Ministry of Education, 2013a, p. 14), and provide statements listing the concepts and content students are to know and understand. As stated on the *Transforming Curriculum & Assessment: Science* (2013d) website, the "renewed Science curriculum… highlights fewer concepts to allow for substantial inquiry time. The level of facts and details in the new curriculum is left open to individual customization by the educator, allowing more time for in-depth exploration by students" (What's new? section, para. 1). However, the Ministry also notes that "the familiar skills and processes of science remain an integral part of the Science curriculum and reside in the curricular competencies" (What's the same? section, para. 1), and "through the curricular competencies, the Science curriculum gives students the opportunity to develop the skills, processes, attitudes, and scientific habits of mind that allow them to pursue their own inquiries" (How does the Science curriculum support inquiry? section, para. 2).

Using Digital Technologies in Secondary and Tertiary Classrooms

For the purposes of this study, I examine how digital technologies and texts impact teachers' pedagogy in the high school Biology classroom in British Columbia. A significant body of evidence identifying the affordances of using digital technologies in the classroom exists, and continues to emerge as new iterations of digital technologies enter into the classroom. Empirical evidence of the affordances of digital technologies have included: increased student enthusiasm for school work (Vahey & Crawford, 2002); decreased student referrals for discipline (Knezek, Christensen, & Owen, 2007); increased parental involvement in and communication with the school (Rockman, 2003); increased frequency and quality of supportive interactions between students and teachers (Light, McDermott, & Honey, 2002); and increased student achievement as evidenced by significantly higher test scores than for comparison schools in science, mathematics, visual arts and performing arts (Muir, Knezek, & Christensen, 2004).

To date, a significant amount of the research analyzing the use of computers in the classroom has focused on identifying and cataloguing ways in which students and teachers use the technology. Researchers have noted that common uses of digital technology include word processing, spreadsheet creation, making presentations, and carrying out research on the internet (Hill & Reeves, 2004; Oliver & Corn, 2008; Russell, Bebell, & Higgins, 2004). On surveys, teachers self-reported that the advantages of using the Internet and computer-based resources for research include currency of content and having content made available to students in a variety of modes (Zucker & McGhee, 2005). Teachers view this as advantageous because it allows them to “present information to students in a variety of ways, thereby allowing for a more flexible instructional style” (Zucker & McGhee, 2005, p. 17).

However, cataloguing how teachers and students use the technology is not the same as determining what methods are effective at supporting students’ learning. Some studies have reported that using networked laptops has led to a more student-centred, constructivist style, with teachers assuming a role more like that of facilitator (Hill & Reeves, 2004; Jeroski, 2003; Ricci, 1999; Russell, Bebell, & Higgins, 2004; Schaumburg, 2001). Additional advantages regarding the use of technology in the classroom are the ability to assess students' work and respond with timely feedback, and the ability to provide personalized, tailored remediation as appropriate (Kerr, Pane & Barney, 2003; Ricci, 1999; Russell et.al., 2004). In an action research project using iPads to deliver content to Grade 11 students in U.S History classes, Garcia (2011) compared the use of paper-based primary information sources to primary sources delivered via iPads. She found that "students working with the paper readings all read independently and did not discuss the material with their peers. On the contrary, the iPads facilitated and encouraged group collaboration which ultimately positively impacted student achievement" (Garcia, 2011, p. 35).

Visualizations and visual display of data have proven to be an effective way for learners to understand scientific concepts (Linn, Lee, Tinker, Husic & Chiu, 2006; American Educational Research Association, 2007). The high-resolution display now available on digital technologies allows learners access to clearly visible, detailed views of simulations, animations, and video clips, along with individual control over how, when, and how often they view these. As one twelfth-grade respondent in a study by Zucker and Hug of the use of laptops in physics stated, "It makes it so much easier to understand a concept if you can see it happen in an animation" (2008, p. 592).

Computing devices support instruction in ways that are different from paper-based methods. In an Australian study of sixteen teachers and 104 students across several subject areas, students who shared tablet PCs were compared with students who purchased their own tablet PC and with students who did not have tablet PCs (the control group). In surveys, students reported that “technology tools help improve the quality of their work…[and] that the Tablet PCs assisted in making school tasks easier and quicker to complete” (Neal & Davidson, 2009, p. 115). From classroom observations, it was noted that teachers used tablets in ways different from how they used notebook computers, using the tablet pens to “make real-time (instantaneous) modification of content. For example, they wrote, marked, and underlined things that were displayed on a data projected screen…annotate[d] material and [drew] diagrams to alert students to key points” (Neal & Davidson, 2009, p. 114).

Ultimately, the use of digital technologies in a classroom setting must consider methods that motivate and engage learners, as well as promote the development of conceptual understanding by students. In their summary of design elements required to create an effective learning environment, Bransford, Brown, and Cocking (2000) determined that learning environments should be learner-centred, knowledge-centred, assessment-centred, and community-centred. A learner-centred environment starts from the existing knowledge, skills, attitudes, and beliefs a learner brings into their learning environment; identifies for the learner what needs to be learned, why it is important, and the criteria used to determine mastery; provides learners with an understanding of their own progress along with opportunities to revise and refine their understanding; and creates and establishes connections between learners that supports attainment of understanding (Bransford, Brown, & Cocking, 2000). These considerations are important in supporting the development of student understanding, independent of whether or not digital technologies are used in the classroom.

Expanding on this premise, a meta-analysis of over 6500 students studying introductory physics at the high school, college and university levels carried out by Hake (1998b) defined interactive-engagement methods “as those designed at least in part to promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and/or instructors, all as judged by their literature descriptions” (p. 2). Hake went on to identify interactive-engagement instructional strategies as including: “Collaborative Peer Instruction, Microcomputer-Based Labs, Concept Tests, Modeling, Active Learning Problem Sets or Overview Case Studies, Socratic Dialogue Inducing Labs, and use of a physics-education-research based text or no text”, and contrasted them with traditional strategies such as “passive-student lectures, recipe labs, and algorithmic-problem exams” (1998b, p. 2). A comparison of results on standardized tests of conceptual understanding of Newtonian mechanics found that the instructional methods Hake described as interactive-engagement produced gains in understanding almost two effect sizes greater than those found in courses taught using traditional methods (1998a). Similar results were reported for small group learning methods employed in undergraduate science, technology, engineering and mathematics courses (Springer, Stanne, & Donovan, 1999), for cooperative learning techniques used in high school and college chemistry courses (Bowen, 2000), when using constructivist teaching techniques with first-year university biology students (Burrowes, 2003), and when using peer instruction, pre-class written responses, a research-based textbook and cooperative learning discussion in Signal Processing Courses (Buck and Wage, 2005).

Supporting the Implementation of Digital Technology in the Biology Classroom

To incorporate digital technologies into the classroom, teachers need to be comfortable with the technology they plan to use before they can effectively support students learning with that technology. At a minimum, a teacher must know how to turn the device on and off, adjust the screen brightness and contrast, turn the sound on and off, use a mouse to interact with on-screen elements, find and restore a network connection, download and install a software program, launch a web browser such as Chrome, Firefox, Internet Explorer or Safari, and launch and play a video from a site such as YouTube. Such knowledge will ensure that the teacher can carry out basic troubleshooting on digital technologies they use in class.

Once a teacher is comfortable using a hardware device, they may need guidance and support on how this technology can best be integrated into their classes. “It is important for faculty to have time to consider and prepare for the impending technological shift. Schools will need to facilitate collaboration among the faculty to determine which applications will be purchased and utilized within the classroom” (Salerno & Vonhof, 2011, p. 2).

It also is helpful for teachers to be given guidance and provided with enough time to determine what resources are most useful in teaching their subject area, why those resources are useful, and what can be done using the resource that cannot be done in any other way in a classroom setting. Guidance can be provided through support for professional development, or participation in a professional learning community. In either case, these types of supports help teachers share ideas about what works and what does not, identifies limitations of devices when used in a classroom environment, and generates and elucidates ideas for effective use of the technology (Palak & Walls, 2009).

Discussion and Critical Summary

To incorporate digital technologies into classroom instruction, devices used must be supported by a sound instructional philosophy and robust infrastructure (Salerno & Vonhof, 2011). Development of this infrastructure is a crucial first step in bringing these technologies into the classroom in a meaningful way. Studies also have shown that effective teaching practices include methods that allow students to use technologies to actively construct knowledge through a variety of interactions with their peers (Hake, 1998a; Hill & Reeves, 2004; Jeroski, 2003; Ricci, 1999; Russell et. al., 2004; Schaumburg, 2001). Although digital technologies are not the only means through which this goal can be achieved, they do support this pedagogy very well, and provide mechanisms for student-to-student and student-to-teacher interaction that more traditional paper-, textbook-, and lecture-based strategies do not.

Before utilizing digital technologies in a classroom setting, teachers must become familiar with the device to be used, including the benefits and shortcomings of the specific device selected. A basic understanding of how to use and troubleshoot the device is essential to successful integration of the technology into the classroom. Additionally, teachers must be supported in developing strategies and resources to implement the use of digital technologies in their classroom (Dunleavy, Dexter, & Heinecke, 2007; Salerno & Vonhof, 2011). Without this essential step, implementation will not produce significant, positive impacts on student learning.

A significant and growing body of literature supports the use of digital technologies in in a variety of classes in tertiary institutions (Bowen, 2000; Buck & Wage, 2005; Burrowes, 2003; Hake, 1998a; Springer, Stanne, & Donovan, 1999). These devices can be used in many ways, but seem most effective when they build on sound pedagogical practices found within learner-centered, knowledge-centered, assessment-centered, and community-centered learning environments (Bransford, Brown, & Cocking, 2000) that support interactive-engagement instructional strategies used within a constructivist framework (Hake, 1998a; Hill & Reeves, 2004; Jeroski, 2003; Ricci, 1999; Russell et.al., 2004; Schaumburg, 2001).

Conclusion

In this literature review, I began by explaining how science curriculum content is designed in British Columbia based on categories in the cognitive, affective and psychomotor domains. Next, I outlined four commonly-used instructional approaches in British Columbia classrooms: transmission, constructivism, social constructivism and self-directed or personalized learning. After this, I discussed the existing literature that examines the use of digital technologies in secondary and tertiary classrooms; and described some of the affordances and challenges of such technologies for biology teachers' pedagogy. In so doing, I found several areas that have an impact on a teacher's ability to use these technologies in an effective manner. I narrowed these areas down to three key ones: 1) creation of a supportive infrastructure; 2) understanding how student learning is best supported by digital technologies; and 3) providing support to teachers as they develop the skills and knowledge needed to utilize these technologies effectively in their classrooms.

Through the literature we can understand that the first pre-requisite to using digital technologies effectively in classrooms includes preparing an infrastructure that supports student use of digital technologies. This infrastructure must include effective and supportive leadership, a financial commitment adequate to provide for the purchase, maintenance, repair and insurance of the technologies, technological support for bandwidth, network access, software and storage, and clear articulation of the philosophical framework around why and how the digital technologies will be used.

Once the infrastructure is in place, teachers need to be engaged. A base level of knowledge about a digital technology and how to use it are essential. After this, teachers need to learn how to support student learning with digital technologies, as well as develop some ideas about how the digital technologies can be used to engage students and support them as they construct understanding. Ongoing support needs to be provided, ideally through regular, sustained professional development or participation in a professional learning group targeted at the specific grade and subject area being taught.

Finally, students need to be provided with a rich environment that places them at the centre of their learning, with the teacher acting in a strongly supportive role. The classroom should be set up to provide students with the information, media, and other supports necessary to engage students in the subject-matter, starting from what they know, and then using constructivist techniques to build a deeper and richer understanding of the conceptual knowledge, skills, and attitudes that support a mastery of the subject area under study. In the following chapter I discuss the selection, development and implementation of the methodology I employed to answer my research question.

Chapter Three: Methodology

Introduction

In the first chapter of this thesis I contextualized how I came to this research; recounting my pre-service teacher education; describing the contexts in which I taught as a science educator; and reporting on how I integrated technology into my own science teaching practice. In the second chapter, I defined the key terminology used for my research question, and proceeded to examine the literature pertinent to this question. Through the literature I identified and discussed: selected prescribed learning outcomes in the British Columbia Biology 11 and 12 curricula as grounded in conceptualizations of the cognitive, affective and psychomotor domains; four varied approaches to instruction – transmission, constructivism, social constructivism, and self-directed or personalized – that are used within British Columbia secondary classrooms; and three key factors that impact teachers' classroom use of digital technologies. These factors include a functioning technological infrastructure; understanding how student learning can be supported by digital technologies; and professional learning support for teachers' technological skill and knowledge development. While acknowledging my personal and professional contexts, and the existing literature regarding science teaching and technology, I now move to answering my main research question: "How do digital technologies and texts impact teachers' pedagogy in the high school biology classroom?"

In this chapter, I explain the research design that I selected for this study, and describe how I came to modify it in response to the challenges of carrying out research in the complex environment found in a contemporary high school setting. I summarize my selected methods and discuss their benefits and limitations. Further in this chapter I describe the participant sampling strategy that I used, my data collection tools and instruments, the timelines that I followed, and the processes for my data collection and analysis. I conclude by commenting on the validity of the data that I collected, and outline the ethical considerations pertinent to my study. The rich data that I collected for this inquiry, including descriptions of the teacher-participants, and my analysis of that data, will be presented in Chapter 4.

Population

To solicit teachers for participation in this study, a non-probabilistic, purposive sampling strategy was employed. As described by Trochim & Donnelly (2006), "nonprobability sampling does not involve *random* selection" (Nonprobability Sampling section, para. 1), and "in *purposive* sampling, we sample with a purpose in mind. We usually have one or more specific predefined groups we are seeking" (Purposive Sampling section, para. 1). For my study, the specific predefined group that I was seeking out was teachers of Biology 11 and/or 12, teaching in either a secondary or senior secondary public school, located in any one of the three school districts located in close geographical proximity to where I live on Southern Vancouver Island: School District 61 (Greater Victoria); 62 (Sooke); and 63 (Saanich). Selecting subjects in close proximity to where I lived allowed me to travel to their classrooms to interview them and observe the impact of digital technologies and texts on their pedagogy first-hand.

To recruit participants for this study, I initially mailed a letter to the superintendent of each of these three School Districts that outlined the study's parameters, and requested permission to contact the principal in each secondary or senior secondary school in their district (Appendix F). Upon receiving permission to do so, I sent an email to the principal of each secondary or senior secondary school in the district requesting permission to contact all staff members who taught Biology 11 and/or 12 (Appendix G). Upon receipt of their permission, I then sent an email (Appendix H) with attached letter (Appendix I) to each Biology 11 and/or 12 teacher-contact provided by their principals. The email and letter described the study, and invited the teachers to consider volunteering to be a participant. My goal was to obtain as many Biology 11 and/or 12 teachers as possible to take part in the quantitative strand of my study, and between three to five participants in the qualitative strand of my study. These strands are described in more detail below.

Research Design

To answer the question "How do digital technologies and texts impact teachers' pedagogy in the high school biology classroom?", I initially decided to employ a mixed methods approach "in which the investigator collects and analyzes data, integrates the findings, and draws inferences using both qualitative and quantitative approaches or methods in a single study" (Tashakkori & Creswell, 2007, p. 4). A mixed methods approach was deemed most appropriate because I understood that neither a quantitative nor qualitative approach was sufficient on its own to provide a fulsome answer to my research question.

As Creswell & Plano Clark (2011) state,

> Qualitative research and quantitative research provide different pictures, or perspectives, and each has its limitations. When researchers study a few individuals qualitatively, the ability to generalize the results to many is lost. When researchers quantitatively examine many individuals, the understanding of any

> one individual is diminished. Hence, the limitations of one method can be offset by the strengths of the other method, and the combination of quantitative and qualitative data provide a more complete understanding of the research problem than either approach by itself. (p. 8)

Selection of a mixed methods approach carries with it both advantages and challenges. According to Creswell and Plano Clark (2011), the advantages of utilizing a mixed methods approach include: (1) strengths of using both qualitative and qualitative strands in the same study negate the weaknesses present when either approach is used alone; (2) all data tools available to researchers can be used, rather than being restricted to the tools typically used in one or the other of the two approaches; (3) questions can be answered that cannot be answered by using one or the other approach alone; (4) the ability to bridge the divide that may exist between qualitative and quantitative researchers; and (5) encouraging the use of multiple paradigms. Challenges to employing a mixed method approach include: (1) the need for researchers to have skills in both quantitative and qualitative data collection and analysis techniques; (2) having enough time and resources available to complete the study in a timely manner; and (3) convincing others in the research community of the value of employing a mixed methods approach (Creswell & Plano Clark, 2011, pp. 12-16).

To answer my research question, I felt that the advantages of taking a mixed methods approach greatly outweighed the disadvantages, as well as being able to provide me with a more complete answer to my research question than I would have obtained by taking a purely qualitative or quantitative approach. As outlined in Figure 4 below, and described in more detail in Appendix A, my original research design was to carry out the quantitative and qualitative strands independently, utilizing an embedded design where "the researcher collects and analyzes both quantitative and qualitative data within a traditional quantitative or qualitative design…the researcher may…add a quantitative strand within a qualitative design, such as a case study" (Creswell & Plano Clark, 2011, pp. 71-72). My original plan was to perform the collective case study as the prioritized qualitative strand, and supplement this with a quantitative strand consisting of an anonymous online survey. Choosing a collective case study for my qualitative strand provided the benefits of hearing my participants' voices directly, and providing a detailed understanding of the contexts and settings in which they taught (Creswell & Plano Clark, 2011, p. 12). The decision to supplement the collective case study with a quantitative strand allowed me to, as Bryman says, "triangulate [my] findings in order that they may be mutually corroborated" and "bring together a more comprehensive account of the area of inquiry in which… [I am] interested" (as cited in Creswell & Plano Clark, 2011, p. 62). After data collection, I planned to mix the data during the data analysis phase of my research.

For the qualitative strand of my study, I chose a collective case study approach, where an "extensive study of several instrumental cases, intended to allow better understanding, insight, or perhaps improved ability to theorize about a broader context" was utilized (Berg & Lune, 2012, p. 336). As Yin states, "multiple cases are frequently considered more compelling, and the overall study is therefore regarded as more robust" (as cited in Berg & Lune, 2012, p. 336). Using a collective case study approach, I felt, would produce a richly textured, detailed understanding of the current, lived experiences of these high school biology teachers as they used digital technologies and texts in their classrooms. Data collected during the classroom visits then included teacher-participants' lesson plans, observational field notes, digital photographs and audio recordings of the physical classroom context, and participants' answers to semi-structured interview questions. I supplemented the collective case study with a quantitative strand consisting of an anonymous, online survey. In doing so, I understood that I would end up with a more complete account regarding the impacts of digital technologies and texts on high school Biology teachers in southern Vancouver Island.

Figure 4. Diagram of the planned flow of activities in this study.

Although I planned on carrying out the quantitative strand before starting the qualitative strand and mixing the data of the two strands during the data analysis phase, this plan evolved within the realities of classroom research. Due to the time it took to recruit participants, I ended up modifying my plan to carry out the quantitative and qualitative strands concurrently. As a result of this change, I ended up moving the point at which I mixed the data from the analysis phase to the results phase, as depicted in Figure 5 below.

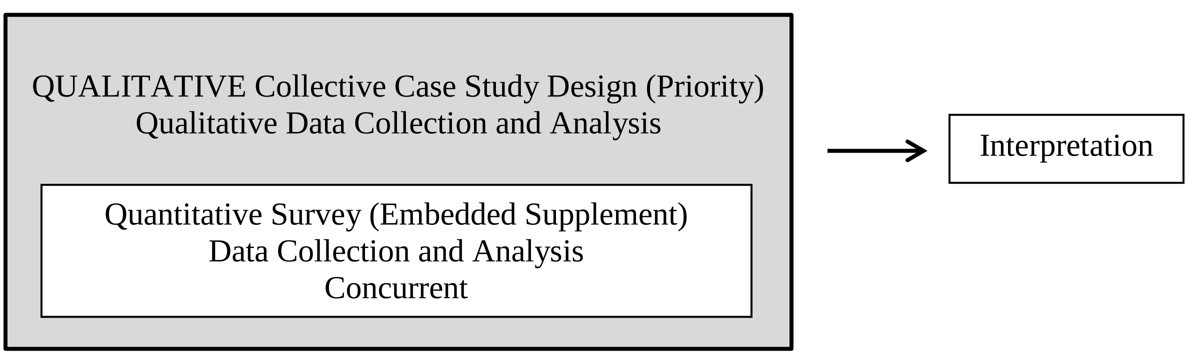


Figure 5. Diagram of the actual flow of activities in this study.

Instrumentation

Overview. Several tools were chosen by me for this research design to collect data during the quantitative and qualitative strands of my study. I designed this study and its data collection in reference to pertinent mixed quantitative and qualitative research methodology literature, and in consultation with my graduate supervisor. Typically, the graduate committee collaboratively responds to a proposed design of the study, guides the ethics approval and conduct of the research. This work became the sole responsibility of my supervisor as my other committee member had to withdraw due to emerging health concerns during this study. An alternate member joined my committee as I drafted this thesis.

The instrument that I used in the quantitative strand was a survey that I developed, and then administered through an online survey website. For the qualitative strand of my study I employed methodological triangulation and created a set of questions to be asked during semi-structured interviews that followed each classroom observation, set up a double-entry journal in which to record field notes, digitally photographed and audio recorded each classroom and lesson, and adapted a lesson plan framework for participants to use when planning the lesson they would deliver during each classroom observation session. Each of these tools and its use within my study is described below.

Quantitative strand. I planned to collect quantitative data first. To design the survey questions, I consulted the Research Methods Knowledge Base (Trochim & Donnelly, 2006). The survey that I developed contained a mixture of demographic, multiple choice, and open-ended questions to be administered in an anonymous online survey. Draft survey questions were reviewed and revised based on feedback from my graduate supervisor. The purpose of the online survey was two-fold. First, I needed to collect enough demographic information on respondents to determine whether or not they were members of my target population. Second, I wished to collect data on the types of digital tools and technologies that they employed in their teaching practice. Analyzing this information, I hoped to enhance the description of my target population and their teaching contexts beyond what I noted during the planned classroom observation sessions; that is, to enhance my understanding of the qualitative strand of my research.

The survey was created using the FluidSurveys (v.4.0) website. I selected this website because it is available cost-free, it can be accessed easily via the Internet for both the survey author and respondents, it is hosted on Canadian servers and therefore is not subject to the United States of America's *PATRIOT Act* (United States Department of Justice, 2001), and it supports all of the question types proposed in the survey design. For the anonymous online survey, high school biology teachers were asked simple, direct questions to create a snapshot of their teaching experience and the interaction between survey respondents and the digital environment as it pertained to their teaching practice during the fall of 2013. In this survey, I asked respondents about their teaching assignment, their years of teaching experience, to identify – from a list of currently-available web-based tools – which tools they used as part of their teaching practice, and to list any URLs, apps and computer programs they used as part of their teaching practice. A copy of the survey questions are provided as Appendix B.

Information collected in the survey was tabulated and frequency tables were prepared by me. I did this to triangulate survey results with the qualitative data for mutual corroboration, and to create a more comprehensive account of how high school biology teachers use digital technologies and texts in their classrooms.

Qualitative strand. I originally planned on collecting qualitative data after collection of quantitative data concluded, but that sequence changed due to the length of time that it took me to access the target population. In addition, public school teachers in the districts that I had recruited were approaching a province-wide job action. As a result, I modified my procedure to collect both sets of data concurrently.

Data collection for the qualitative strand occurred during, or in close proximity to the classroom observation sessions planned for each study participant. The qualitative instruments that I chose allowed me to hear my participants' voices directly, and provided me with a detailed understanding of the contexts and settings in which they taught. The data that I collected during each classroom visit included: a lesson plan prepared by the teacher before the session for me to use as a frame of reference during their instructional time; field notes within a double-entry journal regarding classroom learning and teaching events that I made during the lesson observation; digital photographs of the classroom environment taken before or after the lesson and digital audio recordings taken during instructional time; and participant's answers to semi-structured interview questions regarding the impact of digital technology and texts on their teaching. I conducted these interviews after their lessons, and recorded the interviews on a digital audio recorder for transcription and member checks at a later date. Each of these qualitative data collection instrument is described here in further detail.

Lesson plans. Before my classroom visit, study participants were asked to create a lesson plan for their lesson that I was to observe. Each of these served as an introduction and frame of reference for my observations during instructional time which is often a very busy and complex environment. In my communication with participants during the qualitative strand of my study, I stated that they were welcome to use any lesson plan format that worked for them. To help indicate to them the level of detail that I was looking for, I provided each participant with a lesson plan outline (Appendix C), modified from a sample that I received during my own teacher training ("Lesson Plan", 1983; Milkova, 2014). This template included considerations of instructional materials, learning objectives, timing, sequencing, procedures, and assessment. I also retained my copy of their lesson plan for analysis. These six lesson plans that I collected are stored in a locked cabinet drawer in my supervisor's office, and will be destroyed after five years.

Digital photographs and audio recordings. I used a compact digital camera to take 75 digital photographs of the classroom layouts, including the location and types of digital technologies present. I took these photos upon each classroom observation, either immediately before or immediately after the instructional time. In this way I documented the physical environment in which the lesson was delivered, and utilized the classroom images for methodological triangulation when analyzing my other data. Throughout the study, I was careful to take digital photographs at a time when students and school staff were not present in the classroom. I also digitally audio-recorded each of the nine lessons that I observed. These audio recordings were meant to serve as a back-up recording to clarify any observations that I had made in the double-entry journal. I did not transcribe these audio recordings, nor did I need to use them to clarify observational data in my double-entry journal.

Field notes. During and immediately after each classroom observation, I recorded field notes in a double-entry journal. Field notes were taken because "memory fades quickly and details are easily lost if one does not note them right away" (Berg & Lune, 2012, p. 229). Information recorded in these notes included "verbal exchanges…. actions, interactions, and activities [in which] participants of the setting are regularly engaged or involved…. [and] implied, inferred, or interpreted connections and associations between observed actions, interactions, and behaviors [sic]" (Berg & Lune, 2012, p. 230).

For each set of field notes, information recorded included a standard header consisting of the date, observation number, teacher participant, school, classroom number, number of students, time in, and time out. Notes pages were divided in half vertically, with observations listed in point form in the left-hand column, and my thoughts and interpretations listed in point form in the right-hand column. A sketch of the arrangement of desks in the classroom was also made. A sample of the layout used for my field notes is provided as Appendix D.

Semi-structured interviews. After each classroom observation, I interviewed the corresponding teacher participant. Each interview lasted on average 24 minutes, and was conducted in a setting selected by the teacher participant that, depending on the participant, was either a quiet corner of the staffroom, a shared teacher preparation area, or an office in the laboratory preparation room. All interviews consisted of a set of semi-structured interview questions that I developed in relation to my research question.

Semi-structured interviews were chosen as a data collection instrument because, as Berg & Lune (2012) describe, "the flexibility of the semistructured [*sic*] interview allowed the interviewers both to ask a series of regularly structured questions, permitting comparisons across interviews, and to pursue areas spontaneously initiated by the interviewee. This resulted in a much more textured set of accounts from participants than would have resulted had only scheduled questions been asked" (p. 114). Following guidelines provided by Berg & Lune (2012) regarding question order, content, and style, I began the interviews with "a few easy, nonthreatening (demographic) questions…. [followed by] the more important questions for the study topic" (p. 119). Questions were worded to "provide the necessary data" (p. 122), and were asked "in such a manner as to motivate respondents to answer as completely and honestly as possible" (p. 122).

After creating the questions, my supervisor reviewed and provided feedback on their approach and purpose in relation to my research question. The semi-structured interview questions that I used are included as Appendix E, and include a focus on the teacher-participants' understanding of: specifics of their teaching practice; the types of digital resources and interactions they utilized; information on ways in which they used the digital environment to support student learning; ways in which the digital environment complemented to their pedagogy; and ways in which the digital environment complicated their pedagogy. The main purpose of these questions was to better understand the lived impact of digital texts and technologies on each of the teacher's instructional experiences. As afforded by semi-structured interview, any additional questions that I asked were dependent upon the relationship of the content of lesson plan that the teacher provided to me before the instructional session, and the emergent nature of the instruction that I observed during the presentation of the lesson to the class.

Participant Recruitment and Response

In this section, I discuss how I selected participants for both the quantitative and qualitative strands of my study, where and when data collection occurred, and the processes of data collection during each strand of my study.

Quantitative strand. I collected the quantitative data through the anonymous, online survey described above. I made this survey available to secondary science teachers in Vancouver Island School Districts 61 (Greater Victoria), 62 (Sooke), and 63 (Saanich) via a FluidSurveys (v.4.0) website. Participants were solicited through a series of email messages: superintendents were asked to forward invitations to participate to high school principals in their district, high school principals were asked to forward invitations to participate to high school biology teachers in their school, and high school biology teachers whose email addresses were provided to me by their principals were emailed directly and asked to participate in the online survey. By employing this method, I estimate that contact was made with approximately 30 high school Biology teachers.

The online survey was launched October 23, 2013 and intended it to be 'live' for a period of 30 days. However, because I had received only three responses at the end of the 30-day period, I decided to extend the time period the survey was open to January 10, 2014. Since teachers were wrapping up their semester one activities and preparing for final examinations in mid-January, I decided to close the survey at that time, as I did not expect to receive any more responses.

Responses to the anonymous survey questions were collated by the FluidSurveys (v.4.0) website, and downloaded by the researcher to a Microsoft Excel (v.2010) spreadsheet file. A total of five responses were collected: these responses were tabulated (Appendices O to T, inclusive) and frequency tables were prepared.

In my design I intended to use the data collected in the online survey to compare with the findings obtained in the qualitative strand; to create a more comprehensive picture of the types and range of digital technologies and texts used by high school Biology teachers. However, after keeping the survey open for 80 days and receiving a response rate of only five, and with the teacher job action in mind, my supervisor and I decided that the possibility of more responses was limited despite the realization that the low response rate meant that my sample size was too small to be generalizable to a larger population. I did keep the survey data, electing to use it as demographic context and enrich the description of how digital technologies and texts were being used by selected British Columbia high school Biology teachers in their classrooms as observed during the qualitative strand of my study.

Qualitative strand. Employing a purposive sampling strategy, I received applications from four high school Biology teachers who volunteered to take part in the qualitative strand of my study. A few days after his volunteering to be a participant, one of the teachers informed me that he had received notification that he had been assigned a student teacher for eight weeks, which coincided exactly with the window of my data collection phase. This teacher offered to allow me to come in to his classroom to observe his student teacher, but I chose to exclude the student teacher from my study. I was interested in observing practicing high school biology teachers in the field, and I felt that since a student teacher is not yet certified to practice, they did not meet the requirements necessary to take part in my study. As a result, this particular volunteer was excluded from the study. The remaining three volunteers were selected to take part, and all three agreed to do so.

Two weeks before data collection began, I visited each participating high school to discuss the research plan and goals with each teacher-volunteer, and collect a signed copy of the Consent Form: Teacher (Appendix L). During this site visit, I also made a short presentation to describe the research plan and goals to the classroom students, and provided each student with a copy of the Consent Form: Student (Appendix M) and Consent Form: Parent (Appendix N). Although students were not the focus of this study, classroom interactions between the students and participating-teachers form part of the observational classroom data, and inform the teachers' reflection on their science instruction with digital technologies and texts. Therefore, the participating teachers' students or their parents (if students were under 18 years of age) were invited to sign and submit the *student consent form* or the *parent consent form*, with the signed copies returned to their classroom teacher. I made it clear to the students that their decision to have their classroom interactions included in the study's data would not in any way impact their experience of the course, or their results in the course. Classroom teachers used their class list to track and record the forms returned, and place the returned forms into a folder for the researcher to collect during the first classroom observation session. In class 1, 23 out of 25 student forms and 9 out of 25 parent forms were returned; in class 2, all 14 student and parent forms were returned; and in class 3, 28 out of 28 student forms and 14 out of 28 parent forms were returned. All returned forms were photocopied by me, and the copied forms were returned to the students. I retained the original copies and will keep them in a locked cabinet drawer in my supervisor's office for five years after the completion of my study. The classroom interactions of those students or parents who did not provide consent were not included as observational data in this study.

After three teacher-participants were selected, detailed information about their teaching context was collected. The school's setting (rural, municipal district or urban), population size, and socioeconomic status was determined. The school's timetable was scrutinized to identify whether classes were offered over the course of the full school year or were separated into semesters, and the duration of each class period was recorded. Specific data regarding classroom composition was compiled, including class size and gender split. Each teacher's background, including their training, area of specialization, number of years of teaching experience, and number of years teaching secondary Biology was gathered during the first of the three semi-structured interview sessions and is presented at the beginning of Chapter 4. For each participant, a pseudonym is used to protect their identity.

Qualitative Data Collection and Interpretation

In this section I describe my qualitative data collection experiences. Immediately before each classroom observation session, I collected lesson plans from the teacher-participants to gain an understanding of the lesson's goals, as well as an understanding of how the teacher planned to incorporate digital technologies and texts into the lesson they were presenting that day. I observed each participant teaching three times with these observations, and corresponding digital photographs and semi-structured interviews, spaced approximately one week apart during one term in the spring of 2014. The data collected allowed me to gain an understanding of the ways in which each teacher used the digital environment to support their teaching practice; how this support transformed or reified their approaches to teaching secondary Biology; and how students interacted with the teacher, the classroom digital technologies and texts as directed by their teacher. For each classroom observation I took digital photographs of the physical classroom context before and after instructional time, I did a digital audio recording during class time, and made field notes in a double-entry journal. Each lesson observation was followed as soon as possible (either during the next class period if the participant had a preparation period, or during the lunch break if they did not) with a semi-structured interview, where participants were asked about the goal of their lesson, methods and activities they used to attain the goal of the lesson, ways in which the use of technology complemented of complicated what they were able to do in the lesson, and for critical thoughts on what they might do differently if they were to present the same lesson again.

A fixed set of questions formed the core of each interview (Appendix E), but the questions asked at each interview varied based on what occurred during the classroom observations immediately preceding the interview, as well as on the teacher’s responses to the interview questions asked. The digital audio recordings of the semi-structured interviews that were made were later transcribed by me for analysis and submitted to the teacher-participants for member checking.

Upon completion of the classroom observations for a study participant, the lesson plans, field notes from the classroom observations, and transcripts created from the semi-structured interviews were all read once for me to become familiar with the entirety of the data collected for that participant. The data was then read a second time, during which content relevant to my research question was highlighted. Highlighted passages were copied and cut out, read a third time, and grouped to establish open, grounded code categories within each case. Axial coding was then used to group items identified by the open coding process into within-case categories. Within-case categories were then compared across cases, and any categories that occurred in two or more cases were incorporated into the categories identified as findings within the collective case study (Berg & Lune, 2012).

Data Validity

As I was conducting a mixed methods study, I had to consider how to ensure the validity of the data collected in both the quantitative and qualitative strands. "Validity differs in quantitative and qualitative research, but in both approaches, it serves the purpose of checking on the quality of the data, the results, and the interpretation" (Creswell & Plano Clark, 2011, p. 210). In this section, I will describe what I mean by validity, and then explain the methods I used to check the validity of my results.

Quantitative strand. Data collected in the quantitative strand was designed to be descriptive in nature: determining whether the respondent was a member of the target population and, if so, what types of digital tools and technologies were employed by respondents in their classrooms. To this end, the type of validity with which I was concerned was construct validity, the ability of my survey items to "measure what they intend to measure" (Creswell & Plano Clark, 2011, p. 210). To determine construct validity, I defined the constructs I wanted to measure, carried out a self-assessment to determine whether I would capture aspects of the constructs in my measurements, and asked my supervisor to assess whether my measurements made sense to him.

Qualitative strand. As Creswell and Plano Clark (2011) state, "checking for qualitative validity means assessing whether the information obtained through the qualitative data collection is accurate … Member-checking is a frequently-used approach, in which the investigator takes summaries of the findings … back to key participants in the study and asks them whether the findings are an accurate reflection of their experiences" (p. 211). Other validity approaches include triangulation of data, reporting of disconfirming evidence, and asking others to review the data (Creswell & Plano Clark, 2011). To validate the data collected during the qualitative strand of this study, data triangulation was carried out by comparing and contrasting observations and interpretations recorded in the field notes made during the classroom observations with the answers provided to the semi-structured interview questions and analysis of the information provided in the lesson plans. Additionally, after the semi-structured interviews were transcribed, copies of the transcriptions were emailed to each participant, and participants were asked to carry out member checks. However, due to job action taking place between the public school teachers and the Government of British Columbia during the data analysis phase of this study, only one of the study participants responded to the request for member checks. Disconfirming evidence was not reported, nor was anyone else asked to review my data.

Ethical Considerations

An Application for Ethics Approval was submitted to the University of Victoria's Human Research Ethics Board. Approval was obtained (Appendix J) prior to recruitment of participants and data collection occurred. Additional approval was sought and obtained from each school district (Appendix F). Once school district approval was obtained, informed consent forms were provided to school principals (Appendix K), teachers participating in the study (Appendix L), students in the classes observed (Appendix M) and parents of the students in the classes observed (Appendix N).

Limitations

When designing this mixed methods study, I also considered limitations on the quality of the data collected in both the quantitative and qualitative strands. "The limitations of the study are those characteristics of design or methodology that impacted or influenced the application or interpretation of the results of your study. They are the constraints on transferability and utility of findings that are the result of the ways in which you chose to design the study and/or the method used to establish internal and external validity" (Labaree, 2014, Definition section, para. 1).

Methodological limitations encountered in my study included (1) small sample size; (2) the measure I used to collect data in the quantitative strand; and (3) the collection of self-reported data in the qualitative strand. First, with only five respondents to the anonymous online survey, the sample size was just too small to ensure the sample was representative of the population under study. As a result, the data collected was neither generalizable nor transferrable: indeed, it became merely another form of data that informed the collective case study. Second, my decision to use a self-generated tool to collect survey data rather than using an already-validated instrument limited the validity of the survey results gathered. Third, the use of self-reported data in the qualitative strand means that the data collected cannot be independently verified, and that the data may contain sources of bias including selective memory, telescoping, attribution, and exaggeration (Labaree, 2014, Descriptions of Possible Limitations section, para. 3).

Summary

During the survey phase of this study, numeric and text data was collected in an anonymous online survey made available to all Biology teachers in School Districts 61 (Greater Victoria), 62 (Sooke), and 63 (Saanich).

Concurrent with collection of survey data, a non-probabilistic, purposive sampling strategy was used to select study participants from teachers identified as high school Biology teachers. As part of the qualitative strand of the study, participants volunteered to take part in three classroom observation sessions. During each classroom observation session, participants provided a written copy of their lesson plan before the observation session, the researcher observed the class and made field notes, and the observation session was followed by a semi-structured interview during which the participant's responses to questions were recorded as a digital audio file. Interviews were transcribed, and qualitative data collected was coded and analyzed for categories. Within-case and across-case categories were developed and compared, and used to create a collective case study.

In chapter four, I will present the data and describe the findings gleaned from that data as collected during the online survey phase. After this, data is presented through categories identified during the within-case and across-case analyses – these are identified and described, creating a rich understanding of how digital technologies and resources impact teachers' pedagogy in the high school Biology classroom.

Chapter Four: Data Presentation and Findings

In this collective case study, I endeavour to answer the main research question: "How do digital technologies and texts impact teachers' pedagogy in the high school biology classroom?" In the first phase of my study, an anonymous online survey was used as a tool to gather information from high school biology teachers in southern Vancouver Island regarding: their teaching background; access to digital resources; and the digital technologies and texts that they preferred to use in their classrooms. The data collected by this survey will be presented in the first sections of this chapter and used later in this thesis to enhance the qualitative data to create a more comprehensive picture of the types and range of digital technologies and texts used by high school biology teachers.

For the second, qualitative phase of this study I utilized methodological triangulation. After selecting three biology teachers using purposive sampling, these qualitative methods included: on-site observation, with a double-entry journal, of the three selected teachers' classrooms three times each during one semester; collection and review of each teacher's lesson plans for the three classroom visits; digital photographs and audio recordings during the visits; and semi-structured interviews following each classroom observation. The semi-structured interviews were transcribed by me, with the transcripts sent to study participants for member checks.

All of the data collected during the classroom observations was coded, analyzed by me for categories within the three single cases, and then re-analyzed by me for categories across the three cases. The cross-case categories were combined to create a rich, multi-layered collective case study. This is presented following the results of the anonymous survey data, which are represented in tables and organized within the categories that I used to group the survey questions presented below.

Survey Data: Quantitative Phase

The anonymous online survey was available to participants on the FluidSurveys website for 80 days. During this time period, a total of five respondents from three different school divisions answered the survey questions (Appendix B). Survey data served to enhance the description of my target population and their teaching contexts beyond what I noted during the planned classroom observation sessions; that is, to enhance my understanding of the qualitative strand of my research. Findings from the survey responses that I received are summarized below.

Table 1

Quantitative Results: Survey Respondent Background

Respondent	Primary Grade Taught	Primary Subject Taught	Years Teaching Experience
1	12	Biology	16 - 20
2	Other	Chemistry	16 - 20
3	11	Chemistry	26 - 30
4	12	Biology	16 - 20
5	12	Chemistry	11 - 15

Respondents. All survey respondents (N=5) self-identified as being members of the target population – high school science teachers. When asked to select the total number of years of classroom teaching experience they have, respondents reported having a minimum of 11 years of teaching experience, with most respondents (N=3) stating they had between 16 and 20 years of experience (Appendix O). Based on their self-reported years of experience, most (N=4) respondents received their pre-service teacher education during or prior to the 1990s, when the use of digital technologies in educational settings was relatively new. Therefore, it follows that the technologies they currently use are ones that they learned how to use on the job or during professional learning events.

Hardware used. When asked to select from a list of digital devices currently used as part of their teaching practice, all respondents (N=5) reported using a desktop personal computer; most respondents (N=4) reported using at least one other type of personal computer, either a laptop or tablet. The majority of respondents (N=3) also use at least one other type of hardware device, either an iPod, digital camera or SMART ® Board (Appendix P). Given that members of the respondent group were all secondary science teachers, it is notable that not one respondent identified laboratory probes as a type of hardware device they use regularly in their classrooms.

Table 2

Quantitative Results: Hardware Used

	Hardware					
Respondent	Desktop Personal Computer	Laptop Computer	Tablet Computer	Digital Camera	iPod	SMART® Board
1	✓	✓		✓		
2	✓					
3	✓	✓			✓	
4	✓		✓			
5	✓	✓	✓			✓

Web-based tools used. When asked to select from a list of web-based tools currently used as part of their teaching practice, the range of web-based tools identified was narrow (Appendix Q), given the number of open-source, no-cost options available to teachers. For all categories of web-based tools provided (content sharing, calendaring, photo sharing, collaborative authoring, video sharing, social networking, blogs, file sharing, and communication tools), a maximum of one type of software was used in any one of the given categories. The only exception to this was respondent four, who reported using three different tools for video sharing. "No response" was provided for 29 out of the 45 available categories in Appendix Q, indicating that respondents did not use any of the web-based tools available in that category. Of the more than one billion websites currently available on the Internet (Netcraft, 2014), the five respondents to this online survey reported using a total of five websites to support their teaching practice (Appendix R).

Table 3

Quantitative Results: Web-Based Tools Used

Tool	Respondent				
	1	2	3	4	5
Content Sharing	Google Docs	Moodle	x	x	Server
Calendaring	x	x	Weebly	x	Outlook
Photo Sharing	x	x	x	x	x
Collaborative Authoring	x	x	x	x	Wikipedia
Video Sharing	x	x	YouTube	• Khan Academy • Vimeo • YouTube	Moodle
Social Networking	Twitter	x	Facebook	x	x
Blogs	x	x	Weebly	x	x
File Sharing	x	School Dropbox	Dropbox	x	Moodle
Communi-cation Tools	x	x	x	x	Zimbra

x = No response

Computer programs / apps used. When asked which computer programs they used regularly as part of their teaching practice, survey respondents listed some type of office software suite, a document reader, a journal, and a gradebook (Appendix S). A minority of respondents (N=2) stated they were obliged to use no-cost, open-source alternatives to Microsoft Office, and noted this was problematic, in their opinions, because this software did not work as well as Microsoft Office. Concern regarding lack of funding was noted as a probable cause for them being directed to make this choice. When asked which smartphone or tablet computer apps they used regularly as part of their teaching practice, use of only one smartphone or tablet app (Appendix T) was reported, which was lower than anticipated given that a few (N=2) respondents reported using a tablet computer (Appendix P). While there is a lack of high-quality, science-specific apps available at present, many other types of apps that have classroom utility are readily available at no or low cost.

Framing the qualitative data. Trends identified within the survey data indicate that represented southern Vancouver Island high school Biology teachers are experienced educators. Although many of them received their pre-service education before the digital devices currently in use, such as tablets and smartphones, were widely available, they do have access to such hardware. But, they are unlikely to make classroom use of the range of web-based tools, programs or applications available to them. Having reviewed the survey questions and summarized the survey data collected from the respondents, I will describe the three participants selected to take part in the qualitative strand of my study, their classroom contexts and the school in which they teach. In this manner I provide a context in addition to the survey data for a clear within-case understanding of each of the teacher-participants. I later present their rich data – collected through a methodological triangulation of lesson plans, classroom observation, and semi-structured interviews – through categories that emerged in a cross-case analysis of Edward's, Luisa's and Diane's (pseudonyms) experiences teaching with digital technologies and texts in contemporary secondary biology classrooms.

Study Data: Qualitative Phase

In the following sections I introduce and describe each of the three teacher-participants, their classroom contexts, and provide an overview of their two school environments.

Participant one: Edward. At the time of the study, Edward taught Biology 11 and 12. He had been teaching for 16 years, with the past five of them at his present school. He earned a Bachelor of Science in Agriculture from the University of Alberta, as well as a Post-degree Professional Program Diploma in Education from the University of Victoria. He valued the high degree of independence afforded him at his school, the supportive department in which he worked, and the wide variety of students that attended the school.

The Biology 12 class in which I observed Edward was composed of 25 students; 11 of whom were male and 14 of whom were female. Of the 25 students in this class, 23 were residents of the community in which the school was located, and two were international students.

As can be observed in Figure 6 below, Edward had a computer workstation on his desk and a projector attached permanently to the ceiling of his classroom. During the lessons that I observed, Edward used the computer and projector regularly to display video clips, notes, and assignment outlines. I did not observe students using his computer during class time.

Figure 6. Edward's classroom.

School 1. Edward's school is a secondary school located in a district municipality that had a population of 15,725 in 2011. 84.4% of this population are of European origin, 68.9% of the population age 25 to 64 have a postsecondary degree, certificate or diploma, and members of the population in this district age 15 years and over have an average income of $46,687 (Statistics Canada, 2014a). As a result, the population of this district has a socioeconomic status that is somewhat above the provincial average. The school itself is located in a rural neighborhood just outside of a small municipality, from which it draws its population of 938 students (British Columbia Ministry of Education, 2013b). It offers a wide range of programs, including academic, athletic, international and artistic. The school also supports a very active social justice program.

For this school, the school year is divided into two equal-length semesters. Biology 11 and 12 courses are offered five days per week. Monday, Tuesday and Thursday classes are 85 minutes long, whereas Wednesday and Friday classes are 75 minutes long to accommodate Teacher Collaboration time on Wednesdays, and early dismissal on Fridays.

Participant two: Luisa. During the time of my study, Luisa taught grade 12 Biology, as well as Science 9 and 10, Mathematics and French Immersion in the same school that Edward taught. She had been teaching for 17 years, 14 of them at this secondary school. Luisa obtained her Bachelor of Science with a major in Biology and a minor in French from the University of Victoria, as well as a Post-degree Professional Program Diploma in Education from the University of Victoria. She appreciated how collaborative and supportive fellow staff are, liked the diversity in the student body and the level of engagement in the students she taught. She was glad that many of the students she taught "aren't necessarily doing it for the marks, …but they actually wanna (sic) know about their body, and they want some life-long knowledge out of it."

The Biology 12 class in which I observed Luisa was composed of 14 students, two of whom were male and 14 of whom were female. All 14 of the students were residents of the community in which the school was located.

As can be observed in Figure 7 below, Luisa used a tablet computer located on a small desk situated at the front of her classroom. It was attached to a projector mounted permanently to the ceiling of her classroom (not visible in photo). Visible on the mobile cart is a graphing display and overhead projector used for the mathematics classes she also taught. During the lessons I observed, Luisa used the tablet and projector regularly to display class notes, video clips, and websites. I did not observe students using her tablet during class time.

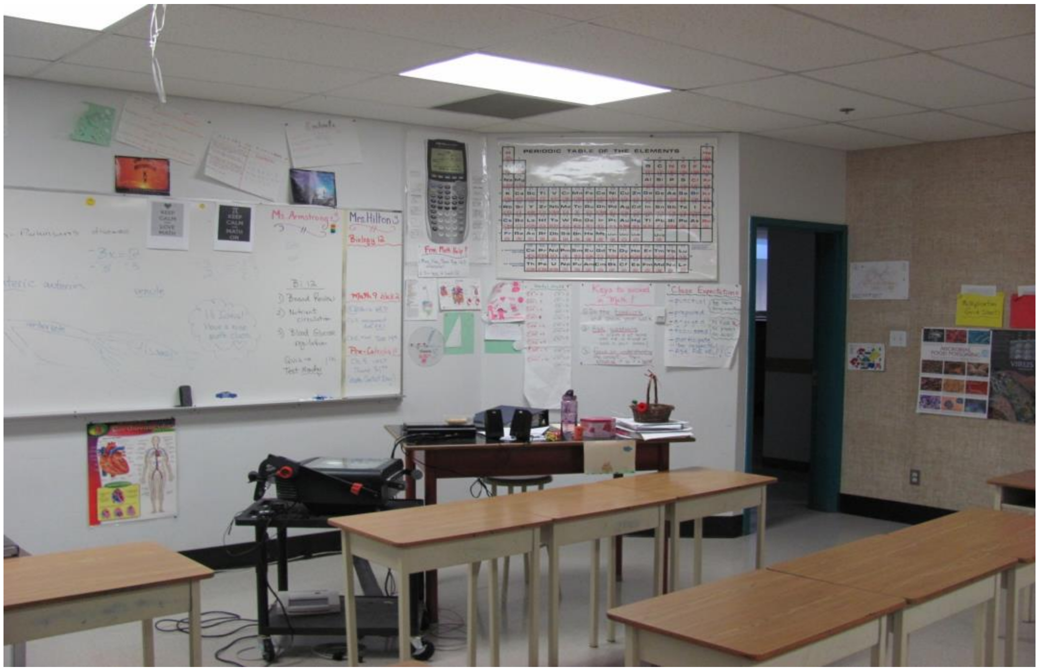


Figure 7. Luisa's classroom.

Participant three: Diane. Diane currently teaches Science 10 and Biology 11. She has been teaching for 22 years, the past 14 at this secondary school. Diane obtained a Bachelor of Science with a major in Biology and a minor in English from the University of Victoria, as well as a Bachelor of Education from the University of Victoria. She genuinely enjoys working with her students, and loves the energy they bring to the classroom.

The Biology 11 class in which Diane was observed consisted of 28 students, 7 of whom were male and 21 of whom were female. All 28 of the students were residents of the community in which the school was located.

As can be observed in Figure 8 below, Diane had a computer workstation on her desk that was connected to a projector located on a mobile cart. Also available for her use on the mobile cart was a VCR. During the lessons I observed, Diane used the computer and projector regularly to display PowerPoint presentations, video clips, and websites. I did not observe students using her computer during class time.

Figure 8. Diane's classroom.

School 2. Diane's school was a secondary school located in a city that had a population of 28,955 in 2011. 79.9% of this population are of European origin, 61.7% of the population age 25 to 64 have a postsecondary degree, certificate or diploma, and members of the population in this district age 15 years and over have an average income of $40,530 (Statistics Canada, 2014b). The socioeconomic status for the population in this district is at the provincial average.

This school is located in a city, and draws its population of 1,408 students (British Columbia Ministry of Education, 2013c) from both the city and its surrounding area. In addition to the regular provincial curriculum, this school hosts an institute for sports excellence, and institute for global solutions, and a pursuit of academic excellence program. The school year is divided into two equal-length semesters, with Biology 11 and 12 courses offered five days per week. Monday, Tuesday, Wednesday and Thursday classes are 80 minutes long, but Friday classes are 66 minutes long to allow for early dismissal.

Cross-case Data and Categories

In the above section, I framed the qualitative strand by describing the within case data. Teacher-participants taking part in the qualitative strand were introduced, their teaching assignments recounted, and their pre-service teacher education described. After this, the student population making up their classes was identified, and the technology configuration present in each classroom was reported. Next, significant details about the municipality in which each school is located and demographic information pertaining to the socio-economic status of each community were described. I closed this section with details regarding each school's calendar year and timetable. In the following section, I move from a discussion of the within-case data to the cross-case data. The cross-case data is described and organized into emergent categories. These categories include:

Category 1: Adaptable, shareable digital texts. All participants in this study appreciated that working in a digital environment that allowed them to create lesson support documents such as notes made with a word processing program and slide decks made with presentation software such as Microsoft PowerPoint. Digital texts made in this way were permanent enough to be stored for re-use or sharing with others, yet these texts were adaptable to new classes, curriculum, or users.

Using a word processor allowed the three teachers to create a note skeleton into which they could insert detailed content, hyperlinks to other related web content, and graphic images. Once created, documents could be saved for the teacher's own personal use, shared with other teachers, or uploaded to a website such as the school's *Moodle site* (an online learning platform that supports learning and communication outside the physical classroom) for sharing with students and parents. An additional advantage noted was that, once created, documents could be improved and/or re-purposed.

Diane, in particular, was fond of using PowerPoint for presenting notes to her class. When asked to describe some of the ways in which using technology added to what they were able to do in their classroom, this teacher stated:

> PowerPoint notes are so much better than I could do if I had to write them out on the board. I can bold things that I need to bold, I can put diagrams with them that complement the notes that I'm giving…[my notes are] much more clear, concise, everything is just much nicer, … and then, of course, you're not trying to figure out on the on the fly, where should I put an indentation, where is this subtitle supposed to be, …I don't have to worry about forgetting stuff, I can edit it so easily when I need to, … I love PowerPoint.

Other advantages to having a digital copy of one's notes that were identified by the participants included having the ability to improve the quality of content over time, re-purposing notes on a particular topic for use in another class, and being able to search and easily find topics already covered while reviewing course content with students; contrast this with the impermanence of writing notes on a chalk or white board, and this aspect of the digital environment was perceived by participants to be a definite benefit to teachers' pedagogy in the high school Biology classroom.

A significant advantage to working in a digital environment was identified by study participants as the ease with which one's files and resources could be shared with other audiences. Participants regularly shared files with colleagues working in the same school, in a different school in the same school district, and even between districts. Files were also shared between home and school, primarily from the teacher to their students and/or the students' parents. Less common was a sharing of files within the classroom: when done, it was almost always directed from teacher to student, for example, when providing notes to a student who missed class.

Participants appreciated that they could share lesson plans, information, image files and enrichment activities with colleagues they met at conferences and professional development events, as well as with colleagues working in their own school district. As Edward states:

> I just started to use Google docs, and so that's actually allowed me to share some lesson plans and information with people that I've met at these pro-D [professional development] conferences, specifically Biology 12 teachers with, you know, enriching activities, the lab we did today is not an example, but there's very similar stuff that have, it's been shared from people that are teaching Bio [Biology] 12 throughout the province that come from the [United] States [of America] and all over Canada.

Luisa had also created a Moodle site, and found it to be a valuable link between home and school that engaged parents.

> Technology is helping with home communication, it helps engage parents, too, because you're not playing telephone tag or email tag … I had to send out …

> an introductory letter to all the parents explaining to them here's the web site, here's how you get to it and this is what I'm going to use it for. And so now I think they're going there, and then they'll … check it, but he still has these questions. But at least they made that initial check, right? So … it's being used to sort of, help kids be proactive, it's being used in instruction, it's being used to sort of, monitor and verify. I'm trying to use it for a variety of different things.

The ability to share digital texts extended the relationship between teacher and student as well. Study participants found the notes they posted online were useful when a student missed a class, and also thought that allowed students to download, create and personalize their own copy of the notes provided by the teacher.

Category 2: Online digital texts conserves a teacher's time. A significant impact of the digital environment on all three teachers' pedagogy was the time that these teachers were able to save using online digital resources. The participants noted that quality instructional resources are plentiful and readily available on the Internet. A combination of searching with Google and/or YouTube was used commonly – even during a lesson in progress – to respond to a student's question. This was because teachers found that they could find answers to specific student questions and enhance, or clarify, a verbal description of a biological process that they were making in class almost instantly, without taking a trip to the library or consulting with another teacher. Teachers also reported that they preferred this informal approach, because it was self-directed, responsive to student questions, and fast.

Participants also noted how much easier YouTube was to use than previous video options, such as digital video discs (DVDs) or video home system (VHS) tapes. Digital videos can, using a search taking only a few seconds, be found online relating to almost any topic. In contrast with physical media, digital video accessed online was free of charge. Additionally, it did not require: physically rooting through a shared library or collection to find the correct item; submitting a request to a shared library and waiting for the media to arrive; booking a playback device and physically moving it to/from the classroom; and the extra time required to fast-forward to a desired location on the media.

Teachers also appreciated how quickly they were able to access new ideas: indeed, as Edward noted, "the biggest impact [of using technology] for me is … quick access to ideas. You can find out what other people are doing at anytime, anywhere ... and you don't have to reinvent the wheel, so … the Internet's a time saver, definitely, for lesson planning". All three study participants were very comfortable turning to Google for almost any purpose, ranging from checking facts, finding pictures and videos, locating lesson ideas and plans, and even checking sections of text taken directly from a student's assignment to see if it appeared online as a spot-check for copying. Participants reported finding websites in a variety of ways: through their own research, in discussions with colleagues, and shared at professional development opportunities in which they took part.

This point was illustrated dramatically during my first classroom observation of Edward, where he taught, for the first time, a lesson he had recently downloaded from the Internet. The lesson was designed to provide students with a better conceptual understanding of a topic that, in my experience, is difficult for students to understand: enzyme function. In this lesson, one member of each group used their hands as the enzyme "toothpickase". Their task was to break toothpicks (the substrate) in half.

Enzyme function was slowed by wearing gloves (mimicking denaturation of the enzyme), the addition of paper clips to the pile of toothpicks (mimicking inhibitors), and placing their hands in a bath of ice water (effect of temperature). The students were focused and engaged throughout this lesson.

Another clear advantage, as it emerged from the data, with online digital texts and resources is that the teachers no longer have to wait for the rare occasions when they are able to connect one-on-one with others teaching the same subject, such as at professional development days or during meetings of specialist councils, to share resources. Instead, they can turn to online professional learning networks of colleagues for ideas and plans whenever they are looking for a new idea. Participants reported this definitely improved the quality of the lessons they prepared for and presented to their students.

Category 3: Digital technologies consume time. Although digital resources can provide significant time savings, study participants also noted that digital technologies and resources can create a significant drain on their time, as well. One facet of time consumption identified by the study participants was the feeling that it required a significant investment of time to learn how to use digital technologies in meaningful ways. Participants sometimes struggled to use available technologies effectively, realizing that the technology was capable of being used in certain ways, but they found that they lacked the skills to do so, and felt that many of the technologies they would like to use had steep learning curves. For example, one teacher said they would like to be able to edit video clips to pick out only the sections they wanted to show, and then stitch them back together in a logical manner. They were aware that it was possible to do this, but admitted they personally lacked the skills to do so, and were not sure how or where they could pick up this skill set.

All study participants noted that they had not learned how to use these technologies in university during their pre-service teacher education, and found it difficult to access technology training because although the training was scheduled, it was not necessarily at a time or in a location convenient to them. They also realized that they did not know enough about digital technologies and how they worked. As Diane summarized, “My answers are limited by my own experience”, while Luisa stated “I don’t know enough about it and how they work, and how it can be implemented in my classroom”. Edward questioned the value of putting “dozens of hours of time into learning something so you can use it for your half-hour of lesson time, … you have to look at where your energies need to go. Especially during the school year, trying to do your marking and plan for the next day’s lessons”.

Another aspect of the time that is consumed by digital technologies related to finding digital texts to use in class. One participant found it time-consuming to find subject-appropriate resources on the Internet that contained meaningful, accurate content delivered at the right level of difficulty for their students. They appreciated the fact that the videotape resources they previously used were pre-screened, on topic at the right level of difficulty, and good to go right out of the box, with no modifications necessary. Another participant lamented the amount of time they spent flipping through a slide deck when trying to find a particular slide, but did acknowledge this process was faster than using the fast-forward and rewind functions on a videocassette recorder (VCR) to find specific sections on a videotape.

Category 4: Increasing student engagement. All of the teacher-participants noted that their learners were more engaged when using texts from the digital environment. It was the participants' opinions that students tended to find digital resources both more personally relevant, and more interesting. Digital video especially was felt by participants to pique students' interest, grabbing and holding their attention. This was evident to me during the classroom observations that I made. Students in all three classrooms observed were quiet, attentive, and had their eyes focussed on the screen whenever they were watching online video.

For presenting notes to their students, participants appreciated the ability to layer their presentations, add colour to their notes, adjust the sequence, content and depth of content coverage, and incorporate a variety of file types including images, audio, video, animations, and quizmeBC questions into a lesson presentation. Use of quizmeBC questions afforded teachers the opportunity to do a quick check of students' conceptual understanding, by generating 10-question online quizzes that include questions similar in format to the following (Taylor & Yeow, 2014):

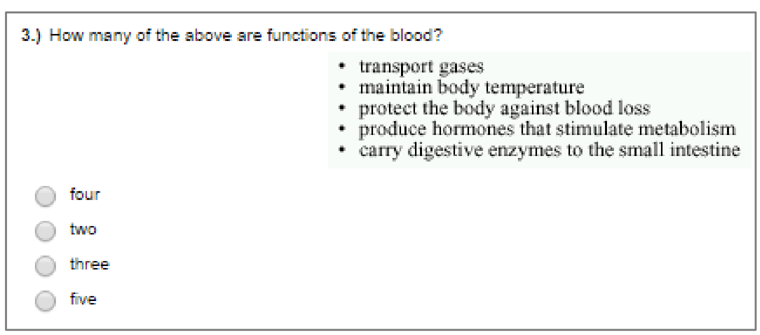


Figure 9. Sample QuizmeBC question.

Participants also reported that providing notes to students using a tablet and projector, along with the use of colour, seemed to engage students better and kept students focussed during the activity of note-taking. This again was evident in the classroom observations I made as students in all three classrooms observed were attentive and focused on the screen whenever they were taking notes projected onto a screen.

Diane noted the challenges of writing on a standard classroom white board for a person who is shorter than average, and explained the benefits digital technology afforded them in the classroom in this way:

> Because I'm a terribly short person, … I don't like writing on the board. I like drawing on the board, and labelling on the board. But if I actually have to write notes, I'm too short, I can't use the top of the board, … and then the kids who, if I'm writing at the bottom of the board, the kids can't see my writing at the bottom of the board. So, it was always a struggle."

She solved her problem using a projector (labelled "B" in Figure 10 below), to which her computer (labelled "C" in Figure 10 below) was connected and from which she could then display her lesson notes onto a screen (labelled "A" in Figure 10 below), which was clearly visible to every student in her classroom.

Figure 10. Example of classroom technology configuration.

Additional advantages to presenting information to students using a projector were identified by the three teachers. They found that this presentation style helped with classroom management, because it allowed the participant to face their students when presenting notes, rather than turning their back to the class when writing on the board. As Diane further noted,

> … one of the things I like the least about using the board is I don't like having my back to the class, and not because I think they're being bad, it's because when you talk to someone, you want to look them in the eye and address them, and I find it's a much more personable way to teach kids.

Luisa also discussed the impact of presenting material with the digital technologies in her classroom:

> I think it's helped with management. I'm facing them all, I'm not turning your (sic) back. And there's no paper balls, and that kind of thing, cause you're not turning your back…and they're seeing your face the entire time, so I can monitor things, but I think they just feel in on it the whole time. They don't feel like you've left them every time you turn around." and "I've found that …they just feel like they can clarify more. They seem to ask more, I don't know what it is, maybe it's less intimidating because I'm not physically waking in front of the room, I'm seated with them. I don't know. I've just noticed that. As opposed to when I'm up there, they feel like they're interrupting me.

Category 5: Communication style is multimodal. The study participants felt that using the digital environment allowed them to present information to their students in a variety of new and unique ways. For example, Edward was pleased to note that:

> … it's nice for them [students] to hear a different style of presentation, I mean, that presenter is selected because they're breezy and humourous and, you know, even though we try to achieve that level in our classrooms, it doesn't

> always get there, and it gives me a chance to sorta (sic) watch the kids learning and listen to what they're talking about as well while it's playing.

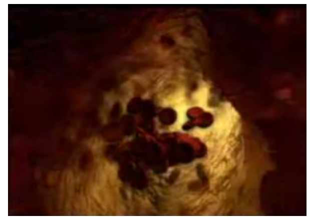
Another participant noted that the use of resources gathered from the digital environment allowed them to show dynamic processes occurring in a continuous flow, thereby illustrating a process far better than they could using a verbal explanation, textbook reading or series of diagrams. An added advantage was the ability to pause a video clip or animation to zero in on a particular segment of the process at any time, scrub back and forth to clarify a part of the sequence, rewind and view a section again, or jump ahead to another part of the process.

Participants also noted that using digital files and projection technology to display information to students ensured that all students looked at the same thing at the same time. Their presentation of information to students was far more dynamic than writing on the white board, and this format allowed them to quickly jump from one topic to another to answer a question or relate a newly-covered concept to something that had been covered previously. This, they felt, helped students to better relate and connect concepts and topics together. Through trial and error, one teacher found that she further enhanced her students' ability to do so by using the same font colour throughout a particular topic to visually chunk related concepts together.

Participants also noted the value of using digital animation. One example offered involved showing a video clip to students called "Cardiovascular Disease", which was a combination of live action and animation of a heart attack extracted from *Body Story: The Beast Within* (Discovery Channel, 1998) and made available on YouTube. It transitioned back-and-forth between the actor displaying the symptoms of a heart attack, an image of his heart showing the damaged area of the organ, and an image of the inside of the actor's coronary arteries showing them clogged with fat and blood cells (Thrush, 2010).

Organism View

Organ View



Cellular View

Figure 11. Screen captures from "Cardiovascular Disease".

Teachers also experimented with using digital technology in more interactive ways. For example, one participant noted that they could project an image on the white board, and have their students take turns coming up to the projected image and labelling parts of the heart on the white board. This teacher also played audio files they found online for a variety of heart sounds, both normal and abnormal. They felt that these clips helped their students to experience and understand the role of a physician listening to a human heart through a stethoscope as they tried to diagnose an illness – a resource not readily available to high school students and their teachers through any other means.

Finally, Luisa appreciated that the availability of digital technology expanded their options. They could use any digital media they liked, while still retaining the option to supplement digital resources with analog ones, either for variety or to pick which tool they thought worked better for whatever they happened to be doing with their students in that lesson/topic.

Category 6: Changes students' learning processes. Participants expressed concerns regarding how their students use the Internet. The teachers I observed felt that students are more likely to copy and paste information from websites without critically evaluating the information now than they were in past years. Also, since "it is really easy for them to just put their name on someone else's work" (Luisa), teachers have found that they need to re-think the value of such methods as the research report; how they structured it as an assignment, how they ask students to present their findings, and how they as teachers evaluate it.

Another concern expressed to me centred on how students took notes. One participant found that handing notes out to their students, whether as printouts from a digital source or by making digital files directly available to students through a website, resulted in poor retention of the content. In this teacher's experience, she felt that when students wrote notes out themselves, and followed the act of scribing up with colouring, highlighting, and rewriting their notes, students tended to retain the content much better.

Another concern expressed by participants centered on a significant shift in the place of learning 'facts' in a school setting. Diane noted that:

> …you don't have to remember anything. … you have a question, you're in a group of friends or peers or whatever and you have a question, and you don't even have to discuss the question anymore … what do you think about this question, what information do you have? They just pull out a phone and they look it up.

This aspect of the current digital environment was found to be particularly challenging by this participant during a lesson they taught on animal classification. Beginning by handing out a set of colour images of invertebrate organisms to groups of students, Diane wanted her students to use their own critical reasoning based on observable morphology to sort the organisms into groups. She worried about students accessing their cell phones during the exercise, and said "I certainly wouldn't want them [students] to use their cell phones, and then start looking stuff up. They'd try to find the answers to things. So, in that respect, I wouldn't want them doing that." She wanted students to focus on the process, rather than the 'correct' answer. To reinforce this during the lesson, she walked around the classroom making sure students did not access their cell phones, and explained to more than one group of students the importance of careful observation of the organism's structures, along with application of logic, were necessary to develop a classification scheme for the organisms.

All three teachers expressed concerns about working in a digital environment, and the effect the digital environment had on both them and their students. Concerns expressed included giving up control over instruction. Luisa stated, "…you don't want the technology, whatever it is, to be the teacher." Another participant felt that, when they used digital technology to present notes to their students, their delivery style was not as free-flowing or as responsive to student interest and questions as when they used a more traditional 'stand-and-deliver' (transmissive) presentation style. The data indicates these participants' awareness of the tensions between more traditional processes of learning in the classroom and the opportunities now afforded to students and teachers through the digital tools to which they now had access.

Category 7: Expense. All of the participants noted that accessing and using digital technologies and texts in the classroom could sometimes came with a hefty price tag. This included examples such as replacing bulbs on older digital projectors, or initiatives to provide all students with tablet computers. They went on to state that funding limitations and stipulations meant individual teachers, or their departments, sometimes had to make difficult decisions about where to spend their scarce educational dollars. Such decisions determined which learning supports were funded, and which were not, and had implications on purchases made in areas other than technology. As a result, desired tools and resources may not be available to teachers, which, in turn, impacted the ways in which those teachers could teach.

Category 8: Unreliable technology. Study participants expressed concern about the digital environment letting them down from time-to-time. “Well, when it doesn’t work, like today” related Luisa, “sometimes I just abandon it. The tablet can be a bit temperamental, or we’re having a complete Internet issue”. Indeed, all participants in the study relayed several examples of technology not working. This included dead hyperlinks, video clips removed from a previously bookmarked site, the network going down during class time, and frustration with the amount of ‘dead time’ that occurred during class while they tried to troubleshoot a device that was not working. As Diane summarized, “you realize how dependent you are on this particular mode of deliverance. And you’re just like, oh my goodness! … it really radically changes your … presentation if you can’t use that technology… or I’ve forgotten my thumb drive at home.” Luisa made sure that she had a fall back plan. “I also have a binder. I like to still have that base, so if I lost that technology, I’d still be fine”.

Category 9: Requires specific contexts. Participants noted it was extremely easy to find content and lesson plans on the Internet. However, they felt that this content needed to be personalized and made their own before they could use it; synthesizing the material into something meaningful to them and their class because, as one participant noted, “each teacher is different, [just as] each learner is different” (Edward). Luisa said, “…it’s never ever exactly the same. You cover that topic, you cover those outcomes, but the delivery is always different and the number of hands-on, or visual, or tactile, or breaks in between theory varies, every single time.”

Participants also felt that digital video clips also needed to be contextualized to be meaningful. They found many available videos to be too long, or the content provided too easy or too difficult, not interesting, or not relevant. One participant found a need to provide open-ended questions before starting a video clip, to help focus their students on finding the intended meaning of the clip. They also expressed worry that using video took away from their lecture time.

Another digital technology and text criticized by study participants was slide decks. Although slide decks were easy to come by and share with colleagues, participants didn’t like the state of many of the decks they obtained from colleagues. Diane described the slide decks she received from one of her colleagues thusly:

> … they were horrid. They had little tiny fonts, and there was tons of stuff on a page, and she loves pictures, so there’d be tons of pictures shoved in there, so every time I did, I’m taking Sponge Bobs out, and, um, making font bigger, and spacing things more.

To be useful, participants found that slide decks received from others had to be heavily edited before they felt comfortable using the slide deck in their own classrooms.

Participants also questioned the effectiveness of the slide decks that they used. One participant felt that slide decks were too dissociative, separating the teacher from their students. This participant also felt that using slide decks prevented their students from thinking, as students tended to focus on creating exact copies of the notes presented on the slides, and expressed fear that they might miss something if they did not copy down every word from every slide. This participant felt that, as a direct result of this action, their students did not learn how to take notes critically.

Category 10: Not multisensory. Because it is a science, an important part of the study of biology occurs in the laboratory. This is an area in which participants felt digital technology did not support student learning very well. One participant preferred to carry out a simulated enzyme activity using laminated cards to represent enzymes, substrates, products and cofactors because students could move the papers and thereby simulate activity occurring in their cells in a physically active way. The same participant stated that they felt that colouring black-line diagrams helped their students grasp and retain knowledge of anatomical structures and relationships better, and using personal white boards to write and display answers to questions asked was both engaging and revealed to this teacher how well their students understood content presented in class.

Another participant felt that an activity they used to teach students about animal classification would have been easier for students to do accurately if they had three-dimensional models of the organisms, rather than using two-dimensional, digitally-printed images of the organisms. For example, this teacher felt that their students would have classified the worms differently if the students were able to handle and manipulate a three-dimensional flatworm (Phylum Platyhelminthes), round worm (Phylum Nematoda) and segmented worm (Phylum Annelida), because they would be better able to see the structural differences between each type of worm in a model rather than in an image.

The third participant found that using real laboratory equipment, such as stethoscopes with which students could listen to each other's hearts, was a very engaging activity to do in their class. They also felt that when students did not manipulate organisms in the lab, for example, when dissecting the skull of a pig fetus to expose and view the brain, their students did not gain the type of psychomotor skills they needed later in university, for a career in medicine or dentistry, for example. This participant also expressed an interest in purchasing three-dimensional models of human organs or a torso, which would allow their students to look at the structure of the internal organs, the relative position of organs to one another and within the body as a whole, and provide their students with the ability to explore, move and touch the model organs – all tactile experiences that they felt would reinforce student understanding and retention.

Summary

In the quantitative strand of this mixed methods study, I collected survey data from high school science teachers about the number of years they taught, the type of digital hardware they used regularly, and the types of web-based tools, websites, computer programs, and apps with which they supported their teaching practice. This data was used to compare with the findings obtained in the qualitative strand, to create a more comprehensive picture of the types and range of digital technologies and texts used by high school Biology teachers.

During the qualitative strand of my study, I visited the classrooms of three high school Biology teachers. In each classroom, I observed three different lessons. During each observation, the teacher shared with me their lesson plan for the class, allowed me to observe the lesson and make field notes during my observation, and sat down with me to provide answers to questions I asked as part of a semi-structured interview after each observation session. During these classroom observation sessions, I was able to collect rich data on how digital technologies and texts impact the pedagogy in these particular high school Biology teachers' classrooms. This data was reviewed; important statements and ideas found in the materials gathered from each case were colour-coded, analyzed and sorted into categories, after which across-case thematic analysis was applied. From this data several common categories emerged, as discussed in detail above.

An overarching connection between the study participants was an expressed need to "find a balance that works for me" (Luisa). All three participants in the qualitative strand of this mixed methods study used the digital environment in their classrooms. In all three cases, using the digital environment was not cost-free; the balance point for each study participant was different. The decision to use a particular aspect of the digital environment, or the digital environment in a particular way, often simultaneously complemented and complicated the teacher's pedagogical practices in their high school biology classroom. As a result, each of these teachers had to strike a balance between their use of the technological and textual elements in their classrooms: the digital and analog environments in which they worked, providing information they felt their students needed while keeping their students interested in the subject matter, spending time learning to use a technology versus the in-class value using it provided, and receiving a resource from the digital environment, yet needing to customize it to fit the unique needs and context of their classroom. It is these broader thematic findings, and the complexities revealed through their contradictions, that will be examined in this thesis' next and final chapter.

Chapter Five: Discussion

Synopsis

I became interested in my research question gradually, over the course of my teaching career. When I began teaching, digital technologies had just started to enter public school classrooms. Many students used calculators to help them with mathematical and scientific calculations, and computers were recent additions located in specialized classrooms. Student interaction with computers consisted of learning the parts of these machines, practicing keyboarding, and writing some basic programs. It was not possible to access the Internet from within a public school in Alberta at that time.

Over time, digital technologies and texts became increasingly available and accessible to classroom teachers, including me. I have always been interested by the possibilities created at the interface between the digital and real worlds, yet often frustrated by the practical challenges created at these points of intersection. To deepen my understanding, I decided to focus my study on one of these points of intersection, and investigate for an answer to the question: “How do digital technologies and texts impact teachers’ pedagogy in the high school biology classroom?”

To this end, I planned on employing a mixed methods approach. However, based on the low response rate to the survey, I elected to use the survey data collected to enhance the qualitative data collected in the collective case study. An anonymous online survey was used to collect descriptive data from high school Biology teachers in southern Vancouver Island about their teaching background, access to digital resources, and the digital tools and texts they preferred to use in their classrooms. I utilized the data gathered in the survey to enhance my understanding of the qualitative strand of my research.

During the qualitative strand, three teacher participants' classrooms were visited three times each during one semester. Data collected during each site visit included a paper copy of the teacher's lesson plan, an observation of their lesson during which field notes were made, and digital photos and audio recording were taken, and answers to semi-structured interview questions that were digitally recorded and later transcribed. Data collected during these classroom observation sessions were coded, analyzed for categories within cases, and then re-analyzed for categories across cases. The cross-case categories were combined to create a rich, multi-layered combined case study, discussed in the previous chapter. In this chapter I will discuss my findings, identify implications and recommendations related to them, comment on their transferability, and make suggestions for future research.

Findings

My inquiry was guided by a pragmatic worldview. Working within this framework, I carried out my study in the type of classroom environment that I knew well, having taught in a similar setting for nearly twenty years: a high school biology classroom.

Although I intended to gather enough responses to the anonymous online survey to develop a more generalized view, the five responses that I received were used to provide demographic context and enrich the descriptions created as part of the qualitative strand. Data collected from the five respondents in the survey indicated that they, as high school biology teachers in southern Vancouver Island, tended to have several of years of teaching experience, and had a range of hardware devices available to them that provided access to a variety of digital technologies and texts. However, there appeared to be a fairly low adoption rate of non-video resources for classroom use, and the range of computer programs, websites and apps used was quite narrow.

During the qualitative strand of my study, I entered three different classrooms to make detailed observations and engage in rich, textured discussions with my hosts. In all three cases, digital technologies and texts were readily available and regularly used. This provided me with ample opportunity to catalogue the affordances and challenges faced by high school biology teachers when using these technologies and texts. Following this analysis, observations I made were coalesced into three main themes using open, focused and axial coding techniques. These three main themes include: changing pedagogy requires support; inhabiting a new space creates contradictions; and there is a role for traditional teaching methods within a digital world.

Theme 1: Changing Pedagogy Requires Support

All three participants in this study saw value in using digital technologies and texts, and were observed regularly employing both in their classrooms. Because of this, I was able to observe ways in which digital technologies and texts afforded and challenged these teachers. This is important, as it illustrates the struggles experienced by teachers trained in traditional methods as they figure out how to deliver content to digital natives. Underscoring this importance is the timing: the Ministry of Education in British Columbia is currently re-writing the high school Biology curriculum, while simultaneously supporting principles of ‘21st Century Learning’. My findings can inform this transition.

One of the aspects of digital technologies and texts identified as adding value to teachers' pedagogy was the frequent observation that using digital technologies and texts engaged students better, which corresponds with Hake's findings (1998b). Participants in their answers to semi-structured interview questions, and I through my field notes agreed that learners were often observed to be quiet, focussed and more attentive when interacting with digital technologies and texts. Examples of this were seen in observations of students watching digital video on YouTube, or taking notes from texts projected onto a white board from a desktop or laptop computer displaying a teacher-generated PowerPoint presentation.

Using digital technologies and texts also allowed teachers to present information to their students in different ways, including: showing content created and presented by an engaging actor or noted authority in a field; using digital animation and video to illustrate dynamic biological processes occurring in a continuous flow while allowing teachers to pause, review, replay or jump ahead to focus learner attention and assess and ensure learner understanding; and playing audio files to focus learner attention specifically on the auditory input channel. During interviews, all participants felt that these methods improved delivery of content to their students, helping students better understand biological concepts and principles. This is consistent with the findings of Zucker and McGhee (2005), where teachers self-reported the advantages of making content available to students in a variety of ways.

It also emerged from the data that digital technologies and texts posed some significant challenges for participants. Digital technologies are expensive to purchase and support, forcing teachers and schools to make difficult decisions on how to allocate scarce educational dollars. Although all three classrooms observed had permanent broadband Internet connections, projectors, and either a desktop or tablet computer in them, all three study participants noted the technology was unreliable. Since teachers cannot rely 100% on the digital technologies working, they needed to be prepared with backup plans and alternatives for when the technologies failed.

Another challenge for study participants was the finding that the use of digital technologies and texts requires contextualization. Teachers noted that they could not obtain a digital text from a colleague and add it to their teaching repertoire without modification. Modifications and adaptations were required to meet the specific background of the receiving teacher, their students, the classroom learning environment, and the geographical location in which learning is occurring. This came with a cost to study participants, in terms of the time they had available to carry out such modifications, and whether or not they had the technological proficiency and access to necessary hardware and software resources needed to enact the modifications they desired.

Finally, during the semi-structured interviews, I heard from all three participants that they had received their pre-service teacher education in the pre-digital world. In all three cases, their present classrooms contain digital technologies, which each uses regularly to access digital texts. However, the teacher education they received has occurred on an *ad hoc* basis, primarily through sharing ideas and discussions with colleagues. As noted by Palak and Walls (2009), Dunleavy, Dexter, and Heinecke (2007), Salerno and Vonhof (2011), and echoed by the findings in my study, professional development support, or participation in a professional learning community, provides teachers with a supportive environment for sharing ideas about what works and what does not, identifies limitations for devices used in a classroom environment, and generates and elucidates ideas for effective use of technology. All three participants felt that they would benefit from extra guidance and support on how to use digital technologies and texts more effectively. As the provincial Biology 11 and 12 curricula changes, authors (Ministry) and implementers (administrators) of the new curriculum should build in mechanisms to support teachers to make this transition.

Theme 2: Inhabiting a New Space Creates Contradictions

When all three participants started their teaching careers, they worked in only one space: the classroom. Students and teachers shared a particular physical location in the school for a particular time period, during which the teacher presented a lesson that they had planned themselves to their students. Since that time, a new space has opened up: the digital. Communication between students and teachers is no longer limited to what occurs during scheduled class time. Participants are able to email notes to their students, or upload notes and other digital texts to websites or Moodle courses for students to access whenever they have the time to do so.

This study has shown that widening the classroom to include both digital and physical space has created contradictions for teachers to navigate. One of these contradictions relates to time usage. On the one hand, digital texts help teachers to save time because teachers now can readily access quality instructional resources on the Internet. Teachers quickly find answers to student questions and easily share resources with colleagues who are on the same staff, or teaching at a distance. Yet, on the other hand, digital technologies also cost teachers time. Participants stated that it took time to learn how to use the digital technologies available to them, which corresponds to the findings of Palak and Walls (2009). Teacher-participants additionally noted that it was sometimes quite time-consuming to find a digital text that was subject-appropriate, meaningful, accurate, and at the right level of difficulty for their students, with technological breakdowns taking time to troubleshoot. As a result, teachers supported and used digital technologies and texts regularly, but often expressed frustration at doing so.

A second contradiction found within my study's data centred on teacher support. Participants appreciated that digital texts were easy to share with colleagues, and felt this to be a valuable support to their practice. All three participants had obtained digital texts from colleagues, publishing companies, and other sources, and later adapted the texts they received to meet the needs of their own unique teaching context. However, they also expressed concern that digital technologies and texts were undermining them and their practice. As an example of this, teacher participants identified the ability of students to look up facts almost instantly on their cell phones. Study participants saw this as a challenge to the need for learning facts, something participants viewed as foundational to building conceptual understanding. Another example identified in the data was the ability of students to create lengthy research reports on a topic in a matter of minutes, either by copying and pasting data gathered from an Internet search, or by paying someone to write the report for them. Since the research report has been a staple assessment item for a long time, teachers saw this development as a challenge to a significant method of assessing students' learning.

A third contradiction related to change, which created both affordances and challenges to teaching practice. The affordances of digital technologies and texts to support teachers' pedagogy are complementary to students' and teachers' experiences in these contemporary high school biology classrooms. The ability to access high-quality resources enriches classrooms that were previously limited to using the resources that were physically present, such as textbooks, videotapes, and DVDs. Although teachers still have access to the textbooks, videotapes, and DVDs in their classrooms, they now have an expanded set of instructional supports, including the wide range of digital texts available to them on the Internet. This corresponds to the findings of Zucker and McGhee (2005). Additional benefits to this level of access include rapid connection with quality resources, and the ability for teachers to modify these digital texts to meet their, and their students, own unique needs and contexts.

Challenges occur when teachers and the curriculum try to keep pace with the speed of technological change. British Columbia's current Integrated Resource Package (IRP) was written in 1996 and updated in 2006. As noted previously, it is currently under revision. However, the time that it takes to consult, produce and disseminate revisions to the Prescribed Learning Outcomes (PLOs) and Suggested Achievement Indicators is a problem for practicing teachers. The digital space inhabited by students is changing at a rate difficult for both teachers and the Ministry of Education to keep pace with. Yet, keeping pace is of crucial importance because what has become possible for both teachers and students through digital technologies and texts is not changing in ten-year cycles. This study highlights that changes to what is possible in the digital world impacts the time teachers spend at their job; how they interact with their students, parents, and other teachers; and how their pedagogy is supported in some ways and undermined in others. A need for meaningful, timely support in a rapidly-changing educational world is imperative.

Theme 3: There is a Role for Non-Digital Teaching Methods in a Digital World

All three participants observed used, throughout this study, both non-digital and digital-based teaching methods. As noted above, affordances of digital technologies and texts include time savings, easy access to high-quality resources, improved student engagement, and enrichment of pedagogy. These affordances notwithstanding, study participants noted that there were some non-digital methods worth keeping.

As described in the literature review, students can be understood to learn in relation to three domains: cognitive, affective, and psychomotor (British Columbia Ministry of Education, 2006). These domains are foundational to the British Columbia Ministry of Education's IRPs for Biology: "prescribed learning outcomes in BC curricula identify required learning in relation to one or more of the three domains of learning: cognitive, psychomotor, and affective" (British Columbia Ministry of Education, 2006, p. 17).

Support provided by digital technologies and texts for delivering prescribed learning outcomes in the cognitive domain as outlined in the *Biology 11 and 12 Integrated Resource Package 2006* (British Columbia Ministry of Education, 2006) was apparent and used effectively in all three classrooms observed. Students' engagement and attention - which relates in part to both the cognitive and affective domains - in their biology classes was observed to increase with the use of digital technologies and texts. Less apparent was support for delivering prescribed learning outcomes solely in the affective domain described by Krathwohl, Bloom, and Masia (1956). Since study participants did not raise this as a concern, it did not become a focus for my study.

A key finding, though, of my study was a dissonance in the psychomotor domain as described also by Simpson (1972). Participants noted that the use of digital technologies and texts did not provide for the same type or quality of interaction between student and object studied as did an interaction with a real specimen; whether that specimen was used to create a microscope slide to observe behaviour of micro-organisms, or a fetal pig being dissected to observe, feel and understand the relationship between internal structures and organs.

Part of this dissonance problem is due to a lack of fidelity in the digital technologies and texts currently available to classroom teachers and their students. We have the capacity to digitally represent images and sounds very well, with very high fidelity. Teachers employ these digital texts daily when teaching their students. However, the amount of digital information that would need to be captured and represented as an experience for the other senses of touch, taste and smell is still too great for our current technologies to deliver in a meaningful way. Although the digital texts are multimodal, they are not effectively multisensory. This leaves a significant gap in a teacher's pedagogy for laboratory work, an important and traditional component of Biology education.

Biology, like all sciences, has an experiential, experimental side to it. Although the anatomy of a fetal pig can be memorized through drill-and-practice activities delivered within a virtual environment, the virtual environment available in a public secondary school, at this time, does not provide a Biology student with either the smell of the organs inside an organism's body, or a sense of just how much pressure to apply in order to cut through the skin but not into the muscle or the organs that lie beneath.

Although an argument is often made that it is neither necessary nor important for all students to dissect a fetal pig, some of our students do go on to work in fields that require psychomotor skills learned in Biology classes. Examples of these types of professions include surgeons, dentists, and veterinarians. At the current time, there is no digital technology available that provides the high-fidelity, sensory experience that cutting into a real organism's body does. Although this does not affect a large number of high school biology students, it is important because of the importance to society that this type of work be done, and done well.

Implications for Teaching and Learning

Based on the rich, thick data collected in my study, and the themes that emerge across the three cases, I now identify five ways in which digital technologies and texts can inform the pedagogy of high school biology teachers in British Columbia.

First, digital technologies and texts should be used. The advantages are too great to ignore. Quality information is readily available to anyone at any time. No longer are teachers limited to teaching from the only textbook available in their classroom, which may be more than ten years old and therefore contain a significant amount of out-of-date information. Up-to-date digital texts and resources are readily available in a variety of formats: text, image, audio, video, and animation. It is easy for teachers to collect and sequence quality resources from a variety of sources. Starting from a solid foundation, a teacher can share with other teachers, and improve their own resources every time they re-teach a course.

Second, using digital texts improves communication with students and their parents by opening up new avenues for information exchange. Students and their teachers now can communicate asynchronously through email, texts, Tweets, discussion boards, blogs and a variety of other formats, rather than bounding their interaction to occur within an 80-minute class period. Expanding on this broadened ability to communicate, additional information such as student marks can be calculated and made available on demand, rather than three times per semester when the report card is handed out.

Third, digital technologies will change the ways of learning that teachers privilege and assess. Ready access to digital technologies means people no longer need to commit factual knowledge to long-term memory: it is faster to look it up on demand, and, if the source is good, likely more accurate, too. Evidence for this comes from the field of knowledge workers, where it is impossible to keep up with the explosion of data occurring. Instead, training focuses on teaching workers the path to follow when seeking up-to-date information, rather than asking them to commit to memory processes and facts that very likely will change by the next time they need them (Sparrow, Liu & Wegner, 2011). As my study's participants noted, report writing has also changed. Digital technologies and texts makes copying information fast and easy – a student can prepare a lengthy report in a matter of minutes. It is also possible to hire someone to write a report customized to meet your specific needs, making it very difficult for a teacher to prove plagiarism. Because of this, teachers noted that they needed to re-think reports as a method of capturing, representing and assessing students' learning.

Fourth, the digital environment provides an opportunity to shift responsibility for learning in a significant way from teachers to students. Students now have unprecedented access to information, and, as a result, are able to obtain high-quality, detailed information on any topic that interests them. No longer defined by the physical or resource parameters of the school that they are attending, students can access knowledge and experts from around the world.

Fifth, the biggest challenge facing the current population of practicing teachers is their lack of supported professional learning on how to use digital technologies and texts most effectively. The generation of teachers who were participants in my study did not grow up digital natives as their Millennial Generation students have, and some teachers do struggle to navigate within this constantly-shifting terrain. They need support, not only regarding what is available and would be of help to them, but also with how to effectively use these technologies with their students. Data from my study regarding the need for supported professional learning exists in other studies' findings (Dunleavy, Dexter, & Heinecke, 2007; Palak & Walls, 2009; Salerno & Vonhof, 2011). Teachers may flourish if given the training and support they need when expanding their skill set to include the digital world. At this time of transition to a new Biology curriculum, it is of the further importance that this support is provided in a meaningful way for practicing biology teachers.

Suggestions for Future Research

This study provides a rich description of the thoughts, practices and experiences of three high school biology teachers teaching in British Columbia during the fall of 2013. The data collected by the anonymous online survey provided demographic context and enriched the participants' descriptions, but its sample size was too small to be predictive. A more detailed survey or focus group, carried out using either a simple random or stratified random sampling strategy would provide a more accurate, broadly-applicable insight into what hardware and software tools are used by this population. An additional benefit to employing this methodology would be the ability to look for correlations between the time when a teacher was trained and the types of digital technologies and texts employed in their practice. A connection was hinted at by the data that I collected: I would be interested to see if this connection holds up under more careful and thorough scrutiny.

Further, in the field notes that I made during the classroom observations, I noted two instances where a teacher presented factually incorrect information to their students. The teacher may have corrected their errors during subsequent classes. However, it would be important to investigate the impact on student learning and attitude in science when teachers state something as fact when it is incorrect. This is particularly important in our digital age, as students and teachers are able to access a world of facts at their fingertips, and conceptions of what is important to know and who is the authority in the classroom shifts.

Conclusion

In this collective case study, I have created a rich, textured description of how digital technologies and texts are used currently by three selected biology teachers practicing in British Columbia. Through the analysis of lesson plans, field notes made during classroom observations, and answers made to semi-structured interview questions, study participants identified ways in which digital technologies and texts affected their pedagogy in their high school biology classrooms.

Both affordances and challenges were identified in these teachers' use of digital technologies and texts in their pedagogical practice. Although my research took place in three high school biology classrooms in public schools in British Columbia, the affordances I found illustrate ways in which digital technologies and texts are important and can be used to effectively support contemporary biology teachers' pedagogical practices in a time of rapid change in their classrooms.

The challenges identified are equally as important. At this time of curriculum change, they indicate areas and ways in which teachers are struggling. Paying attention to the challenges identified, and finding ways to mitigate their effects is important work for the provincial government as it re-writes the prescribed learning outcomes and suggested achievement indicators for the soon-to-be released Biology 11 and 12 Integrated Resource Package. More broadly, themes describing the challenges of integrating technology apply to all teachers adapting their classrooms to meet the needs of digital natives. Through analyzing pedagogical possibilities offered by other teachers, such as the ones who took part in this collective case study, it is possible to improve teaching methods, ultimately leading to improvements in students' learning experiences.

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Appendix

Appendix A: Diagram for the Planned Flow of Activities in this Study

Phase	Procedure	Product
QUANTITATIVE Data Collection	• Anonymous survey of secondary science teachers in three school divisions in southern Vancouver Island	• Numeric data and text data (survey results)
• Case Selection • Interview Protocol Development	• Nonprobabilistic sampling strategy from teachers identified in purposeful sampling • Design interview questions	• Cases ($N = 3$) • Interview protocol
QUALITATIVE Data Collection	• Collection of lesson plan • Individual classroom observation with three participants • 30 - 45 minute semi-structured interview with individual after classroom observation	• Text data (interview transcripts and documents)
QUALITATIVE Data Analysis	• Coding and thematic analysis • Within-case and across case theme development • Cross-thematic analysis	• Reading and color coding • Identification of codes and themes • Recurrent and different themes
Results	• Interpretation and explanation of QUALITATIVE results	• Discussion • Implications • Future research

Appendix B: Anonymous Survey Questions

This survey is for secondary science teachers in School Districts 61 (Greater Victoria), 62 (Sooke) and 63 (Saanich). Its purpose is to collect information about what digital resources are being used in secondary science classrooms during the spring of 2013, to help describe the digital environment in which secondary science teachers work. Data collected will be used as part of a master's thesis in Curriculum and Instruction at the University of Victoria.

1. This week, I spent 50% or more of my time teaching students in grade:
   select grade
   a. 9
   b. 10
   c. 11
   d. 12
   e. Other

2. This week, the subject area in which I spent 50% or more of my time teaching was:
   select subject area
   a. Biology
   b. Chemistry
   c. General Science
   d. Physics
   e. Other

3. Not counting this year, the total number of years of classroom teaching experience I have is:
   select total number of years of classroom teaching experience
   a. 0 – 5
   b. 6 – 10
   c. 11 – 15
   d. 16 – 20
   e. 21 – 25
   f. 26 – 30
   g. > 30

4. From the following list of digital devices, select all of the ones you currently use as part of **your teaching practice**:
   a. Smartboard
   b. Desktop personal computer
   c. Laptop computer
   d. Tablet computer
   e. Smart phone
   f. Digital camera
   g. Digital video camera

5. From the following list of web-based tools, select the ones you currently use as part of **your teaching practice**. Use the space to the right of each choice to describe the primary way in which you use the devices you selected.
    a. Content Sharing – used to share websites with students
        i. del.icio.us
        ii. Pinterest
        iii. StumbleUpon
        iv. Other (name it)
    b. Calendaring – used to share calendar entries with students
        i. Cozi
        ii. iCal
        iii. Google Calendar
        iv. Outlook Calendar
        v. Other (name it)
    c. Photo Sharing – used to share photos with students
        i. Flickr
        ii. Instagram
        iii. Photobucket
        iv. Picasa
        v. Other (name it)
    d. Collaborative Authoring – used to write collaboratively
        i. Wiki
        ii. Wikipedia
        iii. Other (name it)
    e. Video Sharing – used to share videos with students
        i. Kaltura
        ii. Vimeo
        iii. YouTube
        iv. Other (name it)
    f. Social Networking – used to communicate asynchronously with students
        i. Facebook
        ii. Google+
        iii. LinkedIn
        iv. MySpace
        v. Twitter
        vi. Other (name it)
    g. Blogs – used to write personal opinions and share ideas
        i. Blogger
        ii. Tumblr
        iii. Wordpress
        iv. Other (name it)
    h. File Sharing – used to share files with students
        i. Dropbox
        ii. YouSendIt
        iii. Other (name it)
    i. Communication Tools – used to communicate synchronously with students

i. Adobe Connect
ii. Blackboard Collaborate
iii. Discussion forums
iv. Google Talk
v. Microsoft Office Communicator
vi. RSS feeds
vii. Skype
viii. Other (name it)

6. In the space below, copy and paste the URLs for any websites you use regularly as part of your teaching practice.

7. In the space below, list any smartphone or tablet computer apps you use regularly as part of your teaching practice.

8. In the space below, list any computer programs you use regularly as part of your teaching practice.

(NOTE: Questions 1-3 were forced choice selection from a drop-down menu, question 4 used checkboxes, question 5 used checkboxes where each possible selection had a text field immediately to the right of it where the respondent could describe how each selected tool was used, and questions 6-8 were expandable text boxes. The survey was constructed using a basic account on FluidSurveys (http://www.fluidsurveys.com/).)

Appendix C: Lesson Plan Template

LESSON PLAN

COURSE:	UNIT:
LESSON TOPIC:	
LEARNING OUTCOMES: •	
MATERIALS / EQUIPMENT REQUIRED: •	

TIME (min.)	LESSON CONTENT - ACTIVITY	TEACHING POINTS AND ORGANIZATION
	Introductory Activities / Motivation •	
	Teaching Strategy / Learning Activity •	
	Closure •	
	Assessment Strategy •	

Appendix D: Double-Entry Journal Layout for Field Notes

Date:
Observation #
Teacher-Participant:
School:
Classroom #
 # Students:
Time in:
Time out:

Observations	Thoughts and Interpretations

Appendix E: Semi-Structured Interview Questions

Asked at the First Observation Only

1. How long have you been a teacher?
2. How long have you taught secondary biology?
3. What program did you take in university for your teacher training?
4. Which university/universities did you attend?
5. How long have you been a teacher at this school?
6. Describe some things you like about your current teaching position.
7. Describe some challenges you face in your current teaching position.
8. What role, if any, do you see technology playing in your teaching practice?

Asked at All Three Observations

1. What was the primary goal of today's lesson?
2. Do you feel you attained that goal?
3. What methods and activities did you use to attain the goal of today's lesson?
4. If you were to present the same lesson again, what would you do differently?
5. What are some ways in which the use of technology [might have] added to what you were able to do in today's lesson?
6. What are some ways in which the use of technology [might have] subtracted from what you were able to do in today's lesson?

Appendix F: Letter to School Districts

Wade Strass
10 Eberts Street
Victoria, BC V8S 5L6

Members of the Board
Greater Victoria School District No. 61
556 Boleskine Rd.
Victoria, BC V8Z 1E8

July 29, 2013

Dear <superintendent> ,

I am writing this letter to request approval of my proposed MA research: *What effect does the digital environment have on a teacher's pedagogy in the high school biology classroom*, to be carried out during the winter of 2013-14.

There are two main questions I hope to answer: *What are the characteristics of the digital environment in which southern Vancouver Island Biology teachers work?* and *What differences are noted when comparing the practice of a teacher who does not use the digital environment at all, to one who uses it in a transmissive (teacher-to-student) way and one who uses it in an interactive (two-way communication between teacher and student) way?*

Researching this topic is part of a natural progression for me. I was a classroom teacher in Alberta for 22 years, most of that spent in a high school biology classroom. During that time, I developed an interest in using digital technology to support student learning, culminating in a secondment to Alberta Education to work on digital learning resource development. At this point in my career, I'm interested in providing a description of the current state of the digital environment as context, and comparing and contrasting three rich stories of teaching practice in the biology classroom to illustrate what a teacher's pedagogy gains and loses depending on how much the digital environment is used as a support for classroom teaching. This research is important because it will help address issues of personalized learning and 21st century teaching: specifically, it looks at how digital tools and resources are being used currently in secondary biology classrooms, and identifies ways in which digital technologies and the digital environment both add to and subtract from a classroom teacher's practice.

The proposed research will take part between September and December of 2013-2014, both as an online survey and as observations in three high school biology classrooms in southern Vancouver Island. The survey will be open for four weeks, from mid-September to mid-October, after which the data analyzed. The classroom observations will consist of a series of three separate visits to each of the three teacher's classrooms. Teachers will be selected who use the digital environment in one of three ways: not at all, to provide information to students in a transmissive way, and to engage in two-way communication with students. The affordances and challenges provided by each will be analyzed.

Full participation would include completion of a short, anonymous online survey, as well as consenting to three classroom observations, followed by a semi-structured interview and sharing of their lesson plan with the researcher as data for the research. There will be no inconvenience or risk to students as a result of this research.

It is very important to me that before, during, and after this research project, I take every ethical step possible to protect students and teachers as much as possible from any emotional, physical, or other kind of harm they may suffer as a result of this research. Consent forms outlining the research will be given to all teacher participants, as well as their students and parents of the students. Teachers who volunteer to take part will be given clear, detailed information about the study well in advance of the observation dates and be able to contact the researcher directly should a participant have any concerns or require a last-minute change to the observation date. Teacher participants will be given a choice of observation dates, and have the flexibility to re-schedule observation dates if needed. Preview copies of interview questions will be given, so participating teachers know in advance what they will be asked. No student information will be shared or reported in the study results. Digital audio recordings of the classroom observations will be made, but all recordings will be destroyed after transcription of the recording is complete. Consent forms will be kept until successful defence of my thesis when they will be shredded.

I have received approval from the University of Victoria Human Research Ethics Board to conduct this research. I can assure you that students and parents will be fully informed of the methods used, the intended and possible uses of the data collected, and any potential harm to which the student may be exposed before they are asked to fully consent to the process.

I ask for your support in this proposed research and your formal permission to recruit students of SD61 for this research. Attached is a package including my application for ethics approval submitted to the UVic Human Research Ethics Board and my research proposal approved by my MA committee.

If you have any questions or concerns, please do not hesitate to contact my supervisor, Dr. James Nahachewsky (250-721-7780, jnahache@uvic.ca), the UVic Human Research Ethics Office (250-472-4545, ethics@uvic.ca), or me (250-590-6311, wstrass@uvic.ca). Thank you for considering my request.

Sincerely,

Wade Strass

Appendix G: Email to Principals

Request from UVic MA student to carry out research in your school this fall

Hello <Principal>,

I am a Master of Arts student in the University of Victoria's Faculty of Education, Department of Curriculum and Instruction. I have received permission from <name and title> (attached), to contact you to inform you of my study, and request your permission to carry out research in your school this fall. My research topic is "What effect does the digital environment have on a teacher's pedagogy in the high school biology classroom?", and I am seeking as many high school biology teachers as possible to complete an online survey, as well as three high school biology teachers to take part in a separate collective case study.

Attached you will find a copy of a letter that provides some background to my study, and outlines my research proposal. My request is that you review the attached document, and, if you approve, give me permission to contact the biology teachers in your school to request their participation in my study.

If you are unable to open any of the documents or have further questions, please don't hesitate to contact me.

Kind Regards,

Wade

Appendix H: Email to Teachers

Request from UVic MA student to carry out research at <secondary school> this fall

Hello XXX,

I was given your contact information by <name of principal>. I am a biology teacher taking my MA at UVic, and am ready to begin researching my thesis topic "*What effect does the digital environment have on a teacher's pedagogy in the high school biology classroom?"*

Attached is a letter that describes what I'm researching, and provides more detail about how I plan to conduct my research. If you are interested in participating, or have any questions, I would be happy to discuss this in more detail with you at your convenience. I'd also appreciate you passing this information along to any other Biology teachers you know who might be interested in taking part in this study.

Thank you for considering my request.

Kind Regards,

Wade

Wade Strass
10 Eberts Street
Victoria, BC V8S 5L6
Phone: 250.590.6311
Cell: 250.858.6311
Email: wstrass@uvic.ca

Appendix I: Letter to Teachers

Wade Strass
10 Eberts Street
Victoria, BC V8S 5L6

<name of biology teacher>
<address of secondary school>

September 24, 2013

Dear <teacher's name>,

I am writing this letter to request your participation in my proposed MA research: *What effect does the digital environment have on a teacher's pedagogy in the high school biology classroom*, to be carried out during the winter of 2013-14.

There are two main questions I hope to answer: *What are the characteristics of the digital environment in which southern Vancouver Island Biology teachers work?* and *What differences are noted when comparing the practice of a teacher who does not use the digital environment at all, to one who uses it in a transmissive (teacher-to-student) way and one who uses it in an interactive (two-way communication between teacher and student) way?*

Researching this topic is part of a natural progression for me. I was a classroom teacher in Alberta for 22 years, most of that spent in a high school biology classroom. During that time, I developed an interest in using digital technology to support student learning, culminating in a secondment to Alberta Education to work on digital learning resource development. At this point in my career, I'm interested in providing a description of the current state of the digital environment as context, and comparing and contrasting three rich stories of teaching practice in the biology classroom to illustrate what a teacher's pedagogy gains and loses depending on how much the digital environment is used as a support for classroom teaching. This research is important because it will help address issues of personalized learning and 21st century teaching: specifically, it looks at how digital tools and resources are being used currently in secondary biology classrooms, and identifies ways in which digital technologies and the digital environment both add to and subtract from a classroom teacher's practice.

The proposed research will take part between September and December of 2013-2014, both as an online survey and as observations in three high school biology classrooms in southern Vancouver Island. The survey will be open for four weeks, beginning in mid-October, after which the data analyzed. The classroom observations will consist of a series of three separate visits to each of the three teacher's classrooms. Teachers will be selected who use the digital environment in one of three ways: not at all, to provide information to students in a transmissive way, and to engage in two-way communication with students. The possibilities and challenges provided by each will be analyzed.

Full participation will include completion of a short, anonymous online survey, as well as consenting to three classroom observations, each of which will be followed by a semi-structured interview and sharing of the teacher's lesson plan with the researcher as data for the research. There will be no inconvenience or risk to students as a result of this research.

It is very important to me that before, during, and after this research project, I take every ethical step possible to protect students and teachers as much as possible from any emotional, physical, or other kind of harm they may suffer as a result of this research. Consent forms outlining the research will be given to all teacher participants, as well as their students and parents of the students. Teachers who volunteer to take part will be given clear, detailed information about the study well in advance of the observation dates and be able to contact the researcher directly should a participant have any concerns or require a last-minute change to the observation date. Teacher participants will be given a choice of observation dates, and have the flexibility to re-schedule observation dates if needed. Preview copies of interview questions will be given, so participating teachers know in advance what they will be asked. No student information will be shared or reported in the study results. Digital audio recordings of the classroom observations will be made, but all recordings will be destroyed after transcription of the recording is complete. Consent forms will be kept until successful defence of my thesis, when they will be shredded.

I have received approval from the University of Victoria Human Research Ethics Board to conduct this research. I can assure you that teachers, students and parents will be fully informed of the methods used, the intended and possible uses of the data collected, and any potential harm to which the student may be exposed before they are asked to fully consent to the process.

If you have any questions or concerns, please do not hesitate to contact my supervisor, Dr. James Nahachewsky (250-721-7780, jnahache@uvic.ca), the UVic Human Research Ethics Office (250-472-4545, ethics@uvic.ca), or me (250-590-6311, wstrass@uvic.ca). Thank you for considering my request.

Sincerely,

Wade Strass

Appendix J: Ethics Approval

University of Victoria

Human Research Ethics Board
Office of Research Services
Administrative Services Building
PO Box 1700 STN CSC
Victoria British Columbia V8W 2Y2 Canada
Tel 250-472-4545, Fax 250-721-8960
ethics@uvic.ca www.research.uvic.ca

Certificate of Approval

PRINCIPAL INVESTIGATOR:	**Wade Strass**	**ETHICS PROTOCOL NUMBER** Minimal Risk - Delegated	**13-133**
UVic STATUS:	**Master's Student**	ORIGINAL APPROVAL DATE:	10-Jun-13
UVic DEPARTMENT:	**EDCI**	APPROVED ON:	10-Jun-13
SUPERVISOR:	**Dr. James Nahachewsky**	APPROVAL EXPIRY DATE:	09-Jun-14

PROJECT TITLE: **What effect does the digital environment have on teacher's pedagogy in the high school biology classroom?**

RESEARCH TEAM MEMBER None

DECLARED PROJECT FUNDING: **None**

CONDITIONS OF APPROVAL

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

Modifications
To make any changes to the approved research procedures in your study, please submit a "Request for Modification" form. You must receive ethics approval before proceeding with your modified protocol.

Renewals
Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.

Project Closures
When you have completed all data collection activities and will have no further contact with participants, please notify the Human Research Ethics Board by submitting a "Notice of Project Completion" form.

Certification

This certifies that the UVic Human Research Ethics Board has examined this research protocol and concluded that, in all respects, the proposed research meets the appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Participants.

Dr. Rachael Scarth
Associate Vice-President, Research

Certificate Issued On: 10-Jun-13

13-133 Strass, Wade

Appendix K: Consent Form: Principal

University of Victoria | Curriculum & Instruction

Consent Form: Principal

<u>Project Title:</u>
What effect does the digital environment have on teachers' pedagogy in the high school biology classroom?

<u>Researcher:</u>
Wade Strass,
Graduate Student
Faculty of Education, Department of Curriculum & Instruction
University of Victoria
Telephone: 250.590.6311
Email: wstrass@uvic.ca

<u>Supervisor</u>:
Dr. James Nahachewsky
Faculty of Education, Department of Curriculum & Instruction
University of Victoria
Telephone: 250.721.7780
Email: jnahache@uvic.ca

<u>Purpose and Objectives of the Research:</u>

- To better understand the influence the digital environment has on the teaching practice of southern Vancouver Island high school biology teachers.
- To collect information about the types of digital tools and resources currently being used in secondary biology classrooms, and the ways in which digital technologies and the digital environment influence the pedagogy of secondary biology classroom teachers.
- Comparing three high school biology teachers:
  - one who does not use the digital environment at all.
  - one who uses the digital environment to provide information in one direction: from teacher to student.
  - one who uses the digital environment in an interactive way, sending information digitally back and forth between teacher and student.

<u>This Research is Important because it:</u>

- Looks at how digital tools and resources are being used in secondary biology classrooms.
- Identifies ways in which digital technologies and the digital environment both add to and subtract from a classroom teacher's practice.

<u>Participation:</u>

- I am seeking permission to contact secondary biology teachers in your school who:
  - ☐ do not use the digital environment at all.

- use the digital environment to provide information in one direction: from teacher to student.
- use the digital environment in an interactive way, sending information digitally back and forth between teacher and student.

- Participation in this project is entirely voluntary.
- Whether one of your staff members chooses to participate or not will have no effect on their position [e.g. employment] or how they will be treated.

Procedures:

- Participants will be observed teaching three separate classroom lessons. For each observation, a participant will be asked to:
  - Pre-lesson, use a template to write a plan for the lesson being observed.
  - Be observed presenting the lesson to their class.
  - Post-lesson, answer questions as part of a semi-structured interview.
- Method of recording participation:
  - Field notes will be collected, coded, and analyzed for themes.
  - Digital audiotape recording of the classroom teacher will be collected, transcribed by the researcher, coded, and analyzed for themes, after which the recording will be destroyed. Verbal interactions between the teacher and his/her students may be captured as part of the data collection process. During transcription, any student names and identifying information will be altered to protect student anonymity.
  - Digital photos of classroom layout will be taken, but no students or teachers will be in the photos. Photos will be used for reference when describing the study site.
  - Digital images and screen captures of digital technologies used in observed lessons will be made. Identifying information will be cropped out of the photo, either when framing the photo, or through digital manipulation of the photo. Photos may be used for reference when describing the study context and student activities.
- **Duration:**
  - Writing lesson plan – approximately 15 minutes.
  - Classroom observation – regular class period.
  - Semi-structured interview – approximately 60 minutes.
  - Total of three observations, each taking approximately 75 minutes of time in addition to the lesson taught.
- **Location:**
  - At your school.
- **Inconvenience to the participant is expected to include extra time spent:**
  - Arranging a mutually-convenient time for lesson observations.
  - Completing the lesson plan template.
  - Taking part in the post-observation interview.

Compensation:

- A small token of appreciation (thank you card, drink and a snack) will be given to each participant before beginning each interview as a thank you for donating their time.

Benefits:

- Increased awareness and understanding of the role of digital technologies can play as supports for student learning.

- May lead to a better understanding of what integration of digital technologies in secondary biology classrooms adds to and subtracts from a teacher's pedagogy.
- May impact the manner in which the digital environment is used in secondary biology classrooms in British Columbia.

Risks:

- Additional stress on the teacher being observed in their classroom.
- Time required meeting the information-gathering requirements of the researcher.

Risk(s) will be addressed by the researcher providing participants with:

- Clear, detailed information about the study well in advance of the observation dates.
- Contact information, including a cell phone number, as a means to contact the researcher directly should a participant have any concerns or last-minute changes.
- A choice of observation dates.
- A standardized lesson plan format to complete.
- A preview copy of the semi-structured interview questions.
- Flexibility should a participant need to re-schedule an observation date.

Withdrawal of Participation:

- Participants may withdraw at any time without explanation or consequence.
- Should a participant withdraw, their data will not be used in the analysis and will be destroyed physically by the researcher.

Continued or On-going Consent:

- One week before each classroom observation, the researcher will send a participating teacher a list of students for whom signed student and parental consent to participate in the study have been received. The researcher will ask the participating teacher to review the list, and identify any students in their class who may be present the day of the classroom observation, but for whom signed student and parental permission to participate has not been received. New students will be given the same letter of consent. Students new to the study will be given the option of obtaining signed student and parental letters of consent to enable them to take part in the study. The researcher will make note of students attending class without a signed letter of consent, and ensure that their interactions with the classroom teacher are neither audiotaped nor documented.
- To each classroom observation session, the researcher will bring the original copy of the signed letter of consent. It will be reviewed with the participant, and the participant will be asked to sign and date the letter of consent to indicate their willingness to participate in the current session of the research.
- The researcher reserves the right to analyze the research data for purposes other than this research.

Anonymity and Confidentiality:

- Participants will be referred to using a pseudonym; any identifying information and features will be made as generic as possible or changed where that is not possible.
- Signed confidentiality agreements will be obtained and archived.
- No student information will be shared or reported in the study results.
- All electronic recordings will be destroyed after transcription of the recording is complete.

- All transcriptions of electronic recordings and coded data will be saved to a password-protected thumb drive and stored in a locked filing cabinet accessible only to the researcher and his supervisor.
- Data will be stored for five (5) years from the date of study completion, after which the thumb drive will be mechanically destroyed.

Research Results will be Used/Disseminated in the Following Ways:

- Findings of study will be summarized and presented directly to participants through an information session, either by video- or teleconference (depending on type of access participants have).
- In the researcher's thesis, used in partial fulfillment of the requirements of his Master of Arts degree.

Research Results may be Used/Disseminated in the Following Ways:

- As part of an article published in a peer-reviewed journal.
- As part of a presentation at a scholarly meeting.

Questions or Concerns:

- Contact the researcher(s) using the information at the top of page 1;
- Contact the Human Research Ethics Office, University of Victoria, (250) 472-4545 ethics@uvic.ca.

Consent:

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researcher, and that you consent to participate in this research project.

______________________	______________________	______________
Name of Principal	*Signature*	*Date*

A copy of this consent will be left with you, and a copy will be taken by the researcher.

Appendix L: Consent Form: Teacher

University of Victoria | Curriculum & Instruction

Consent Form: Teacher

Project Title:
What effect does the digital environment have on teachers' pedagogy in the high school biology classroom?

Researcher:
Wade Strass,
Graduate Student
Faculty of Education, Department of Curriculum & Instruction
University of Victoria
Telephone: 250.590.6311
Email: wstrass@uvic.ca

Supervisor:
Dr. James Nahachewsky
Faculty of Education, Department of Curriculum & Instruction
University of Victoria
Telephone: 250.721.7780
Email: jnahache@uvic.ca

Purpose and Objectives of the Research:

- To better understand the influence the digital environment has on the teaching practice of southern Vancouver Island high school biology teachers.
- To collect information about the types of digital tools and resources currently being used in secondary biology classrooms, and the ways in which digital technologies and the digital environment influence the pedagogy of secondary biology classroom teachers.
- Comparing three high school biology teachers:
    - one who does not use the digital environment at all.
    - one who uses the digital environment to provide information in one direction: from teacher to student.
    - one who uses the digital environment in an interactive way, sending information digitally back and forth between teacher and student.

This Research is Important because it:

- Looks at how digital tools and resources are being used in secondary biology classrooms.
- Identifies ways in which digital technologies and the digital environment both add to and subtract from a classroom teacher's practice.

Participation:

- You were identified by your district technology coordinator or principal as a secondary biology teacher who either:

- does not use the digital environment at all.
- uses the digital environment to provide information in one direction: from teacher to student.
- uses the digital environment in an interactive way, sending information digitally back and forth between teacher and student.

- Participation in this project is entirely voluntary.
- Whether you choose to participate or not will have no effect on your position [e.g. employment] or how you will be treated.

Procedures:

- Participants will be observed teaching three separate classroom lessons. For each observation, participants will be asked to:
  - Pre-observation, use a template to write a plan for the lesson being observed.
  - Be observed presenting the lesson to their class.
  - Post-lesson, answer questions as part of a semi-structured interview.
- Method of recording participation:
  - Field notes will be collected, coded, and analyzed for themes.
  - Digital audiotape recording of the classroom teacher will be collected, transcribed by the researcher, coded, and analyzed for themes, after which the recording will be destroyed. Verbal interactions between the teacher and his/her students may be captured as part of the data collection process. During transcription, any student names and identifying information will be altered to protect student anonymity.
  - Digital photos of classroom layout will be taken, but no students or teachers will be in the photos. Photos will be used for reference when describing the study site.
  - Digital images and screen captures of digital technologies used in observed lessons will be made. Identifying information will be cropped out of the photo, either when framing the photo, or through digital manipulation of the photo. Photos may be used for reference when describing the study context and student activities.
- **Duration:**
  - Writing lesson plan – approximately 15 minutes.
  - Classroom observation – regular class period.
  - Semi-structured interview – approximately 60 minutes.
  - Total of three observations, each taking approximately 75 minutes of time in addition to the lesson taught.
- **Location:**
  - At your school.
- **Inconvenience to you as a participant is expected to include extra time spent:**
  - Arranging a mutually-convenient time for lesson observations.
  - Completing the lesson plan template.
  - Taking part in the post-observation interview.

Compensation:

- A small token of appreciation (thank you card, drink and a snack) will be given to each participant before beginning each interview as a thank you for donating their time.
- It is unethical to provide undue compensation or inducements to research participants. If you would not participate if the compensation was not offered, then you should decline.

Benefits:

- Increased awareness and understanding of the role of digital technologies can play as supports for student learning.
- May lead to a better understanding of what integration of digital technologies in secondary biology classrooms adds to and subtracts from a teacher's pedagogy.
- May impact the manner in which the digital environment is used in secondary biology classrooms in British Columbia.

Risks:

- Additional stress on you being observed in your classroom.
- Time required meeting the information-gathering requirements of the researcher.

Risk(s) will be addressed by the researcher providing you with:

- Clear, detailed information about the study well in advance of the observation dates.
- Contact information, including a cell phone number, as a means to contact the researcher directly should you have any concerns or last-minute changes.
- A choice of observation dates.
- A standardized lesson plan format to complete.
- A preview copy of the semi-structured interview questions.
- Flexibility should you need to re-schedule an observation date.

Withdrawal of Participation:

- You may withdraw at any time without explanation or consequence.
- Should you withdraw, your data will not be used in the analysis and will be destroyed physically by the researcher.

Continued or On-going Consent:

- One week before each classroom observation, the researcher will send you a list of students for whom signed student and parental consent to participate in the study have been received. The researcher will ask you to review the list, and identify any students in your class who may be present the day of the classroom observation, but for whom signed student and parental permission to participate has not been received. New students will be given the same letter of consent. Students new to the study will be given the option of obtaining signed student and parental letters of consent to enable them to take part in the study. The researcher will make note of students attending class without a signed letter of consent, and ensure that their interactions with the classroom teacher are neither audiotaped nor documented.
- To each classroom observation session, the researcher will bring the original copy of the signed letter of consent. It will be reviewed with the participant, and the participant will be asked to sign and date the letter of consent to indicate their willingness to participate in the current session of the research.
- The researcher reserves the right to analyze the research data for purposes other than this research.

Anonymity and Confidentiality:

- Participants will be referred to using a pseudonym; any identifying information and features will be made as generic as possible or changed where that is not possible.

- Signed confidentiality agreements will be obtained and archived.
- No student information will be shared or reported in the study results.
- All electronic recordings will be destroyed after transcription of the recording is complete.
- All transcriptions of electronic recordings and coded data will be saved to a password-protected thumb drive and stored in a locked filing cabinet accessible only to the researcher and his supervisor.
- Data will be stored for five (5) years from the date of study completion, after which the thumb drive will be mechanically destroyed.

Research Results will be Used/Disseminated in the Following Ways:

- Findings of study will be summarized and presented directly to participants through an information session, either by video- or teleconference (depending on type of access participants have).
- In the researcher's thesis, used in partial fulfillment of the requirements of his Master of Arts degree.

Research Results may be Used/Disseminated in the Following Ways:

- As part of an article published in a peer-reviewed journal.
- As part of a presentation at a scholarly meeting.

Questions or Concerns:

- Contact the researcher(s) using the information at the top of page 1;
- Contact the Human Research Ethics Office, University of Victoria, (250) 472-4545 ethics@uvic.ca.

Consent:

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers, and that you consent to participate in this research project.

_________________________	_________________________	_____________
Name of Participant	*Signature*	*Date*

A copy of this consent will be left with you, and a copy will be taken by the researcher.

Future Use of Data *PLEASE SELECT STATEMENT*

I consent to the use of my data in future research: ______________ (Participant to provide initials)

I **do not** consent to the use of my data in future research: ______________ (Participant to provide initials)

I consent to be contacted in the event my data is requested for future research: ______________ (Participant to provide initials)

Appendix M: Consent Form: Student

University of Victoria | Curriculum & Instruction

Consent Form: Student

Project Title:
What effect does the digital environment have on teachers' pedagogy in the high school biology classroom?

Researcher:
Wade Strass,
Graduate Student
Faculty of Education, Department of Curriculum & Instruction
University of Victoria
Telephone: 250.590.6311
Email: wstrass@uvic.ca

Supervisor:
Dr. James Nahachewsky
Faculty of Education, Department of Curriculum & Instruction
University of Victoria
Telephone: 250.721.7780
Email: jnahache@uvic.ca

Purpose and Objectives of the Research:

- To better understand the influence the digital environment has on the teaching practice of southern Vancouver Island high school biology teachers.
- Comparing three high school biology teachers:
  - one who does not use the digital environment at all.
  - one who uses the digital environment to provide information in one direction: from teacher to student.
  - one who uses the digital environment in an interactive way, sending information digitally back and forth between teacher and student.

This Research is Important because it:

- Looks at how digital tools and resources are being used in secondary biology classrooms.
- Identifies ways in which digital technologies and the digital environment both add to and subtract from a classroom teacher's practice.

Participation:

- I am seeking permission to observe your biology teacher as they teach three biology classes with you in attendance.
- You will participate as you normally do when you attend classes.

- If you do provide consent, you are allowing me to audio tape your classroom conversations and exchanges with your teacher. This consent is entirely voluntary. Please note that I will not be including anything that you say or do in my report
- If you do not provide consent, I will refrain from audio taping you.
- Whether you choose to consent or not will have no effect on your grade in biology, or how you will be treated in your biology class.

Procedures:

- Your biology teacher will be observed teaching three separate classroom lessons.
- Method of recording observations:
  - Field notes will be collected.
  - Digital audiotape recording of the classroom teacher will be collected and transcribed, after which the recording will be destroyed. I will not transcribe or include anything that students say or do.
  - Digital photos of the classroom layout will be taken, but no students or teachers will be in the photos. Photos will be used for reference when describing the study site.
  - Digital images and screen captures of digital technologies used in observed lessons will be made. Information that could identify the location or a person will be cropped out of the photo, either when framing the photo, or through digital manipulation of the photo. Photos may be used for reference when describing the study context and student activities.
  - The researcher will make note of students attending class without a signed letter of consent, and ensure that their interactions with the classroom teacher are neither audiotaped nor documented.
- **Duration:**
  - A total of three of your biology classes will be observed.
- **Location:**
  - At your school.

Compensation:

- No compensation or inducements will be provided to you for participating in this research.

Benefits:

- No direct benefits to you are expected through your participation in this research.

Risks:

- No direct risks to you are expected through your participation in this research.

Withdrawal of Participation:

- Student participants may withdraw at any time without explanation or consequence.

Continued or On-going Consent:

- One week before each classroom observation, the researcher will send the teacher a list of students for whom signed student and parental consent to participate in the study has been received. Your teacher will be asked to review the list, and identify any students who may be present the day of the classroom observation, but who do not have signed student and parental permission to participate. New students will be given the same letter of consent. Students new to the study will be given the option of obtaining signed student and parental letters of consent to enable them to take part in the study. If they choose not to obtain signed student and parental letters of consent, they will be opted out of the study and need to work somewhere else in the school under someone else's supervision (such as in the library, another classroom, or the school office).

- The researcher reserves the right to analyze the research data for purposes other than this research.

Anonymity and Confidentiality:

- Teacher participants will be referred to using a pseudonym; any identifying information and features will be made as generic as possible or changed where that is not possible.
- Signed confidentiality agreements will be obtained and archived.
- All electronic recordings will be destroyed after transcription of the recording is complete.
- No student information will be shared or reported in the study results.
- All transcriptions of electronic recordings and coded data will be saved to a password-protected thumb drive and stored in a locked filing cabinet accessible only to the researcher and his supervisor.
- Data will be stored for five (5) years from the date of study completion, after which the thumb drive will be mechanically destroyed.

Research Results will be Used/Disseminated in the Following Ways:

- Findings of this study will be summarized and presented directly to the teacher participants through an information session, either by video- or teleconference (depending on type of access participants have).
- In the researcher’s thesis, used in partial fulfillment of the requirements of his Master of Arts degree.

Research Results may be Used/Disseminated in the Following Ways:

- As part of an article published in a peer-reviewed journal.
- As part of a presentation at a scholarly meeting.

Questions or Concerns:

- Contact the researcher(s) using the information at the top of page 1;
- Contact the Human Research Ethics Office, University of Victoria, (250) 472-4545 ethics@uvic.ca.

Consent:

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researcher, and that you consent to participate in this research project.

Name of Student	*Signature*	*Date*

A copy of this consent will be left with you, and a copy will be taken by the researcher.

Appendix N: Consent Form: Parent

University of Victoria | Curriculum & Instruction

Consent Form: Parent

Project Title:
What effect does the digital environment have on teachers' pedagogy in the high school biology classroom?

Researcher:
Wade Strass,
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Purpose and Objectives of the Research:

- To better understand the influence the digital environment has on the teaching practice of southern Vancouver Island high school biology teachers.
- Comparing three high school biology teachers:
  - one who does not use the digital environment at all.
  - one who uses the digital environment to provide information in one direction: from teacher to student.
  - one who uses the digital environment in an interactive way, sending information digitally back and forth between teacher and student.

This Research is Important because it:

- Looks at how digital tools and resources are being used in secondary biology classrooms.
- Identifies ways in which digital technologies and the digital environment both add to and subtract from a classroom teacher's practice.

Participation:

- I am seeking permission to observe your son's/daughter's biology teacher as they teach three biology classes with your son or daughter in attendance.
- Participation in this project is entirely voluntary.
- Your son or daughter will participate as they normally do when they attend classes.

- If you do provide consent, you are allowing me to audio tape your child's classroom conversations and exchanges with his/her teacher. This consent is entirely voluntary. Please note that I will not be including anything that your child says or does in my report.
- If you do not provide consent, I will refrain from audio taping your son or daughter.
- Whether you or your son/daughter chooses to consent or not will have no effect on their grade in biology, or how they will be treated in their biology class.
- Whether your son/daughter chooses to participate or not will have no effect on their grade in biology, or how they will be treated in their biology class.

Procedures:

- Your son's/daughter's biology teacher will be observed teaching three separate classroom lessons.
- Method of recording observations:
    - Field notes will be collected.
    - Digital audiotape recording of the classroom teacher will be collected and transcribed, after which the recording will be destroyed. I will not transcribe anything that students say or do.
    - Digital photos of the classroom layout will be taken, but no students or teachers will be in the photos. Photos will be used for reference when describing the study site.
    - Digital images and screen captures of digital technologies used in observed lessons will be made. Information that could identify the location or a person will be cropped out of the photo, either when framing the photo, or through digital manipulation of the photo. Photos may be used for reference when describing the study context and student activities.
    - The researcher will make note of students attending class without a signed letter of consent, and ensure that their interactions with the classroom teacher are neither audiotaped nor documented.
- **Duration:**
    - A total of three of your son's/daughter's biology classes will be observed.
- **Location:**
    - At your son's/daughter's school.

Compensation:

- No compensation or inducements will be provided to your son/daughter for participating in this research.

Benefits:

- No direct benefits to your son/daughter are expected through their participation in this research.

Risks:

- No direct risks to your son/daughter are expected through their participation in this research.

Withdrawal of Participation:

- Student participants may withdraw at any time without explanation or consequence.

Continued or On-going Consent:

- One week before each classroom observation, the researcher will send the teacher a list of students for whom signed student and parental consent to participate in the study has been received. The teacher will be asked to review the list, and identify any students who may be present the day of the classroom observation, but who do not have signed student and parental permission to participate. New students will be given the same letter of consent. Students new to the study will be given the option of obtaining signed student and parental letters of consent to enable them to take part in the study. The researcher will make note of students attending class without a signed letter of consent, and ensure that their interactions with the classroom teacher are neither audiotaped nor documented.
- The researcher reserves the right to analyze the research data for purposes other than this research.

Anonymity and Confidentiality:

- Teacher participants will be referred to using a pseudonym; any identifying information and features will be made as generic as possible or changed where that is not possible.
- Signed confidentiality agreements will be obtained and archived.
- No student information will be shared or reported in the study results.
- All electronic recordings will be destroyed after transcription of the recording is complete.
- All transcriptions of electronic recordings and coded data will be saved to a password-protected thumb drive and stored in a locked filing cabinet accessible only to the researcher and his supervisor.
- Data will be stored for five (5) years from the date of study completion, after which the thumb drive will be mechanically destroyed.

Research Results will be Used/Disseminated in the Following Ways:

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Questions or Concerns:

- Contact the researcher(s) using the information at the top of page 1;
- Contact the Human Research Ethics Office, University of Victoria, (250) 472-4545 ethics@uvic.ca.

Consent:

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researcher, and that you consent to have your son/daughter participate in this research project.

____________________ ____________________ ____________

Name of Parent *Signature* *Date*

A copy of this consent will be left with you, and a copy will be taken by the researcher.

Appendix O: Quantitative Results: Survey Respondent Background

Respondent	Primary Grade Taught	Primary Subject Taught	Years of Teaching Experience
1	12	Biology	16 - 20
2	Other	Chemistry	16 - 20
3	11	Chemistry	26 - 30
4	12	Biology	16 - 20
5	12	Chemistry	11 - 15

Appendix P: Quantitative Results: Hardware Used

Respondent	Hardware Used					
	Desktop Personal Computer	Laptop Computer	Tablet Computer	Digital Camera	iPod	SMART® Board
1	✓	✓		✓		
2	✓					
3	✓	✓			✓	
4	✓		✓			
5	✓	✓	✓			✓

Appendix Q: Quantitative Results: Web-Based Tools Used

Web-based Tool Used	Respondent				
	1	**2**	**3**	**4**	**5**
Content Sharing	Google Docs	Moodle	x	x	District Servers
Calendaring	x	x	Weebly	x	MS Outlook
Photo Sharing	x	x	x	x	x
Collaborative Authoring	x	x	x	x	Wikipedia
Video Sharing	x	x	YouTube	• Khan Academy • Vimeo • YouTube	Moodle
Social Networking	Twitter	x	Facebook	x	x
Blogs	x	x	Weebly	x	x
File Sharing	x	Internal school dropbox	Dropbox	x	Moodle
Communication Tools	x	x	x	x	Zimbra

x = No response

Appendix R: Quantitative Results: Uniform Resource Locators (URLs) for Websites Used Regularly

Website	Uniform Resource Locator (URL)	Respondents Who Use Website (#)
YouTube	http://www.youtube.com/	1
Iannone's Chemistry Page	http://iannonechem.com/	1
BC Ministry of Education	http://www.gov.bc.ca/bced/	1
Chemistry 11 Website Mr. Colgur	http://www.colgurchemistry.com/Chem11/chem_11.htm	1
Claremont Secondary School	http://claremont.sd63.bc.ca/	1

Appendix S: Quantitative Results: Computer Programs Used Regularly

Computer Program	**Description**	**Respondents Who Use Program (#)**
Adobe Acrobat (Reader)	Proprietary, no-cost viewer for portable document format (PDF) documents.	2
Integrade (Pro)	Proprietary, commercial, web-based gradebook.	1
Journal	Insufficient detail provided by respondent to determine which product this is.	1
Libre Office	Open-source, no-cost office software suite.	2
Microsoft Word	Proprietary, commercial, word processor portion of office software suite.	2
[Apache] Open Office	Open-source, no-cost office software suite.	1

Appendix T: Quantitative Results: Smartphone or Tablet Apps Used Regularly

App	Description	Respondents Who Use App (#)
Explain Everything	Interactive whiteboard and screencasting tool	1