

# **The Interdependence of Technology, Pedagogy, and Epistemology: A Self-Study of My Pedagogy of Technology Teacher Education**

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Thesis Submitted in Partial Fulfillment of the  
Requirements for the Degree of  
Doctor of Philosophy

in the  
Educational Technology and Learning Design Program  
Faculty of Education

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Fall 2019

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# Approval

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or

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## Abstract

This research investigates teacher candidates' theories of knowledge in a technological environment and a post-secondary teacher educator's pedagogy of technology teacher education. This dissertation attends to the pedagogical interdependence of purposeful technological environments with a view to narrowing the epistemic gap between students and teachers through the design of educational technology within an undergraduate course. The research uses self-study methodology to investigate and improve my pedagogy of technology teacher education and simultaneously advance the fields of educational technology and learning design and technology teacher education. Self-study of teaching and teacher education practices (S-STTEP) is a type of educational research methodology that is concerned with the understanding and improvement of one's practice and the relationship between teaching and learning in teacher education. A four-part analytical framework in this self-study is used to provide an account of my practice as a technology teacher educator through an analysis of my espoused theories (Argyris & Schön, 1974) (the explicit reasons we give for our actions) and my theories-in-use (Argyris & Schön, 1974) (implicit theories that explain how we behave). The analytical framework coalesces my professional knowledge in an epistemology of practice to help me articulate my assertions for actions as a technology teacher educator using maker pedagogy and experiential learning as technological and educative learning environments. The study of practice as an epistemic source of knowledge supports accesses to one's authority of practice, which is an ontological lens used to study what resides in knowing-in-action. An authority of practice is the warrant that leads to an understanding of professional identity and professional knowledge, and how it develops and is reframed. The epistemic study of practice in this research makes contributions to educational research in the professional development of the teacher educator through the self-study of educational practices and actions.

**Keywords:** technology education; teacher education; self-study of teaching and teacher education practice methodology; Q-methodology; epistemology of practice; maker pedagogy; experiential learning

I dedicate this to my loving mother and father, beautiful sister, and my dear friend Chris.

Thank you for your consistent support and your belief in me.

Your love allowed me to reach this goal.

I love you endlessly.

I did this for you.

## **Acknowledgements**

Many wonderful people have and continue to inspire me along my academic and career journeys. I feel infinitely fortunate to carry out my work with great thinkers, innovative minds, and collaborative people. An important acknowledgement goes to my senior supervisor, Dr. Shawn Bullock, for always listening, supporting, shaping, guiding, and providing me with opportunities to learn and grow. Dr. Bullock, you have made this work possible. I am inspired by your curiosity and embrace it in the work that I do. Another formative mentor and friend is Dr. Nancy Johnston, whom I wish to thank so very much for her never-ending support, deep conversations, guidance, and for offering me so many opportunities to do the work that I love. There are so many people that I admire and enjoy working alongside. Please know that I deeply appreciate each and every one of you and acknowledge the contributions you have made to this work.

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# Chapter 1.

## Introduction

Educational technology is a constituent element of teaching and learning and is “now an utterly integral but wholly unremarkable component of educational conditions and arrangements around the world” (Selwyn, 2013, p. 5). Directives for technology integration in teacher education programs are steadily increasing as Cutri and Whiting (2018) and many other researchers have noted. Teacher education programs are expected to produce new teachers that are classroom ready (Loughran, 2017) and have relevant experiences (Northfield, 1993) with educational technologies (Kosnick, White, Beck, Marshall, Goodwin, & Murray, 2016). Teacher candidates’ expectations are that teacher educators “ensure that they are at least acquainted with ways to engage meaningfully with technology in their classrooms...and to understand why this might be beneficial (or not) for all learners in all curriculum areas” (Garbett & Oven, 2017, p. 3). Yet, teacher educators and teacher candidates have varying perceptions and epistemologies, and their acquaintance with and competencies related to technology are diverse as Garbett and Ovens (2017) and others described.

Other concerns in the field of educational technology and technology integration arise from an over reliance on popular literature as a primary source of information about technology. It is when the seeming success of technology combines with the field of educational technology that some teachers become inspired (and others concerned) by the potential of technology for education. Popular culture in educational technology typically frames technology as the solution for the needs of teachers and promises immense changes to education. As an example, it is not uncommon to read in the popular literature that online learning or massive open online courses, if implemented well, will result in better student outcomes. Examples such as those that illuminate the positive and noble aspects of technology also commonly equate technology with doing good work in education. Every tool appears to provide promise for solving problems inherent in teaching and learning. More than that, popular literature frames technology as having the potential to control outcomes in education. This type of thinking that is not mindful of the history in the field of educational technology, the nature of technology, or

the philosophy of technology has a tendency towards making grandiose claims around technology and education.

Further, technology integration “has been widely investigated during the past several decades as teacher education programs have struggled to implement and model best teaching technology integration practices in the preparation of pre-service teachers” (Bakir, 2016, p.22). Part of the explanation for a lack of guiding principles may be attributed to the inconsistencies in teacher education research and that popular literature tends not to be founded in scholarly thought or research-based claims. For example, it is common to hear that using an iPad for educational gaming will contribute to achievements in student learning. Teachers may vividly vocalize such sentiments and draw conclusions for their teaching practices despite a lack of practical knowledge, a paucity of evidence, uninform approaches, or scholarly approaches. Then, these ungrounded conclusions in the field manifest into myths that teachers strongly believe. This raises questions in the field about technology teacher education and about how to study technology teacher education, particularly in the digital turn (Hamilton & Pinnegar, 2017) when teacher educators crave a greater knowledge base of teacher education (Hamilton & Pinnegar, 2000).

## **1.1. A Way Forward**

Teacher education programs are particularly concerned with the transition of students from academia to professional environments as the labour market requires work-ready people with relevant skills and abilities in their field. Within the purview of academia, institutions may lean towards enhancing structures that strengthen students’ ability to flourish in their careers upon graduation. Technology is often presented as a solution to educational challenges in 21<sup>st</sup> century skills frameworks (Liakopoulos, 2002). Yet, proposed technological innovations are unlikely to reach their full potential without proper attention given to the rigorous study of the dynamics of student and teacher interactions, the nature of knowledge and its development, and an intentional position on technology (Howard, 1994).

Educational institutions have an opportunity to enhance the learning environments that support teacher candidates’ epistemological developments in their transitions between academic and professional contexts. By understanding the theories

of knowledge that students bring to the learning experiences, the teacher educator can better design learning environments for educational technology that pay attention to the nature of technology (Bullock, 2016). The need to advance the field of educational technology and learning design in an integrated and scholarly way requires systematic study of teacher educators' practices. "The paradox is that while educational technology is rapidly changing, the philosophical and theoretical development of research on, with, and for such technology are developing at a slower rate (Garbett & Oven, 2017, p. 6). Practitioner-generated knowledge (Zeichner, 2007) from educational research such as self-study methodology provides a way forward in the rapidly shifting landscape of educational technology and learning design.

## **1.2. The Study**

This dissertation attends to the pedagogical interdependence of purposeful technological environments with a view to narrowing the epistemic gap between students and teachers through the design of educational technology within an undergraduate course. This research investigates teacher candidates' theories of knowledge in a technological environment and my epistemology of practice as a post-secondary technology teacher educator. Self-study teaching and teacher education practice methodology is used to investigate and improve my pedagogy of technology teacher education with the view to simultaneously advance the field of educational technology and learning design, and technology teacher education. This study is necessary and differs from traditional educational technology research in that it goes beyond "examining technology as a 'way of doing,' [which,] gives us insight into what technology does, but does little to improve our understanding of what technology means, giving us insight into the existential impact educational technology has on learners and teachers" (Howard, 1994, p. 365). This study examines technology "as a 'way of being,' [and] influences the questions one might ask regarding technology within the context of education. We can look beyond the effect projectors, computers, and video recorders have on student performance and begin to examine how technology mediates students' lives, what meanings students attach to the educational experience as a result of technological mediation, and what implications those meanings have for pedagogy" (Howard, 1994, p. 365).

The research context is an undergraduate teacher education course that positions maker pedagogy and experiential learning as educational technologies that have the potential to produce skilled and work-ready teachers who can transition to professional environments. This dissertation seeks to understand: 1) teacher candidates' beliefs about the nature of knowledge in technological environments, and 2) professional knowledge and its development. This dissertation sheds light on the pedagogy of technology teacher education and the nexus between epistemology, pedagogy, and technology within the said context.

### **1.3. Overview of Research**

The objectives of the research are to understand my pedagogy of technology teacher education to articulate my professional knowledge and actions that I may take to improve my pedagogy. My professional knowledge is understood through an analysis of 1) my practices and actions, and 2) teacher candidates changing theories of knowledge, which are insightful for the design of educational technology. Self-study research supports the understanding of the tacit knowledge embedded in my teaching actions and allows me to recognize the ontological difference between my practice and action. Self-study methodology narrows the space in one's practice where there may be "dis-juncture between our belief and our action" (Bullough & Pinnegar, 2001, p. 15) in order improve the educational outcomes for the benefit student learning.

The specific research questions guiding this study are:

1. How do students' theories of knowledge drive the ways in which they construct knowledge in technological environments?
2. What, if any, degrees of coherence exist between how teachers and students view the nature of knowledge in technological environments?  
and,
3. How might my personal pedagogy of technology teacher education be influenced by my perceptions of students' changing theories of knowledge for the design of educational technology within a post-secondary environment?

## **1.4. Outline of Dissertation**

### **1.4.1. Chapter 2: Literature Review**

This chapter provides the conceptual foundation for this dissertation and ties together big ideas from the history of the definition of technology, educational technology, technology teacher education, and how teachers' professional knowledge is studied. This chapter highlights the respective associations in the literature and reviews supporting and contradictory ideas. The literature review begins with a definition of technology, takes a position in the philosophy of technology, and is accompanied by the intellectual historicity of educational technology. Following this, a review of technology teacher education and its alignment with the field of educational technology are detailed. Teacher professional knowledge and how it is studied epistemically provides a lens from which to extend the study of teacher professional knowledge and how it develops in practice. The literature reviewed provided the conceptual foundation for an analysis of the epistemology of practice in educational technologies.

### **1.4.2. Chapter 3: Research Design, Methodology, and Analytical Framework**

This chapter presents the research design and methodology including: the context; design for the research; the methods for data collection; and, data sources. Self-study of teaching and teacher education practice methodology as the framework for this research is described, inclusive of the definitions, characteristic, pillars that frame the methodology, and warrants for making assertions for action. This chapter also presents the four-part analytical framework used to understand one's practices and actions to arrive at the findings, which are presented in Chapters 4, 5, and 6. The analytical framework for this self-study is a method that professionals may use to articulate an epistemology of practice and make assertions for actions on how to improve their practice.

### **1.4.3. Chapter 4: Theory of Knowledge in Technological Environments**

This chapter presents the analysis of the data that answers the first and second research questions, which are:

1. How do students' theories of knowledge drive the ways in which they construct knowledge in technological environments? and,
2. What, if any, degrees of coherence exist between how teachers and students view the nature of knowledge in technological environments?

This chapter interprets the theories of knowledge of teacher candidates in technological environments and presents the theory of knowledge of the teacher educator. The analysis examines the coherence between teacher candidates' and the teacher educator's theory of knowledge.

### **1.4.4. Chapter 5: Identification of Authorizers in the Self-Study Data**

This chapter presents the analysis of the self-study data from Part 1 and Part 2 of the analytical framework. Exemplars from the self-study data are used to organize and communicate the teacher educator's authorizers as drawn from espoused theories of practice. Authorizers are viewed as things that one interacts with that shape, authorize, and create one's professional knowledge.

### **1.4.5. Chapter 6: Professional Knowledge in an Epistemology of Practice**

This chapter presents the analysis of the authorizers through an examination of the theories of actions as outlined in the analytical framework. The understanding of one's practices and actions is supported by the self-study of teaching and teacher education practice methodology and through access to the authority of practice. This chapter also answers the third research question:

3. How might my personal pedagogy of technology teacher education be influenced by my perceptions of students' changing theories of knowledge for the design of educational technology within a post-secondary environment?

The self-study coalesces the teacher educator's epistemology of practice and presents assertions for the understanding of professional knowledge and actions to improve practice.

#### **1.4.6. Chapter 7: Conclusions**

The conclusions chapter presents the scholarly contributions of this research to the field of an epistemology of practice, educational technology and learning design, technology teacher education, and self-study of teaching and teacher education practice methodology. Future areas for research are discussed.

## **Chapter 2.**

### **Literature Review**

This chapter begins by defining core concepts such as technology, educational technology, and technology teacher education. The literature review then moves into a discussion about the philosophy of technology to develop a foundation that informs a philosophy of educational technology. Findings from the field of educational technology are presented to establish the historical movements, accomplishments, and challenges in the field that are informative to technology teacher educators. Following this, ideas from the field of technology teacher education are presented through a consideration of contemporary themes and issues in technology integration that require teacher educators' consideration. In closing, the literature review considers an epistemic way to study teacher educators' professional knowledge to advance the field of technology teacher education.

#### **2.1. Definitions**

##### **2.1.1. A Definition of Technology**

The definition of technology has changed dramatically throughout history and it is crucial to review its intellectual heritage and the language and culture around technology in order to develop an intentional position on technology. This section draws on a few scholars including Howard, Skolimowski, and Marx to examine the changing definitions of technology through historical semantic and ideological lenses. It is this historical overview of "what technology itself is" (Skolimowski, 1966, p. 371) that anchors the upcoming section on the philosophy of technology.

Marx (2010) provided a helpful starting point to think about the word technology. The early definitions of technology began as a branch of learning and field of study interested in the mechanic arts (Marx, 2010). Technology arose as a popular keyword in public discourse in the 1930s (Marx, 2010) and shed light on historical events by acting as a conceptual marker that described innovations and changes in society and culture and had a part in creating our industrial society (Marx, 2010). Technology was a

“keyword in the lexicon we rely on to chart the changing character of contemporary society and culture (Marx, 2010, p. 563).

The early uses of the word technology did not describe what specific things changed and the word was conceptually and semantically void (Marx, 2010). Marx (2010) signaled this as hazardous because there is meaning carried in the concept of technology and the role it permits in discussions about the mechanic arts, namely: as discrete entities that are “capable of becoming a virtually autonomous, all-encompassing agent of change” (p. 564). The intention of Marx’s offering is to illustrate the harm of technologically determinist thinking and highlight assumptions made by the mechanic arts, which suggested that innovation was the driving force of human history (Marx, 2010).

The 1840s brought ideological and substantive developments that prompted the concept of technology to shift. The semantic void of technology would eventually be “filled by the concept of technology” (Marx, 2010, p.564). Ideological developments continued to attribute technology to progress and there was “respect for the power of innovations in the useful arts to transform prevailing ideas about the world” (Marx, 2010, p. 565). The nature of this thinking is embedded in modernist philosophies wherein the meta-narrative is underscored by ideas of progress with technology being a demiurge (Skolimowski, 1966). In this view, technology is identified by its role in the “final cause which shapes the destiny of mankind” (Skolimowski, 1966, p. 371) and was driven by scientific innovations as agents of progress (Marx, 2010). The aims of technology were “at the total subjugation of man to the machine or, in other words, at turning the human being into a technological component” (Skolimowski, 1966, p. 371). This notion of progress was the hinge that shaped worldviews about the sacred effects of science and mechanic arts and prevailed in historical thought in that innovation improved the human condition.

Radical thinking emerged that did not equate human progress with the advance of the mechanic arts (Marx, 2010). These revolutionaries appreciated mechanical innovation but only as a means of achieving progress and arriving at social and political ends. These thinkers felt that the real measure of progress was liberation from monarchic oppression, resulting in more peaceful and just societies (Marx, 2010). But this thinking did lose some force as the political landscape shifted into the profitable capitalistic system, which was founded on innovation in the mechanic arts. The

entrepreneurial elite “believed that innovations in the mechanic arts could be relied upon, in the long run, to result in progress and prosperity for all” (Marx, 2010, p.566). Yet, there was some criticism about the mechanical means, and intellectuals spoke up about progress as a symptom of moral negligence and political regression (Marx, 2010). After World War II, techno-utopianism shifted in some respects arising from post-modern pessimism and adversary culture. Although some professions like architecture continued to pursue techno-utopian thinking into the 1970s, some post-modernist thinking about innovation of technology went from optimism to pessimism and was associated “with a Moloch who will bring doom to mankind” (Skolimowski, 1966, p. 371). Between the 1840s and 1960s there was pronounced ideological backlash that technological innovation was not always positive, and critical views of industrial arts rejected the dominant faith that mechanical arts were socially good. The counterculture of the 1960s revolted against technocracy and would shift the concept of technology towards sociotechnical systems (Marx, 2010). Technology was not viewed as the cause of progress nor the creator of movements towards a republic society (Marx, 2010) and it was thought that only technology was improved and not society.

Substantive and material changes in nineteenth century mechanic arts shaped the semantic void that “the concept of technology eventually would fill” (Marx, 2010, p. 567). Sociotechnical systems advanced, which caused a separation in artifactual equipment and technical-scientific knowledge (Marx, 2010). The growth and complexity of these systems was attributed to the submission of science to the advancement of the mechanic arts (Marx, 2010). It was this “large-scale amalgamation of science and industry [that] helped to create the semantic void that would eventually call for the new concept” (Marx, 2010, p. 569) of technology.

These shifts in the nineteenth century along with Treadwell and Bigelow’s (1829) resurrection of the esoteric word technology called “to name the mechanic arts as a field of study...but not in the current sense, as a reference to the arts themselves” (Marx, 2010, p. 570). Despite Walter Gropius’s proclamation of an art and technology unity in 1923, the expanded notions of technology did not take root until after the Second Industrial Revolution (circa 1880-1910) and stemmed from scientific advancements (Marx, 2010). At the turn of the century, “in spite of-or perhaps because of-its abstract, inert, general character, its very lack of denotative specificity” (Marx, 2010, p. 572), the word technology caught the attention of American social scientists. Veblen in 1906

disseminated the word technology as having material and economic significances. Further, Veblen (1906) stated that technology could “transform the mental habits and, most importantly, the moral and metaphysical assumptions of those who worked with it” (Marx, 2010, p. 572). In summary, what was formerly a field of study, technology is now the “society’s entire stock of technical knowledge and equipment” (Marx, 2010, p. 575).

This begs the question: Where do we draw the boundary between the socio-technological system and the rest of the society and culture...as the reach of this technology is almost incalculable (Marx, 2010, p. 575-576)? For this reason, the concept of technology is hazardous as it is not specific and is “susceptible to reification” (Marx, 2010, p. 576). By “consigning technologies to the realms of things, this well-established iconography distracts attention from the human-socio-economic- and political-relations, which largely determine who uses them and for what purposes” (Marx, 2010, p. 576) and lead to phantom objectivity. Yet, most writing about technology continues to give it agency and this technologically deterministic lens is embedded in political and economic agendas. For example, former USA President Barak Obama was quoted saying “computers are going to be a big part of our future...and that future is yours to shape.” This ties to views of reform in education (and the lack thereof) because they stem from technological determinism and “by treating these inanimate objects-machines-as causal agents, we drive attention from the human relations” (Marx, 2010, p. 577). “Technology, as such, makes nothing happen” (Marx, 2010, p. 577). The popular belief in technology as a—if not the—primary force shaping the future is matched by our increasing reliance on instrumental standards of judgment, and a corresponding neglect of moral and political standards, in making judgments about the direction of society (Marx, 2010, p. 577).”

The deterministic thinking around technology as an entity and inevitability a disembodied autonomous causal agent of social change that is linked to evolution in the concept of progress is the old ideology. Now it is thought that technology did not equate to the progress of society (Marx, 2010), it equaled the improvement of technology. As such, the challenge is in describing how innovation transforms life conditions and how technology represents a constellation of concepts that are not well defined.

Howard (1994) attempts a cohesive definition of technology and states that:

Technology has its origins as a term in the Greek words “techne” and “logos”. In the broadest sense “techne” refers to making. Through its Roman translation it became associated with “ars”, methods or rules for the application of science, and instrumentum,” pertaining to tools and artifacts (Burch, 1984). According to Marx (1975), the meaning of technology has “suffered from a kind of elephantiasis in recent years” (p. 7). He illustrates the growth of the term by offering three definitions, as they have evolved. The first, which remains close to its etymology, refers to the knowledge, skills, and equipment people use for practical purposes. The second refers to the bureaucratic organizations that surround this knowledge, skill, and apparatus, for example the rise of automotive, medical, space, and computer technologies, often referred to as industries. A third, and much larger concept of technology, he labels as “metatechnology” (p.8) whereby technology dominates and permeates the life of an entire society. The knowledge, skills, and machinery of society are institutionalized and become part of the national ideology. It is this latter portion of the definition of technology, metatechnology, that entices philosophers to target technology as a subject for inquiry (p. 394).

In summary, the brief overview of the history of technology and the changing definitions of technology presented in this section provides a context for understanding the complex nature of the word technology and how it is used to signal cultural changes. This section also illustrated the deep historical technocracy roots, the science and technology divide, and the popular notion of technology as an applied science that still exists today and influences the philosophy of technology.

Marx’s (2010) assertion that technology is both an ill-defined term and a “hazardous concept” requires one to define *technology* for the purposes of this research. To that end, technology in this study is defined as the processes, inclusive of artifacts and tools, that support and facilitate learning. Technology is not just a physical tool, it can be a study or research, or a way of doing something, a process, a mediation, a method, or an extension of our bodies and senses. Our relationship with the world is partly established through technology as a way of thinking and through a way of practice (Howard, 1994).

## 2.1.2. A Definition of Educational Technology

Educational technology encompasses tools, media, and educational theories. Educational technology is a subject defined by the Association for Educational Communications and Technology (AECT) as "the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources" (Januszewski & Molenda, 2008, p.1). Bullock (2016) added to the definition by stating that:

educational technology is tacitly understood by most to be synonymous with both the digital world and novel devices. It is easy to forget that the education system itself is a technology (p.3).

Educational technology shifted from a concept to a field (Januszewski, 2001) in a relatively short time, and this is an enormous accomplishment. As a field, educational technology expanded its self-definition and oriented itself towards systems for learning and less on instructional media (Reiser, 2001). This is a great achievement because the field developed into a profession that advanced the basis for knowing and the knowledge base for the facilitation of learning. Further, the field has utility for learning design and performance that goes beyond academia.

Educational technology is considered a design science (Kozma, 1994); this makes accessible the engagement of objects that are constantly altering (like computing hardware and software systems) alongside the foundations of learning theory to marry processes that continually improve theory and broaden the landscape of the field. The *design* element of educational technology points to the dance between technology and science, and the craft of teaching, which is very exhilarating as this had historically been separated, and much can be learned from how each informs the other. The design elements advanced due to movements in research around the principles and practices of the field and were formative in the rise of Learning Sciences (Hawkins & Pea, 1983) that broadened the theoretical lens and secured the shift from instruction to learning (Januszewski & Molenda, 2008). This way of thinking in the field moves away from a systems or instructional design approaches to the creation of educational processes for learning through student-centric environments.

Attention is drawn in the definition of educational technology to place emphasis on the word *facilitating*. "Educational technology claims to facilitate learning, rather than

to cause or control learning” (Ipek & Ziatdinov, 2017, p. 384). Facilitation recognizes an epistemic position that does not solely focus on the use of technology and moves towards understanding of “qualitative judgment and imaginative roles” (Hunt & Melrose, 2005, p. 70) of practitioners in the design of learning. In this sense, there is a restored relationship that includes the technology and the creative practices in the “bringing-forth of the true” (Heidegger, 1977, p. 17) nature of craft. This reconnection of the aspects of techne support the epistemic shift towards understanding the expertise in action (Hunt & Melrose, 2005). Action “occurs within a network of human relationships” (Hunt & Melrose, 2005, p. 70) of the techne and suggests that inquiry into an epistemology of practice is needed to advance the field of learning design.

In particular, maker pedagogy and experiential learning are the educational technologies used in this study of technology teacher education that represent educative designs for teacher candidates to participate in the development of a theory of knowledge from their experiences that is required of them to perform in their professional roles. Both of these educational technologies may be viewed as technological environments that challenge technical rationalism (Schön, 1983) as they situate the learner in the robust and culturally embedded practices of the professions. The roles that students engage with in these technologies foster the requisite authentic experiences that support the development of the social, emotional, and cognitive skills of their intended professions. Both experiential learning and making technological artifacts give insights into the development of professional knowledge, the nature of how professional knowledge is constructed, and can reveal much about high impact learning design and educational technologies. Maker pedagogy and experiential learning as educational technologies are described in detail in the next section.

### **2.1.3. A Definition of Maker Pedagogy**

Maker pedagogy is an approach that draws from principles in the maker movement that Bullock and Sator (2015) suggested represents a “potentially useful way forward in engaging teacher candidates in thinking about curriculum and working with students through the human impetus to design, hack, create, and adapt” (p.61). Maker pedagogy as an educational technology includes methods that intertwine epistemologies of experience, observation, and reason. “Maker pedagogy is an approach that utilizes the principles of ethical hacking (i.e., deconstructing existing technology for the purpose

of creating knowledge), adapting (i.e., the freedom to use a technology for new purposes), designing (i.e., selecting components and ideas to solve problems), and creating (i.e., archiving contextual knowledge obtained through engaging in the process of making, as well as the actual tangible products)” (Bullock & Sator, 2015, p. 77). “One of the prevalent tenets of maker pedagogy is making technological artefacts through hands-on practice.

Bullock and Sator (2018) found that teacher candidates in maker pedagogy labs are eager to understand more about how to develop and enact science and technology projects for their practicum placements. The mobilization of knowledge between science and technologies encourages an enhanced understanding of the symbiotic relationship between science and technology. This brings creativity and innovation to the front and centre for the maker while they learn by making” (Bullock & Sator, 2015, p. 76). “Making is a participatory activity that draws the whole body of the maker into the creation of the project and the resulting artefact(s) represent the creative process of design, social interaction, and an ethos of sharing inherent in the personal and collective learning process” (Bullock & Sator, 2015, p. 70). Maker pedagogy supports activities that are student-directed in that the goals intersect between students’ interests and the curriculum, are hands-on, include the creation of sharable artifacts, and are process-oriented.

### ***Making and the Maker Movement***

The basic activity of making has deep historical roots in the Arts and Crafts movement (Cobden-Sanderson, 1887) and includes activities such as woodworking, crafts, sewing, and electronics. Making as part of the maker movement is described in many ways, for example, as the next generation of inventing and do-it-yourself (DIY) and includes craft, digital technologies, or the combination of these to construct physical objects. DIY is related to the “how-to” guides and involves things like “how to change a tire;” yet over time, the term has come to describe more broadly any activity that uses an element of creative skills to make or design something on your own. Martin (2015) stated that making is a “class of activities focused on design, building, modeling, and/or repurposing materials objects, for playful or useful ends, oriented towards making a product of some sort that can be used, interacted with, or demonstrated” (p. 31).

Maker is the identity someone takes within the maker movement. It is someone who makes things, or “people who design and make things on their own time because they find it intrinsically rewarding to make, tinker, problem solve, discover and share what they learned” (Kalil, 2013, p. 12). Makers have an ethos that involves the distribution of experiences that includes sharing and collaborating. Makers seem to be less focused on the end-result, rather, are drawn to the creation process through ethically hacking, reusing materials, and remixing technologies that may involve building, tinkering, and working iteratively on their designs. Making takes people away from consumerism towards production, and it provides opportunities for agency and ownership.

The core of making as an activity is to build or adapt objects by hand and at the heart, involves the making of technological artifacts. Some examples of maker activities include: working on gadgets like robots; prototyping and digital fabrication; manufacturing of new products using devices like laser cutters and 3D printers; programming microcontrollers such as the Arduino (an open-source electronics platform that lets makers create interactive objects) or Raspberry Pi; and, ethically hacking programmable devices using free software and tools found across the web. Maker activities involve playing, tinkering, exploring, and fostering exploration and inquiry. Brevan (2017) discussed different types of educative making include: kits, creative construction, and/or tinkering that allow for different levels of learning and knowing.

“Makerspaces are the communities of practice constructed in a physical place set aside for a group of people to use as a core part of their practice” (Halverson & Sheridan, 2014, p. 502). Maker culture has spread to a range of learning environments including libraries, museums, organizations, schools (K-12 and higher education), and after school clubs. Makerspaces are also found in tech shops, homes, and other places with industrial equipment. Other examples of makerspaces include mobile labs, maker buses, classrooms, school makerspaces in mobile buildings, and community makerspaces. Makers thrive in supportive environments that foster deep conceptual learning. It is not based on how bright, new or shiny your technology is; inspiration for making comes from a mindset and ethos that celebrates creation of all kinds.

Making in education is encourages shared learning, nurtures curiosity, and involves collaboration and engagement with knowledge and skills, taking risks and

becoming resilient, and engaging in experimental play. Making is thought to inspire and engage students to be passionate about learning because it gives them agency to create, invokes imagination, and allows learners to design and work on things that are of inherent interest through hands-on experiences (e.g.; Brevan, 2017, Halverson & Sheridan, 2014). Making in education moves away from telling learners about content towards allowing them to discover the content. “A guiding principle of making is that makers communicate not only the final products of their making” (Cohen, 2017, p. 9) but also share with their communities the process of creation (Sheridan et al., 2014). Since making goes beyond the content and is about figuring things out to learn from them, it has profound implications for education. The underpinnings of making in education includes an emphasis on the processes versus the products of learning, learning about how things work, engaging in failure and iteration, design and creation, and tinkering. In a review of making and education, Vossoughi and Bevan (2014) found three major areas of impact on student development; these were 1) encouraged students to participate in science, 2) inspired academic development, and 3) engaged a community of learners.

Making is typically connected to science, technology, engineering, and mathematics disciplines as making originated in rapid prototyping and computational types of thinking. Yet, the connections to arts, crafts, music, fabrics, and wearables is mainstay for makers. There are rich opportunities at all levels of making that can be cross and inter-disciplinary. Making in the context of this study is a space for teacher educator and teacher candidate learning wherein the habits of mind include thinking about one’s identity as a curriculum maker (Clandinin & Connelly, 1992).

#### **2.1.4. A Definition of Experiential Learning**

Experiential learning is described as any change in a learner’s knowledge, skills, understanding or beliefs as a result of an experience. Examples of experiential learning include learning to ride a bike as a result of watching others and being encouraged and assisted to imitate the behaviours or picking up an additional language as a result of traveling through different countries. Eames and Cates (2011) commented that students engaged in experiential learning are concerned primarily with gaining professional experience that aligns with their career goals.

In the definition that Moon (2004) provided, she talked about the internalization of the experience; building on past knowledge; a change in judgements; meaningful discovery where the learner sorts out things for themselves through restructuring; active learning; the structure and sequence of learning; application of learning in new contexts; and, reflection on experiences. McGill and Warner Weil (1989) defined experiential learning as the:

process whereby people individually and in association with others, engage in direct encounter, then purposefully reflect upon, validate, transform, give personal meaning to and seek to integrate their different ways of knowing. Experiential learning therefore enables the discovery of possibilities that may not be evident from direct experience alone (p.248).

Experiential education is distinct from experiential learning and refers to a formal program that has experience at its core, and intentionally links to the learner's academic, professional, and /or personal goals and is directed and monitored by the institution so as to develop the learner's knowledge, skills and values (Johnston & Sator, 2017). Example of experiential education program include co-operative education work placements; service learning; community-based learning; practicums; and field placements.

### **2.1.5. A Definition of Technology Teacher Education**

Technology teacher education in this dissertation is defined as the domain of working with teacher candidates in their learning about the integration of educational technology in their roles as in-service teachers. "The purpose of using educational technology is to enhance pedagogy, and to enable students to learn" (Ipek & Ziatdinov, 2017, p. 383). Thus, the focus is on preparing teacher candidates to learn to teach with educational technologies. Technology teacher education should not be confused with technology education, which Wicklein (2001) stated studies the:

(a) processes used by practitioners (technologists) to develop new technology (this may include critical thinking and problem solving), (b) areas of technology which represent the accumulated knowledge of practice (specific technological applications), and (c) impacts of technology on society and the environment (p. 71-72).

Technology education is concerned with innovation and alterations of natural environments through the interdisciplinary lens of science, technology, engineering and mathematics.

## **2.2. Philosophy of Technology**

This section provides the endorsements drawn from the philosophy of technology for use in a philosophy of educational technology. It is in “philosophy, psychology, sociology, anthropology, political science, and other such schools of thought that we find many of the traditional and contemporary ideas the field of education borrows and incorporates into answering its own questions” (Howard, 1994, p. 393). North America recognized a philosophy of technology in the 20<sup>th</sup> century, around the 1960s (Howard, 1994). de Vries (2018) stated that “while philosophical issues relating to technology have been debated for millennia, the concept of a distinctive philosophy of technology is now an established academic domain, albeit as a relative newcomer” (p. 5). Howard (1994) referenced the work of Rapp (1989) and suggested that the philosophy of technology is a work in progress for the following reasons:

1. Western history of ideas has been dominated by the notion of theory. Practical activity and craft have been relegated to a much lower level of thought, and therefore not worthy of intellectual analysis.
2. There has been a dominant notion that technology is merely applied science and subsumed within a philosophy of science.
3. Prior to the industrial revolution, technology was taken for granted. It is only recently that technology has attracted much attention.
4. Disciplines which have attracted organized philosophic inquiry are those which have developed theories from systematic coherent models. The study of technology is multi-disciplinary; thus, a coalescence of distinct ideas is more difficult to achieve (p. 394).

Morrison-Love (2016) added considerations to the above philosophy of technology to signal the relevance of thinking about the nature of technological knowledge, a position that Skolimowski (1966) also supported. Morrison-Love (2016) stated that the nature of technology has:

*conceptual, procedural* and *tacit* elements (McCormick, 1997, 2006); that it is closely bound to practical activity and that its precise philosophical foundations are still much debated (Fleer, 2015). More specifically, some authors have suggested that this knowledge can be identified in the form of a series of maxims, laws, theories and rules (Ropohl, 1997; Vincenti, 1990). As noted by Norström (2013), for example, many of these are qualitative features, arising directly from practice and not the product of mathematical modelling or scientific verification (such as the relationship between drilling speeds and cutter diameter in steelwork, for example). Notably, an overall epistemic framework or comprehensive taxonomy has not been fully established from this (p. 24).

Skolimowski (1966) stated that a philosophy of technology “belongs to the realm of epistemological inquiry and attempts to situate technology within the scope of human knowledge” (p. 371). This philosophy, according to Skolimowski (1966) “aims at the investigation of the nature and structure of technology, conceived as a brand of human learning and analyzed for its cognitive content” (p. 372). A comprehensive philosophy of technology includes implications related to morality, ethics, and considers the influences of technological progress (Skolimowski, 1966). Skolimowski (1966) considered technology to be a form of human knowledge and the philosophy of technology to include the epistemological analysis of technology. The nature of technology in a contemporary view recognizes the interconnections between science and technology as a useful way of understanding the epistemological position of technology; this is through the lens of technological progress as a “pursuit of effectiveness in producing objects of a given kind” (Skolimowski, 1996, p. 383). Through the recognition of the technical elements and aesthetics of technological products as complex and methodologically autonomous, a structure of technology was understood (Skolimowski, 1996). Skolimowski’s ideas appeared to draw on Kranzberg’s Second Law that stated: “Invention is the mother of necessity” (Kranzberg, 1986, p. 548) and on Kranzberg’s Third Fourth Law that stated: “Although technology might be a prime element in many public issues, nontechnical factors take precedence in technology-policy decisions” (Kranzberg, 1986, p. 550).

Historically, the sense was that technology is an applied science and the role it played was in the provision of objects that served human survival (Leiss, 1990). However, science is “presupposed by something more primary. In this sense technology precedes science. The very existence of science depends on a technological world-view” (Howard, 1994, p. 394). This line of thought relied on technological thinking as

advocated by thinkers such as Heidegger (1977) and Skolimowski (1966) and drew on Kranzberg's Fifth Law that: "All history is relevant, but the history of technology is the most relevant" (Kranzberg, 1986, p. 553).

de Vries (2018) stressed that a main theme in the philosophy of technology is the nature of technology. Bullock (2016) and Williams (2000) raised attention to a lack of discussion about the nature of technology as a flaw in the field of educational technology as most studies focused on learning-with and doing-things-with technology (the performance angle), but not learning-about technology. Such a position that recognizes the nature of technology would advance the social and epistemic competencies of learning-about technology (Bullock, 2016) in a philosophy of educational technology.

### **2.2.1. Philosophy of Educational Technology and Learning Design**

Philosophical examinations of educational technology enable a review of diverse viewpoints on the influence and the impact technology has on students (Howard, 1994). Howard (1994) said that

if we see educational technology as only tools used and directed through the intentions of a teacher, we may be satisfied with understanding educational technology through the measurement of technology's effects on students. On the other hand, if we view technology as having its own intentionality, our understanding of educational technology may include an examination of technology's existential impact (p. 394).

There are crucial interactions between technology and those who use it; however, this has not always been the dominant perception. Postman's (1996) main message is for educators to be mindful and not fall into the technophile profile of the tool-focused educator that feels that the right technology can solve every educational problem. Educators typically fall into technoromanticism (Barron, 1991; Selwyn 2016) or the tech-hype trap of technology and demonstrate a sense of urgency to use the technology because it is available (Postman, 1996) and makes big promises for educational reform.

Papert (1987) alluded to the traps of technology when he suggested that educators should not have blinders on and enthusiastically create educational purposes for specific technology, but rather focus on how to enhance learning. Papert (1987) cautioned against diagnoses of technocentrism and suggested that we look carefully at

where things are embedded because the context for development is in a culture and not an isolated technology. Postman (1996) also advised against the attempt at solving a psychological problem with a technical solution. Postman (1996) suggested a more balanced approach in the visioning of technology “without the hyperactive fantasies of cheerleaders” (p. 292) by having consideration for how these additions to the culture have capabilities of altering things beyond education, like consciousness. There are many examples of how technology shaped institutions in the accounts that Reiser (2001) chronicled.

In a philosophy of educational technology, understanding the philosophy of technology and the social shaping of technology, which challenges technological determinism for the understanding of properties, affordances, and influences of media, provides useful lessons for technology teacher educators. Technology has meaningful connections to the society where it is active, and this suggests that technology is not comprised merely of fixed features. The next section discusses the social shaping of technology and important considerations for technology teacher educators in a philosophy of educational technology.

### **2.2.2. Social Shaping of Technology**

There are two competing approaches to describe social change. One view is that technology impacts social change and develops independently of social fear (technological determinism) and another view is that society impacts social change (social shaping of technology). Technological determinists such as Ellul (1954) and Toffler (1981) would say that change is inevitable and unstoppable in the ‘information age’ (Toffler, 1981). Toffler (1981) viewed technology as deterministic, autonomous, history defining, and removed the links to social, political, and economic arenas. The flip side of this view is the sociology of technology, which stated that technological innovation is embedded in the social context and arose from the needs related to society, the economy, and the political landscape. This is referred to as the social shaping of technology and argued that technologies cannot be disconnected from the society where they are active. In this view, technology is not deterministic and considers how technology is operated upon as a pressing issue in this belief.

The social shaping of technology theory contends that technological innovation is a process of the technology and society relationship wherein the meaning of a technological artifact is a complex co-construction of social and technological ideas and practices. The view is that technologies cannot be disconnected from society and technological designs result from the interactions between technology and those who adapt it. A great example of the social shaping of technology is the cell phone (Zulto, 2009) and how its evolution and enhanced usability has been shaped by society. The social shaping of technology however has not always been the prevailing perception of social change and technology.

As discussed in section 2.1.1, it was thought that technology impacted social change. It is very easy to see where this line of thought was drawn from, as traditionally, science studies were separated from technology studies on analytical grounds, and historically there had been little attempt to bring them together (Bijker, Hughes, & Pinch, 2012). Recently however, historians and sociologists became concerned with the relationship between science, technology, and society. Contemporary views in the sociology of science shifted attention to the social construction of science that embraced beliefs and knowledge in the social world. Kranzberg's Six Law is informative as it suggested that "technology is a very human activity -as so is the history of technology" (Kranzberg, 1986, p. 557). Bringing this thinking to the study of technology has transference to the notion that technological artifacts are socially constructed. This demonstrates that the study of science and technology together benefit each field as both are socially produced and draw on each other to create their respective bodies of knowledge and techniques (Bijker, Hughes, & Pinch, 2012).

Pinch and Bijker's descriptive theory about the Social Construction of Technology (SCOT) provides a research program and model for viewing the technology and society relationship. Within the theory, the social shaping of technology rests on the concept that society shapes the design of artifacts and the trajectory of innovation programs (Williams & Edge, 1996). SCOT denounces linear models of innovation as well as technological determinism and focuses on the effects of the social and technological context where innovation occurs (Bijker, Hughes, & Pinch, 2012). The supposition is that the trajectory of technological development does not follow a developmental route that is separate from human influences.

## **A Summary of SCOT**

The social construction of technology (SCOT) is both an approach to study the development and change of technological artifacts and is a relational theory about the society and technology relationship (Friis, Pederson, & Hendricks, 2009). SCOT formed as a result of the combination of the science-technology movement, advances in the sociology of science, and through the history of technology (Friis, Pederson, & Hendricks, 2009). Social construction as a construct has historical roots dating back to Berger and Luckmann's work in 1966 that studied the sociology of knowledge, which was founded on Schutz's phenomenological tradition (Friis, Pederson, & Hendricks, 2009).

Social constructivist thinking in science happened when Bloor entered the scene in 1973. Bloor's (1973) 'strong programme' was an approach that combined the fields of the sociology of scientific knowledge and the content of science theory bringing many applications to the field of technology studies. A major outcome of these investigations is that sociologists treated the cause of beliefs and knowledge claims as socially constructed in the social world rather than the natural world (Bijker, Hughes, & Pinch, 2012). To further support social constructivist views in science, Bloor and others used the later philosophical work of Wittgenstein to legitimize the argument that although behavior can not be condensed to psychological and cognitive explanans, it can be concentrated to sociological explanans (Woolgar, 1991). This development in the sociology of science is a pillar in an approach to the study of science and technology. The treatment of scientific knowledge as socially constructed implied that there was "nothing epistemologically special about the nature of scientific knowledge" and that it is a sociological task (Bijker, Hughes, & Pinch, 2012, p.13). This work helps to answer some sociological questions that historians of technology such as Hughes were beginning to ask.

Scholarly movement away from technological determinism to social shaping of technology continued throughout the 1970s. One flavor of this is found in Pinch and Bijker's work, originating in 1984, on the social construction of technology that integrated social constructivist approaches to the empirical study of the social construction of technological artifacts and technological innovation. Drawing from the sociology of scientific knowledge that purports that successful theories arise from social support,

SCOT suggests that successful technological innovations derive from advocates in the social context (Bijker, Hughes, & Pinch, 2012). An interesting line of thinking that follows from this is that assumptions around innovation are socially formed meaning that one innovation cannot be thought of as better or worse than another.

The idea that the social world shapes science is a new relativist thought. It means that science is not deterministic or directed by an internal logic, which is a positivist position. The SCOT research program scrutinized technological innovation in a social context in a manner that is contrary to linear models and technological determinism. The theory contends that technological innovation is a process of the technology and society relationship wherein the meaning of a technological artifact is a complex co-construction of the social and technological ideas and practices. Different meanings can constitute different lines of development, and the descriptive SCOT model offers operationalization of the relationship between the world and actual content of technology (Bijker, Hughes, & Pinch, 2012).

Some of the principles of SCOT are derived from the Empirical Programme of Relativism (EPOR), which was developed for reviewing controversy in the sociology of scientific knowledge. For example, a principle of SCOT suggests that the meaning a technology has is not rigid or fixed in the way it is designed as it is derived from the interaction of the technology and the people that use it (Bijker, Hughes, & Pinch, 2012). The social shaping of technology describes the technology and society relationship inherent in the SCOT theory and contends that technology does not determine society rather human action is what shapes the technology. The focal point is that the meaning of the technology is not an immobile feature of the design but can arise out of the interactions between technology and those who use it. The key is to understand how technology is embedded within its social context.

Social shaping of technology is a critical model for technology scholars because it supports the examination of the different manifestations and meanings of different technological choices. As Pinch, Bijker, and Hughes (2012) discussed, the social shaping of technology provided a method to understand the development of technical objects and the complex, problem-solving components of artifacts and systems. Pfaffenberger (1992) stated that “any sociotechnical system shows the imprint of the context from which it arose, since system builders must draw on existing social and

cultural resources” (p.500). This model gave a lens to the empirical analysis of the social meaning of technological artifacts as constructed within the social context rather than being context dependent. In this way, the environment is a not a factor that is under the control of the system and can be designed as part of the system (Bijker, Hughes, & Pinch, 2012). The concept of social shaping helps the technology designer to avoid reductionist views of technology as they are not concerned with the constituent parts of systems and have respect for technology and society (Bijker, Hughes, & Pinch, 2012).

## **2.3. Educational Technology and Learning Design**

This section presents a scholarly narrative to trace the intellectual heritage, technological developments, and major movements in the field of educational technology since the 1980s. This section also discusses the research methodologies and myths in the field of educational technology to lay a foundational for diverse understandings in the field. The review presented in this section provides lessons for educational technologists to be mindful of as the “intellectual historicity [is] ever present in the questions we ask and the answers we are willing to accept” (Howard, 1994, p. 393). The value of this review is for understanding how the past can shape the future and support the technology teacher educator in the design of educational technology for teaching and learning.

### **2.3.1. Theoretical Heritage**

A brief overview of learning theory most influential to educational technology since the 1980s is presented in this section. Learning theories describe how people learn and have utility for the field of educational technology in supporting how people develop and use learning resources, as well as for the articulation of problems from which research stems. Reigeluth (1983) reminds us about the descriptive-prescriptive distinction in instructional design from learning theory and suggested that it is challenging to derive implications for practice from abstract theory. Reigeluth (1999) stated that while “learning theories are descriptive [and] describe how learning occurs” (p.12), they are “useful for understanding why an instructional-design theory works” (p.13). Learning theories offer “different approaches and learning strategies to develop methods for learning environments” (Ipek & Ziatdinov, 2017, p. 383) and have important

design lessons for educational technologists in the facilitation of learning. The philosophies of each tradition have unique “epistemological design frameworks and design practices” (Ipek & Ziatdinov, 2017, p. 383) for the design of the learning environment.

### ***The Cognitivist Tradition***

Epistemic views in cognitivism are that knowledge is a truth that goes into the mind and is linked to an acquisition metaphor of learning (Sfard, 1998). “Concepts are to be understood as basic units of knowledge that can be accumulated, gradually refined, and combined to form even richer cognitive structures” (Sfard, 1998, p. 5). Knowledge is about “gaining possession over some commodity” (Sfard, 1998, p. 6) and learning is a change in the knowledge state of the individual. Prescriptions from cognitivism include teacher-centric instructional methods that shape learning to activate, displace, or compensate the cognitive processes required for achievement (Salomon, 1979). A cognitively oriented designer develops instruction for cognitive objectives, task analysis, and highly sequences content required for coding via mental processes that expand the learner’s schemata.

### ***The Constructivist Tradition***

The constructivist tradition is comprised of a continuum of learning theories including: constructivism, social constructivism, (Cobb, 1994), and situativity (Greeno, 1998). The generally agreed upon tenet in the constructivist tradition is that knowledge is constructed in context through a process of action. In constructivism, to know means to act effectively in a context (Duffy & Cunningham, 1996) and to learn means to participate in cultural practices (Cobb, 1994). Constructivist ontology is concerned with making meaning for the viability of knowledge and what exists is culturally embedded. Since knowledge is context-dependent, it is less likely to be inert because prior knowledge is activated and used generatively in meaningful contexts (Whitehead, 1929). Each theory within the constructivist tradition places unique emphasis on differing elements of learning, knowing, and knowledge. “Constructivist epistemologies in learning science have been mentioned as alternatives to instructional science” (Ipek & Ziatdinov, 2017, p. 383) and are “concerned with the nature of knowledge, with the understanding of study, and ethical practices of facilitating learning and improving performance in educational technology” (Ipek & Ziatdinov, 2017, p. 383).

## **Cognitive Constructivism**

Piagetian constructivism is concerned with an individual's epistemology and cognition in making sense of the world that is not fully known to them (von Glasersfeld, 1989). The central position is that learning happens through "individual development of knowledge through interaction with the environment" (Toven-Lindsey, Rhoads, & Lozano, 2014, p.3) and is epistemic to a mind-in-head metaphor. Only the individual can know what they have learned (Duffy & Cunningham, 1996) and tacit knowledge and knowing are influential to the interaction. Instructional theories of constructivism are: situated cognition, cognitive apprenticeship, anchored instruction, cognitive flexibility, and problem-based learning (Bendar, Cunningham, Duffy, & Perry, 1991).

## **Social Constructivism**

Vygotsky's work in sociocultural practices extended individual constructivism into the social world and emphasized group collaboration methods of interaction, dialogue, and negotiation (Bonk & Cunningham, 1998) to create knowledge. Knowing is distributed through co-construction of information and is not "attributed to the mental processes of any one individual" (Stahl, 2004, p. 3). The collaborative discourse process is critical in making group knowledge explicit as it draws from the foundation of tacit knowing (Stahl, 2004). The ontological position is that meaning is constructed in group interactions, wherein collective prior knowledge shapes the group's interpreted reality (Stahl, 2004). This suggests that knowledge resides in the mind of the individual-in-social-action (Cobb, 1994). An example of social constructivist instructional theory is Scardamalia and Bereiter's knowledge building theory.

## **Situativity**

Situativity theorists assert that knowing, learning, and meaning only occur *in situ*, meaning that the context is the defining factor and the product of knowledge construction. Situative ontology rests in the individual's perception and relationship to the environment for the construction of reality and epistemic views focus on the adaptation to the affordances and constraints of the environment (Brown, Collins & Duguid, 1989). The goal for learners is to become effective and central participants in the knowledge practices of the community as characterized by an identity in relation to the community (Greeno, 1998). Explicit and tacit knowledge resides in the action, wherein the mind and world are one unit, and knowing only has meaning in a context. The factors of the

situation (conceptual, social, or physical) cannot be readily isolated, which may challenge educational designers who look for evidence of what to change. Metaphors that describe the complex system of the learner(s)-and-situation include examples such as: Engestrom's Activity Theory; Lave & Wenger's Community of Practice; and, Shaffer and Clinton's Tool for Thoughts.

### **2.3.2. Movements in the Field**

#### **1980s**

The 1980s placed technology as peripheral to education and developments were designed with cognitivist foundations. Some examples of technology developments that influenced education included: computer-based training; computer-based learning; LOGO (a tool for thinking and problem solving); intelligent tutor for LISP computer programming; cognitive tutors; and, Thinker Tools (for inquiry and modelling). Other developments included personal computing and distance learning courses using computer networking and digital communication (Reiser, 2001). Two notable mentions are: 1) in 1981, IBM released the first personal computer, and 2) in 1982, satellite TV systems were implemented for military and corporate training.

The rise of the microcomputer had a major influence on educational technology and computer-based instruction production took off (Dick, 1987) along with the development of instructional design practices (Hoadley & Van Haneghan, 2001). Growth in developmental and cognitive sciences (Gardner, 1985) brought movement into educational technology and onto the scene came LOGO (Papert, 1980) and intelligent tutoring systems (Anderson, Boyle, & Reiser, 1985). These educational technologies were grounded in the belief that technologies could alter the way we think and learn for the better (Hoadley & Van Haneghan, 2012).

However, research findings during the 1980s did not demonstrate that instructional design principles were effective in education (Reiser, 2001). For example, LOGO was hopeful in its claim to improve cross-disciplinary problem-solving skills, however, cognitive advantages were not achieved through learning programming skills and these could not be applied outside of the LOGO environment (Rosenburg, 2001). Papert (1987) disagreed with these findings and suggested that the experimental methodology was inadequate to study LOGO as it could not be decontextualized (Pea,

1987). Case and Bereiter (1984) critiqued cognitive tutors and suggested they made false assumptions about novice learners being able to acquire expert thinking through modeling that would result in the transfer of learning. By the end of the 1980s, many educational technologies lost their appeal and became underused due to criticism (Rosenburg, 2001). More than just education, Reiser (2001) stated that instructional design in industry also showed limited influence on training and performance. Further to that, Clark condemned studies about the impact that media had on learning. Clark's (1983) position was that instructional design needed to study the active ingredients of technology that led to effective instruction for learning.

### **1990s**

The 1990s placed technology as supplemental to education and advancement embraced constructivist foundations. The development of the World Wide Web (1991) had an enormous influence on education including email, online video lectures, computer-mediated communication, OpenCourseWare, computer supported collaborative work, groupware (e.g., interactive whiteboards), the sophistication of hardware and software, and personal computing. Examples are:

- Jasper Woodbury video series from the Learning Technology Center at Vanderbilt University (Bransford, Franks, Vye & Shenvood, 1989). Jasper Woodbury is a constructivist educational technology that used a problem-rich media environment to tell a story that anchored a realistic and motivating problem to a real-life context (CTGV, 1992) for the learner. The design principles of Jasper Woodbury included complexity that allowed the instructor to guide via teachable moments (Wise & O'Neill, 2009) within the problem-solving context and to work with real-world complexity.
- Computer Supported Collaborative Learning (1989) is a social constructivist educational technology that supported group collaboration and inter-subjective interaction. Group cognition and knowing are distributed over individuals (Lipponen, 2002) and these interactions created culturally embedded meaning that resulted in epistemic and cognitive objects that encapsulated the knowledge for the community (Scardamalia & Bereiter, 2006).

Some other notable mentions include:

- 1990: Student response systems were released (wireless clickers)
- 1994: CompuHigh was introduced as the first accredited online high school
- 1995: Ward Cunningham announced the first wiki site for collaboration

- 1998: International Society for Technology Education developed the National Education Technology Standards (e.g., digital citizenship, collaboration)

The performance technology movement that began in the 1980s changed views and processes around performance programs and by the 1990s had a large influence that broadened the field of instructional design (Reiser, 2001). Many analyses of performance problems resulted in non-instructional solutions, such as contextual changes to enhance performance (Reiser, 2001). The advancement of electronic performance support systems, which support workers with tasks, changed the field of educational technology toward a focus on human performance technology in the workforce. This altered the profession of instructional designers, who went from developing training programs to designing support systems (Rosenburg, 2001). It also and resulted in a shift in practices from the first model-based instructional design approach (abbreviated as the ADDIE models of instructional design) to rapid prototyping and successive approximation models of learning design.

In the 1990s, movements in the field of educational technology were also driven by advances in constructivist theory and accompanying instructional principles. Plus, the ubiquity of the Internet had a major influence on education technology, such as distance learning. Movements in constructivist thought stemmed from the recognition of the critical role of context in learning. Wise and O'Neill (2009) commented that transfer of learning occurred more readily in constructivist learning environments as the noticeable elements of problems-in-context simulated real world conditions. Cronbach (1975) signaled postmodern criticism by illuminating how psychology was reductionist in its analysis of linear relationships between the learner and intervention. Hoadley and Van Haneghan (2012) argued for the "importance of context [and] suggested that the unit of analysis for understanding learning had to be larger than the individual" (p. 4).

Four theoretical frameworks that influenced constructivist educational technology were:

1. The rekindling of Vygotsky's concept of learning as embedded in cultural artifacts and tools, and the zone of proximal development, which lead to Pea's (1993) distributed intelligence, a concept that technologies are tools that change thinking processes, and Brown and Campione's (1994) community of learner's model for teaching science.
2. Cognition and Technology Group at Vanderbilt (1992) developed anchored instruction that supported the attachment of knowledge to situations to prevent inert knowledge.
3. Lave and Wenger's (1991) situated cognition for the support of learning conditions to resemble authentic contexts.
4. Developments in Learning Sciences towards constructivism, which Schank founded in 1989 from a cognitive science perspective. Design-based research methodology rose to study complex, iterative, and multi-relational designs of learning environments (Barab & Squire, 2004).

Clark (1994), Kozma (1994), and various others agreed that limited research showed evidence that educational technology had an impact on learning. Their debate in 1994 had significant influence on research and design as instructional theory began a shift towards "instructional methods that support the *structural* elements of cognitive processing during learning and transfer" (Clark, 1994, p.22). Clark's separation of media and educational research was a concern as the cause-effect and solutions-method did not take into consideration the social elements, which Kozma (1994) thought were important. Kozma (1994) suggested that technology is not just the tool, but how it is used that brought the design science to the forefront. This may be one of the earliest calls for principles of "underlying structure and function of media" (Kozma, 1994, p. 8) to be considered in educational technology. This shifted the field away from logical research models to analytic approaches that looked at processes.

### ***2000s and Today***

The early 2000s still placed technology as supplemental to education, yet, in a more seamless manner than the 1990s. Ubiquity of the Internet and connectivity was the norm and examples of technology that influenced education included: portable technology, smart devices, YouTube, online learning, online discussions, web-based

training, online communities, and massive open online course (which are arguably designed from cognitivist and behaviorist traditions).

- Examples of social constructivist-inspired educational technologies include BlackBoard Collaborate and BlueJeans, both video conference technologies. The affordances of these technologies include presence and awareness features, chat streams, web camera, multimedia, file and application sharing, voice channel, and whiteboards for presentations and collaboration.
- Examples of situativity-inspired educational technologies include video games, simulations, virtual worlds and reflexive play spaces such as Quest Atlantis (Barab, Gresalfi, & Ingram-Goble, 2010). Gee (2005) stated these educational technologies are used as representative of situations that are analogous to those that professionals would use in context and allowed the learner to act and think as a professional/ expert would *in situ*.

Some other notable mentions include:

- 2005: YouTube was founded
- 2005-2012: Learning Management Systems (WebCT and Blackboard)
- 2007: Flip cameras for digital recording
- 2007-2012: Participatory journalism (readers can post to online newspapers)
- 2008-2012: Khan Academy: online repository of instructional videos; Borg and O'Hara's Edmodo (a Safe Social Networking School)

In summary, today we are in a place where technology is integral to education.

Examples of technological developments include: tablets (the release of the iPad in 2010), multifunctional devices, customization, and personalization.

Given that constructivist designers are not a cohesive group, the field witnessed a plethora of educational technologies that evolved from varied ontological and epistemological positions, and with this came criticism, more research, and substantial progress. Kirschner, Sweller, and Clark (2006) suggested that “the constructivist description of learning is accurate, but the instructional consequences suggested by constructivists do not necessarily follow” (p. 78). Kirschner et al, (2006) provided a critique of constructivism and how it employed minimally-guided instructional frameworks, which they suggested lacked support for learning and did not take into consideration the importance of cognitive architecture and changes in long-term memory. Kirschner et al, (2006) suggested that guided instruction would allow for the

“cognitive manipulation of information in ways that are consistent with a learning goal” (Kirschner et al., 2006, p. 77).

Wise and O’Neill (2009) offered a possible resolution to the minimally-guided versus direct-instruction argument to support work in educational technology. They suggested that the guidance differences cannot be the basis upon which to validate the merits of constructivist approaches to teaching. Wise and O’Neill (2009) found that other dimensions of instruction, such as timing and context, are part of the design toolkit, which provided a useful recommendation for educational technologists.

Movements in the 2000s also recognized ways that educational technology and learning design contribute to and are shaped by technological and societal changes and are witnessed in different conceptions of design and the greater availability of data. A useful example is the massive open online course (MOOC) and the lessons that can be learned for educational technology and learning design, even though MOOCs are not theory-driven (Khalid & Sorensen, 2015). The vision for the MOOC feels like the examples that Reiser (2001) offered in describing the US military’s application of motion pictures for training purposes, and how it did not take root nor gain pervasiveness as intended. The intention of MOOCs to be widespread and disrupt academic institutions did not manifest (Khalid & Sorensen, 2015). The history of educational technology has prepared us for this particularly when the premise is based on efficiency models for delivering learning. Design lessons for educational technology are learned from a review of MOOCs that could present similar to other innovation in the 2000s such as YouTube (Szeto & Cheng, 2014), which may serve well as sources of complementary information in education.

Another trend in technology and society in the 2000s is online communities and social networking. Hill (2012) noted that educators have had long time goals to create communities that enhanced learning and enabled communication. However, the formation and design had proved challenging, and in response to this, Hill (2012) provided useful operational definitions, strategies, and techniques for communities that shifted the conceptions of design. In a similar vein, Barab and Duffy (2000) expanded situativity theory into practice fields for students to work as part of groups and engage in practices that would be realized by real world applications with people who operate in those fields. The design challenge was to create something that feels integral to the

activity of the society and supports inherent motivations for engagement. Barab and Duffy (2000) suggested that some answers may come from creating integral community tasks that legitimately support the development of identity and membership as part of a community, which is an important advancement for educational technologists. A study by Hay and Barab (2001) illuminated learning environment design in constructionist and cognitive apprentice orientations as the findings indicated that different constructivist design principles showed more prominence than the researchers had predicted. This study advanced understandings about qualitative research in the field of educational technology.

Hoadley (2004) suggested that for educational technology to thrive, it had to balance research and design. Hoadley (2004) offered advances to the field of educational technology through the discussion of design-based research (DBR) as a methodology that connects scientific inquiry with the design of micro-learning environments. The premise of the methodology is to investigate iterative design for what works and why, and the relationship to learning theory. With DBR come large amounts of data and the need for different types of analysis as the data tell us more than learner outcomes. This involves learning analytics (LA) which includes measurements that trace and visualize data about learner interactions in context (Verbert, Duval, Klerkx, Govaerts, & Santos, 2013). The purpose of LA is to provide evidence-based drivers of change and action that support learning and teaching (Barab & Squire, 2004) and make claims about causality (Wise & Shaffer, 2015). The field of DBR is still young, and as Dede (2004) pointed out, there is a need for more standards to improve the quality of DBR research (O'Neill, 2012).

### **2.3.3. Research in Educational Technology**

Due to the immense growth of educational technology use and the volume of publications in the journal of *Educational Technology Research Development*, it is clear that educational technology is a really important problem (Calfee, 2006). However, there is much diversity in educational technology research methodology, and some are more acceptable for publication than others. This is largely due to the politics of research, for example, in cases where there were power relations between the researched and researcher, or the context. Historical research in educational technology focused on determining the effectiveness of technology-based and traditional instructional

approaches (Morrison, Ross, Kemp, & Kalman, 2010). The typical aim of this type of research was to prove that the trouble and cost of the technology-based approach was worth it from an efficiency standpoint. Januszewski and Molenda (2008) reviewed research agendas in the field of educational technology and suggested that contemporary research focused less on proving that media and technology are effective for learning and rather moved toward “investigations formulated to examine the appropriate applications of processes and technologies to the improvement of learning” (p.2). This demonstrated that philosophical traditions in ontology and epistemology were also shifting. However, in the field of educational technology, knowing “where to turn for this research is surprisingly difficult” (Hoadley, 2004, p. 6) as there are multiple research communities and the edges defining them are not sharp.

The instructional design and Learning Sciences communities are the largest in the field of educational technology. These communities have characteristics of “scope and goals, theoretical commitment, epistemology and methods, and their history” (Hoadley, 2004, p. 7) that distinguish them. Instructional designers typically conduct experimental studies about the efficacy of an intervention, while learning scientists may use experiments for theoretical substantiations. “Learning sciences review learning from different sets of assumptions and scientific perspectives, than instructional sciences do” (Ipek & Ziatdinov, 2017, p. 386). Learning Sciences requires more than experiments could provide, namely: the focus was on more than one variable while attending to the learning of the practitioner/ researcher during the process of design (Hoadley & Van Hangehan, 2012) and it is from this warrant that design-based research (DBR) arose (Brown, 1992; Collins, 1992).

A vast array of methodologies is used in educational technology research. Movements during the cognitive revolution led to demands for new methods of research and the AECT expanded the range of research methodologies to include reflective practices (2004). A small sample of educational technology research methodologies include: Karr, Weck, Sunal, and Cook (2003), who come from applied frameworks; Richey and Klein (2008) use DBR; Kaufman (2004) uses cognitive and experimental approaches; Greehow, Robelia, and Hughes (2009) use descriptive methodologies; Lowther, Inan, Strahl, and Ross (2009) conduct quasi-experimental studies; Sator and Bullock (2017) use reflective practice and self-study methodology, and Cutri and Whiting (2018) use self-study methodology to understand technology in teacher education.

These ranges demonstrate that quantitative (randomized and quasi-experiments), qualitative/ descriptive (e.g. case study, ethnography), mixed-method, and DBR methodologies include diverse methods as prominent in the field of educational technology.

Ross, Morrison, and Lowther (2010) conducted a modest analysis of the types of research published in *Educational Technology Research and Development*, a top-ranked international journal. In 2006-2008, they found that 58% (of 43) used qualitative/ descriptive educational research methodologies. This is quite different from what Ross and Morrison (2004) found in articles published in 1953-2001, wherein 58% were true experimental design and only 19% were qualitative/ descriptive studies.

Hannafin and Young (2008) provided a cautionary note and suggested that researchers appeared to dismiss findings from older studies. The key lesson is that researchers need to navigate the plethora of inquiries made in the field of educational technology and the respective methodologies, study designs, and methods, to understand the complex outcomes of technology and education, and the influence on educational practices. This lesson is critical to avoid the trappings of popular culture about educational technology that are not based in scholarly thought.

#### **2.3.4. Myths in Educational Technology and Learning Design**

Popular literature is a major source of information for many educators and when the seeming success of technology combines with the field of educational technology, educators become inspired (and concerned) by the potential of technology for education. Myths arise in the field of educational technology because popular literature is not founded in scholarly thought or research-based claims. Popular culture in educational technology typically frames technology as the solution for the needs of students and teachers because it will bring immense changes to education. For example, Raza (2017) described online courses and how technology changed education by making education more accessible, flexible, and engaging. Only the positive and noble aspects of technology are illuminated, and it is commonplace to equate technology with doing good work in education. Every tool appears to provide promise to solving problems inherent in teaching and learning. More than that, popular literature frames technology as having

the potential to control outcomes in education. Consequently, this has put questions into the minds of educators about the potential for technology to replace the teacher.

It is this type of thinking about technology in popular culture that has led to grandiose claims around technology and education. These manifest as myths that educators tend to strongly believe in and vividly vocalize despite a paucity of evidence, uninform approaches, or scholarly thought. This section will explore three popular myths about technology and education and draws from the intellectual heritage in the field of educational technology to argue against those myths and discuss why they persist.

### ***Myth #1: Technology can lead to dramatic changes in education***

The first myth is the belief that technology can lead to dramatic changes in education, though there is a scarcity of historical evidence that would support this claim. Reiser (2001) provided a two-part review of the history of instructional design and technology, up to the 1990s, and shared an unfavorable story about educational technology reform that provided copious evidence against this myth. Reiser (2001) discussed instructional media, visual instruction, audiovisual instruction, instructional radio, and motion picture, and declared that instructional technology and media did not cause major changes in education.

Despite the acceleration of technological advances and the attention that media garnered from educators, Reiser (2001) noted that by the 1990s there was still limited influence of technology in education, even after the computer came onto the scene. In summary, Reiser's (2001) historical account and evidence demonstrated that technology and media did not provide solutions to the performance problems they intended to solve. Thus, the claim that technology can lead to dramatic changes in education is not founded and suggests that choices need to be made around technology-led initiatives.

Other evidence against this myth can be found in the contemporary work of Cuban (2001), which as a response to the myths circulating around the promise that technology had for student learning, transitions post-academia, and by extension, educational reform. Cuban (2001) researched early education, high school, and post-secondary institutions in the Silicon Valley and revealed that technology was used in limited capacities in education by students and educators. Cuban (2001) found that practices in education have largely remained unchanged over the years despite the

increase of technology. Where educators reported using technology, the methods were rather mundane, and this presents a case against the myth that technology dramatically changes education.

Many scholars have reached similar conclusions to Reiser and Cuban that give more evidence against the myth that technology can lead to dramatic changes in education. Selwyn (2016) reminds educators about the need for pessimism in educational technology. As well, Heidegger (1977) and Papert (1987) suggest that it is not the educational technology, rather, how educational technology is implemented that is important.

Culp, Honey, and Mandinach's (2005) longitudinal review reported that no one technology sustained longevity in education. Lai (2008) studied and posited that technology was not overwhelmingly effective in educational practices. After 30 years of technology in education, Lowther, Inan, Strahl, and Ross (2009) stated that in the USA, the incorporation of technology into the classroom demonstrated less evidence of effectiveness and use than presumed. These evidence-based findings do not support the myth that technology can lead to dramatic change in education.

### ***Myth #2: Innovation is good, and technology controls the outcomes in education***

Another prevailing myth derived from popular literature that seems to motivate many educators is that the provision of technology in education is adequate to control good outcomes for education. One popular literature source stated that:

in the era of development of the modern world, the ability to learn becomes the most popular task of the modern man, which can be solved through innovative technologies. Thanks to technology, teachers can keep statistics on student and student performance, analyze data, and understand which teaching methods are better suited (GinnersNow, 2019).

Yet, there is a long history that demonstrates that bringing, providing, or giving technology to students and educators is not a solution. There is little evidence of success in educational reform as discussed above that Reiser (2001), Cuban, (2001) and others have demonstrated in scholarly findings.

At the foundation of this myth is technologically determinist thinking, in which proponents of technology believe that technology controls educative outcomes. The

argument against this myth is founded in socially deterministic thinking that purports the influence and possibility of technology is anchored in the social use of technology and determined by society. Development in social constructivist theory and the sociology of science produced movement away from technological determinism to the social shaping of technology and demonstrated how technology cannot control the outcomes, providing more evidence against the myth. Social construction of technology theory also suggests that successful technological innovation is derived from advocates in the social context (Bijker, Hughes, & Pinch, 2012), and provides evidence against the claim that technology can determine educational outcomes.

Other lessons from the history of technology and education provide more evidence against this myth that a mere implementation of technology can control educative outcomes. Postman and Papert are scholarly proponents for the crucial interactions that occur between technology and users. Papert (1980) alluded to such problems in technology and education and provided scholarly arguments against the myth of technological determinism. Papert (1987) suggested that educators should not have blinders on and enthusiastically create educational purposes for specific technology, but rather focus on how to enhance learning. Papert (1987) cautioned against diagnoses of technocentrism and suggested that educators carefully look at where things are embedded because the context for development is in a culture and not an isolated technology. The lesson from Papert (1980) is to be mindful and not have a sleepwalking attitude towards technology and to think about how technology uses us because the effects are beyond the individual. Postman's (1996) findings also revealed a message for educators to be mindful and not fall into the technophile profile of the tool focused educator that feels that technology can solve everything. As per the myth, educators typically fall into the tech-hype trap and demonstrate a sense of urgency to use the technology because it is available (Postman, 1996), which has not proven to be a viable position.

LOGO provides an example against the myth that technology controls educational outcomes. LOGO is a programming language developed by Papert (1980) that supports the way children think and solve problems. Agalianos, Whitty, and Noss (2006) gave an account of the social process of LOGO development and evolution, and the poor receipt of LOGO in the educational arena. The intended transformative impact of LOGO in education did not manifest as the roll out was shaped by those with power

and there was complexity in the social, technical, political, and economic aspects (Agalianos, Whitty, & Noss, 2006). Just because the technology is available, does not mean the implementation process is simple. The integration is cultural and if there is a social disconnect, for example, between the school and home environment, then obstacles will arise, therefore technology cannot control educational outcomes. The lesson is that for effective technology and education integration, the process has to be social for things to mesh well (Agalianos, Whitty, & Noss, 2006) and technology alone cannot determine this.

Finally, Cuban's (2001) findings, which also have sociological implications, may shed light on this myth as he suggested that contextual factors guide how educators view technological innovations in education. His evidence for effective integrations of technology laid in the hands of adequate educator understanding of technology and their belief in the ability to create education around the technology. Therefore, the alignment of sociological perspectives in facts, ideologies, and socially constructed goals for technology and education guide the collective view. This indicates further that technology itself does not control the outcomes in education.

### ***Myth #3: Technology will take the place of the teacher***

Reiser's (2001) historical accounts and research demonstrated that educational technologies did not take the place of the teacher in education. Bullock (2016) also asserted that we have not yet "reached a point where educational technologies can supplant a teacher who is playing an active role in a classroom, reflecting a transactional or transformational orientation to curriculum" (p.5). Further counter evidence for this myth lie in historical educational investigations and predictive studies carried out by McLuhan (1969), who provided early evidence against the claim that technology will take the place of the teacher. McLuhan was impervious to technological change and felt that society needed to regain control over the ubiquitous acceptance of technologies. McLuhan's (1964) work presented evidence against the myth through the questions he raised about the relationship between media and culture.

In McLuhan's *Understanding Media: The Extensions of Man* (1964) he examined humans' relationships and noted that meaning resulted from interactions with various mediums. McLuhan suggested that meaning does not reside within the form of media or its content, rather through the way that people gather information from their experience

with it. McLuhan (1964) felt that media massaged the brain to behave in particular ways and coined the popular phrase, the “media is the message.” The crux of McLuhan’s (1964) argument is that the way we send and create information is more significant than the information itself. McLuhan’s (1964) thoughts are that the content of the medium is not as important as the meaning that results from it. McLuhan (1964) argued that almost any object that man interacts with shapes their perceptions of the world and how they communicate with others. In this way, media changes the way we behave, and media may be thought of as an extension of the body (McLuhan, 1964).

The lessons learned from McLuhan’s scholarship demonstrated that it is the combination of the good use of technology and good teaching in combination that provided effective results for technology and education. One of McLuhan’s most significant contributions from the concept of the medium is the message suggested that each medium, independent of the content it mediates, has its own intrinsic effects, which are its unique message (McLuhan, 1964). McLuhan (1964) felt that it is not possible to understand social and cultural change without knowledge of the workings of media (McLuhan, 1964). This describes the powerful effects on society that result from the delivery of information via the medium and the concept of the media is the message provides reasons for the inconsistent uses and applications of media (McLuhan, 1964). Most relevant to technology and education is how learners will respond to different media due to the properties of the media, which provide evidence against the myth that it will replace the teacher.

McLuhan (1964) stated that affordances are a property of the object and the way people interact with the affordances causes activity patterns that are pertinent for learning. McLuhan (1964) was concerned that some hot media detached people from their thoughts as they are inactive in their interactions with the media. As new media is presented, society changes and grows accustomed to it without considering the interactions. It is important to consider the properties of objects-in-interaction and how they lead to change. McLuhan (1964) felt that with some media such as a film, lecture, or photographs, people are less interactive with the medium and reduced effort is required to derive meaning from it. McLuhan’s theories were dynamic and take into consideration the context of the age and culture within which the media exists. The crucial lesson is that it is the technology (the processes) around the media, not just the media that lead to changes in education. McLuhan’s (1964) concept of the medium is

the message reminds us again and again, that media should not be equated with technology. Media cannot be merely imported into education for it to work, rather it is how it is mediated, and further, it depends who is in the power position to determine how media is used. The importance of properties and affordances of media and the mediation is front and center for scholars doing contemporary work in the field of educational technology and learning design and the implications are critical for countering the myth that technology can replace the teacher.

Other evidence against the myth that technology will replace the teacher is found in the mixed scholarly findings about the influence of technology and the effectiveness of instruction. Clark (1983), who based his conclusions on a large volume of instructional research, found that it is the method (e.g., teaching practices) and not the media (e.g., technologies) that are influential to learning. Clark (1983) famously referred to instructional media as “mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition” (p.22). Kozma (1994) also demonstrated in his study that it was the correct use of media that could have an impact on cognitive skills. Kozma (1994) posited that both the medium and the method play a critical role in instructional design and his position was that there are

causal mechanisms by which cognitive and social processes are influenced as students interact with a medium’s defining capabilities (i.e., attributes) [and these] must be specified so that appropriate uses of these capabilities (i.e., variables) that is, the ways in which these capabilities may be used to influence the learning for particular student, tasks and situations (p. 13).

The great debate between Clark and Kozma in 1994 revealed support against the myth that technology can replace the teacher and suggested that learning design is the greatest influencer.

### ***The Persistence of Myths about Technology***

When people tell stories, create myths, and invent causations, they do so to make sense and categorize the vast sources and abundance of information. In educational technology myths persist because new information is constant and ubiquitous. All one must do is open their email, check the newspaper or a magazine, or look at the Internet. There is no shortage of popular press around cutting edge and

innovative technologies that claim importance for education. For example, in recent press, *GinneersNow* magazine said:

information and communication technologies offer completely new opportunities for students and teachers. In addition to improving academic performance and interest in learning, improving literacy and the general erudition of students, various types of thinking are activated through telecommunication, the development of creative and intellectual potential takes place (2019).

So, people start reading and often do not check their sources or verify if the content they are reading has been peer reviewed or researched. Further, they do not seek alternatives and begin categorizing information to keep pace with the sheer overload. This process extends into group, instructional, and/or organizational socializations and myths start to take root and gather substantive followers.

The sources for generating these myths makes them fallible, but in order to be considered a fallacy there is the implication that some logic was involved. Myths are not about logic or reasonable ways of thinking (Stupple, Ball, Evans, & Kamal-Smith, 2011) because they are just-so stories and can be harmful, pervasive, and long lasting. Unfortunately, educational technology falls into the mythological trap and I speculate these myths persist for three reasons:

- The history of technology and education perspectives are not considered
- The sociology of technology perspectives is not embraced
- A Learning Sciences perspective is not integral

### **Historical Perspectives**

One reason why myths persist in technology and education is that the history of the field is not considered or understood. In order to understand technology and education, it is critical that educators understand how we have arrived at our current juncture. Without knowledge and appreciation of the historical developments in technology and education, an ahistorical approach runs the risk of repeating past follies that are not reflective of contemporary thinking, research, and the evolution of technology, and so the myths will persist.

There is substantial worth in approaching the field of technology and education from a historical perspective. A proponent of historical work, Lagemann (2000) analyzed

the uneasy history of educational research in the twentieth century and collated this knowledge to provide directions for the future. This work can be extended to make a case for educators to consider the historical foundations of educational technology to help answer questions about what has changed over time, what movements occurred that established principles for the field, and what the current conditions are in educational technology. Bullock (2016) supported historical presence and extended his sentiment to the inclusivity of philosophy in the case of teacher education “so that candidates may develop an understanding of the nature of technology” (p.10).

Cochran-Smith (2005) provided a crucial statement about the importance of historical approaches and said that:

educators need to know how to read, evaluate, critique, and use . . . research in their own work. They need to be able to interpret new research studies by locating them within a larger discourse that is informed by multiple historical, empirical, and epistemological perspectives . . . [and] they need to know how to draw from rich ethnographic studies. In addition to being smart consumers of research . . . need to have expertise in conducting research about their own practices and programs. This involves self-examination and interrogation of the biographical bases of behaviour and beliefs . . . it also involves conducting empirical research on practice in order to determine what the outcomes ...are for their professional performances in schools and classrooms, and for their pupil's learning. Questions of value cannot be settled simply by assembling good evidence . . . these questions can be shaped, reformulated, or understood more profoundly on the basis of evidence, but evidence must always be interpreted (pp. 224-225).

Historical and philosophical understandings may break the grandiose claims of technology and education and halt the spread of myths because people would be more informed of past failures and achievements and how these can support or refute present and future aspirations. With this understanding, the field can enter into different types of conversations, understand arguments and challenges, and distinguish whether they have been resolved, which will take educational technology beyond the just-so stories and myths (O'Neill, 2016).

### **Sociology of Technology Perspectives**

Through his sociological lens, Latour (2004) presented a critique of the concepts of ideologies and facts that shed some light on why myths persist in the field of education and technology. Latour (2004) critiqued the nature of sociology in how ideas

may be conceptualized. His lens of critical studies has utility in providing reasons for why myths in technology and education persevere and he stated that it is due to the perilous nature of ideologies that shift to facts. It is easy to see how this would happen in the field of technology and education as the plethora of available public press in technology is often not founded in academic research. This calls for close consideration of the harm in presenting ideologies because these get accepted as facts by society. The flip side of the argument is also true in that there is danger in assuming facts may be ideologies.

Another consideration about why myths persist is due to technologically deterministic thinking that presents technology as the cause of social change. Most writing about educational technology has been deterministic likely because that is what the political and economic agendas mandated. Therefore, the view of reform in education is problematic as it comes from a technological deterministic lens, consequently also lending an explanation for the lack of educational reform. Yet, it is relatively easy to understand why these ideas prevail because traditionally, science studies have been separated from technology studies on analytical grounds and historically there had been little attempt to bring them together (Bijker, Hughes, & Pinch, 2012).

Contemporary views in the sociology of science and technology have shifted attention to the social construction of science beliefs and knowledge in the social world and this had an influence on technology studies. While Bijker, Hughes, and Pinch (2012) commented that science studies and technological studies are rarely coupled, the social constructivist view in the sociology of science is making an appearance in the sociology of technology. The benefit of this presence to both fields includes a broader recognition of social construction in science-technology studies and the advancement of knowledge and techniques in the field and research.

The field of education and technology needs to look through a sociological lens in order to shift thinking and break the cycle of the dominant myths. It is the sociological perspectives of the human-technology-society interactions and how those shape groups and communities that are not given enough consideration. For these reasons, we witness myths in technology and education as technology is considered by many as the cause of social change. These myths will continue to prevail because the fields of science and technology to some extent still compete for singular disciplinary attention.

## Learning Science Perspective

Learning Sciences is an interdisciplinary field of study that aims to enhance understandings about learning through research and theory development. The field of Learning Sciences is interventionist and aims to understand the validity of theory in authentic settings and advance or develop new theories and principles for learning conceptualizations, the application of principles in instruction, and frameworks for the development of learning design (Kolodner, 1991). The differing positions of Learning Sciences and instructional design indicates why myths in technology and education prevail. “Learning scientists set out to uncover basic scientific principles which would then be applied to instruction [and] instructional designers sought to apply theory to the problems of instruction and systematize the process that took theories and turned them into educational environments” (Hoadley, 2004, p.10). As such, it could be argued that Learning Sciences is better positioned to study dynamic learning systems, yet many enthusiasts often look to learning theory for prescriptions that have practical implications.

O’Neill’s (2016) work in Learning Sciences provided major cues for understanding why myths persist in educational technology. O’Neill (2016) posited that learning scientists have as their research goal a futurist approach to design that is based in a *build the future* or *building for the future* orientation. The *build the future* orientation is a riskier approach for technological design and O’Neill (2016) used a review of historical architectural projects as an analogy to offer suggestions for learning scientists. O’Neill’s (2016) recommendations served as heuristics for understanding why myths in technology and education persist and suggested that designers of technology education typically are not:

1. Wary of the influences of technological trends on design thinking
2. Serious about studying the unintended outcomes of design
3. Committed to taking the long view in the study of design work (p. 148-149)

It is not only technology enthusiasts that may not be mindful of how technological trends influence design thinking. O'Neill (2016) suggested that scholars fall into this trap as well, and he stated that:

many learning scientists follow technological trends closely (e.g., in social media, games, data mining) and report their pedagogical potential. However, these trends can be misleading clues what the future will hold. Because technological changes are often easier to notice than changes in social conditions, they can have disproportional influence on design thinking (p.146).

Another reason why the myths prevail is that Learning Sciences does not have a “systematic way of seeking out and evaluating the unintended outcomes [of] our design” (O'Neill, 2016, p. 148). As O'Neill (2016) suggested, some longitudinal research has been done on a small scale, for example by the Cognition and Technology Group at Vanderbilt (1997). Yet, O'Neill (2016) suggested that the approaches need to be broader to incorporate diverse outcomes and their “potential trade-off relationship with an innovation” (p. 149). Taking from these suggestions, it is through an understanding of a Learning Sciences approach in educational technology that designers may mediate the myths that prevail in technology and education.

## **2.4. Technology and Teacher Education**

Bakir (2016) described some historical movements in the U.S. in his review of the extensive histories of technology and teacher education programs over the almost 50-year history of computer technology in education. In the review, Bakir (2016) discussed the reforms and endeavors of governments, organizations, accreditation bodies, institutions, and business collaborations. It is worthwhile to note the considerable devotion, funding, time, and efforts that helped “develop and integrate different frameworks and policies to encourage the use of technology in teacher training” (Bakir, 2016, p. 21). The historical movements are critical for understanding some of the major markers in the field of technology teacher education and how these developments led to different recommendations and technology integration strategies. The International Society for Technology in Education (ISTE) paved one path and developed standards for technology use in education. The reach of the standards is wide, for example, they support what should be taught to novice teachers; provide vision for administrative leaders; guide the restructuring of teacher education programs; and, relay accreditation

standards (ISTE 2000). The standards are related to technology concepts and operations; the design of learning environments and experiences; teaching and learning; assessment and evaluation; professional practice; and, social, ethical and human issues. The ISTE consistently updates the standards in the rapidly shifting landscape of educational technology and, for example, shifted the field from thinking about learning-about-technology to learning-with-technology in 2007. The standards are a common reference point for the multiple technology integration approaches, methods, strategies, and models that exist in the field of technology teacher education today.

Advances in educational technology and the use of technology in education as described in previous sections provide many lessons and ultimately demonstrate that despite the promised influences of advancing teaching and learning via educational technology, reform was not achieved (e.g., Cuban, 1993; Reiser, 2001). Yet, the demand for adoption and integration of technology in education continues to grow and “teacher education programs have struggled to implement and model best teaching technology integration practices in the preparation of pre-service teacher” (Bakir, 2016, p. 21). The lack of educational reform attracted significant attention (Bakir, 2016) and it could be suggested that this created opportunities to investigate technology integration in teacher education. “With technology rapidly changing, preservice teacher technology skill sets improving, and the notion of the highly qualified teacher licensure requirement, more tech education programs may need to re-evaluate how they are currently teaching technology” (Ottenbreit-Leftwich, Glazewski, & Newby, 2010, p.6).

New in-service teachers have reported that they feel ill-prepared to use technology in the classroom (Sang, Valcke, van Braak, & Tondeur, 2010). This highlights the inherent complexity of the field of technology teacher education as it relates to teacher candidates’ preparation and teacher educators’ abilities (Garbett & Oven, 2017). Many “teacher educators are not trained in the practices of instructional technology and, when mandated or strongly encouraged to do technology integration, they can face challenges and even crises of practice and identity” (Cutri & Whiting, 2018 p. 125). Some research suggested that teacher educators do not have the necessary knowledge and skills to model technology integrations and use technology effectively with teacher candidates (Goktas, Yildirim, & Yildirim, 2009). Other research found that teachers do not have enough support for the integration of technology in their practice beyond learning to use specific technological skills such as programs or software (Lawless & Pellegrino,

2007). Bullock (2016) stated that there is “little attention paid to how future teachers might develop a sense of technology beyond a specific device” (p.3). This is consistent with the findings that most technology courses and research focused on the attainment of skills for using technology (Niederhauser, Salem, & Fields, 1999).

Some movement from a skill-based educational technology focus towards technological literacy is found in the teacher education scholarship. Hasse (2017) explicitly addressed “the analytic capabilities that teachers need in order to engage effectively with technological development” (p. 365). Although programs do often require teacher candidates to design lessons that integrate technology in the coursework, research shows that few teacher candidates transfer this to their in-service practice (Voogt, Fisser, Roblin, Tondeaur, & van Braak, 2012). The challenge may stem from the fact that despite the standards or guidelines that influence the field of technology teacher education in the preparation of teacher candidates, “there are no technology guides that exist specially for teacher educator to operationalize the initiatives” (Foulger, Graziano, Schmidt-Crawford, & Slykhuis, 2017, p. 422) in a coherent way. The field is filled with diverse integration strategies, competencies, and approaches that inform technology teacher educators.

### **2.4.1. Technology Integration**

The purpose of this section is to provide a high-level chronological overview of some the diversity in the field of technology integration as situated in teacher education research. The aim of the overview is to suggest that teacher educators would be well served to know about the complexity of the landscape related to technology integration approaches, methods, competencies, and models as they develop their pedagogy of technology teacher education. Although not expanded in this section due to space limitations, teacher educators need to be mindful of the critiques in the literature of the technology integration strategies, competencies, and investigate the suitability for their context.

Cohen (2017) suggested that:

research on the integration of technology into classrooms consistently shows that teachers are more likely to integrate new technologies and the pedagogies they support into their practice if the teachers (1) possess the relevant technological knowledge (Mueller, Wood, Willoughby, Ross, & Specht, 2008), (2) self-efficacy relative to teaching with technology (Wozny, Venkatesh, & Abrami, 2006), and (3) a belief system which values technology as a necessary ingredient to successful education (Ertmer & Ottenbreit-Leftwich, 2010; Ertmer, 2005; Kim, Kim, Lee, Spector, & DeMeester, 2013).

An aspiration for the field of technology and teacher education dates back to the recommendations of Moursund and Bielefeldt (1999); namely: 1) technology should be integrated into all teacher education courses, 2) teacher educators should model the use of teaching and learning with technology, and 3) field placements mentors should support teacher candidates in their practices with technology. Niederhauser, Salem, and Fields (1999) felt that “the technology course can provide an authentic context for future educators to examine instructional practice and reflect on their learning as they learn new skills and content” (p. 153). The approach taken by Niederhauser, Salem, and Fields (1999) in their research aimed to guide teacher candidates towards the development of a theoretical orientation towards learning. They felt that teachers could then attend to the decision-making processes required for the effective integration of technology in their teaching. A focus on learning theory provides a framework for:

a) examining how different types of computer programs can support different learning goals, (b) how software can be selected to meet instructional goals based on learners’ needs, and (c) how to evaluate new educational technologies in the context of student learning (Niederhauser, Salem, & Fields, 1999, p. 169).

Kay (2006) commented about the deliberations that exist in the research about the most useful methods of technology integration in teacher education. Kay (2006) suggested that teacher educators and in-service teachers are challenged with the adjustments needed in their professional skills to meet the requirements as outlined by the Partnership for 21<sup>st</sup> Century Skills (P21, 2010). “Numerous teacher education programs have made extensive efforts to implement effective and meaningful use of technology, however, the strategies used to attain these goals are complex, diverse, often conflicting and rarely evaluated well” (Kay, 2006, p, 385). Kay (2006) reviewed 68

studies and identified and evaluated ten strategies for technology teacher educators, including:

delivering a single technology course; offering mini-workshops; integrating technology in all courses; modeling how to use technology; using multimedia; collaboration among preservice teachers, mentor teachers and faculty; practicing technology in the field; focusing on education faculty; focusing on mentor teachers; and improving access to software, hardware, and/or support (p. 383).

Between Kay's (2006) review and the National Centre for Education Statistics' (2007) report, it was clear that "teacher education programs utilize three main models. These are "methods/ content course infusion, field-based experience, or stand-alone courses, while still drawing from a myriad of strategies, like focusing on faculty, providing workshops, or using multimedia resources, to strengthen the foundation" (Elwood & Saveney, 2015, p. 2296). The "jury is still out on which strategies work best" (Kay, 2006, p. 395) but there are some suggestions that a combination of strategies best support teacher candidates. A prevailing issue surrounding this is that professional development related to the use of technology for teacher educators, that is critical to the success of technology teacher education, is not offered consistently to in-service teachers (Duffield & Moore, 2006). The typical forms of professional development that support technology integration include modeling, reflection, and collaboration to develop the skills, knowledge, and problem-solving abilities (Derban & O'Neill, 2018). Yet, these models of professional development are often offered as direct-instruction and are practice-oriented with the focal point being on one tool, which presents limitations for supporting the goals of technology integration (Derban & O'Neill, 2018).

Derban and O'Neill (2018) studied teacher's ability to "cope with the inevitable disruptions that take place when they plan to make use of technology in an instructional program" (p. 381). Disruptions result in the "sudden change that occurs when a teacher's plans are interrupted" (Derban & O'Neill, 2018, p. 368). The findings from the study (with elementary teachers) suggested that to develop technological knowledge and problem-solving abilities with technology integration, professional development resources "might better be channeled into just-in-time resources to provide teacher with more immediate problem-solving alternatives" (Derban & O'Neill, p. 382). These suggestions, as Derban and O'Neill (2018) acknowledge, are consistent with recommendations that other researchers have called for, namely: professional development that is situated and

personalized in a sustainable manner for the immediate needs of the teacher provides a sustainable model for professional development.

Ottenbreit-Leftwich, Glazewski, and Newby (2010) investigated more than 100 programs and developed a conceptual guide for technology teacher educators. The guide intended to help the support the selection of the learning experiences for technology teacher education and provided advice about learning design. The conceptual guide addressed the three main elements that should be included in technology experiences:

- 1) approaches (information delivery, hands-on activities, practice in the field, observation or modeling, authentic experiences, and reflection), 2) technology content goals (e.g., standards), and 3) the broader context (e.g., stand-alone course, full implementation) (Ottenbreit-Leftwich, Glazewski, & Newby, 2010, p. 5).

Ottenbreit-Leftwich, Glazewski, and Newby (2010) proposed six approaches for the design of technology experiences. The six approaches and intended outcomes (in brackets) as offered by Ottenbreit-Leftwich, Glazewski, and Newby (2010) were: 1) information delivery (be familiar with specific technology integration content), 2) hands-on skill building activities (build technology skills), 3) practice in the field (apply technology integration knowledge), 4) observation and modeling (recognize quality technology integration) , 5) authentic experiences (discern consequences of instructional technology integration decisions), and 6) reflection (contemplate abilities and how to address gaps). Ottenbreit-Leftwich, Glazewski, and Newby (2010) urged teacher educators to “consider which approach best meet the intended goals of the teacher education program” (p. 20).

Howland (2012) re-united the field of technology and the use of technology in schools by refocusing the connection between technology and thinking about learning. Howland (2012) framed the integration of technology as meaningful learning activities rather than the affordances of technologies. The approach involved meaningful learning-with-technology activities that engaged intentional, active, authentic, cooperative, and constructive learning as attributes of meaningful learning goals. Howland’s (2010) thinking with technology involved:

- Inquiring with technologies
- Experimenting with technologies
- Designing with technologies
- Communicating with technologies
- Community building and collaborating with technologies
- Writing with technologies
- Modeling with technologies
- Visualizing with technologies (p. 2)

The reframing of technology as a partner to learn with emphasized educational activities that “support productive thinking and meaning making” (Howland, 2012, p. 7) and used technologies to engage and facilitate thinking (Howland, 2012).

Okojie, Olinzock, and Okojie-Boulder (2016) appeared to take up the ideas of Niederhauser, Salem, and Fields (1999), who detailed the importance of pedagogy in the success of technology integration through the exploration of the relationship between pedagogy and technology. A chief concern related to technology integration appeared to be the lack of pedagogical principles to guide technology use in teaching and learning (Okojie, Olinzock, & Okojie-Boulder, 2016). To moderate this concern Okojie, Olinzock, and Okojie-Boulder (2016) suggested that:

technology integration should be concerned along with issues involved in teaching and learning. Such issues include developing learning objectives, selecting methods of instruction, feedback, and evaluation and assessment strategies including follow-up activities. Technology used for teaching and learning should be considered an integral part of instruction and not as an object exclusive to itself (p. 66).

This research is fundamental in that it extended the perspective of technology beyond an appendage and reconsidered integration models that included technology as a part of the instructional process (Okojie, Olinzock, & Okojie-Boulder, 2016). The view that technology instruction is inclusive of technical artifacts and “theories about technology instruction and the application of research findings” (Okojie, Olinzock, & Okojie-Boulder, 2016, p. 66) repositioned the relationship between pedagogy and technology as a process that facilitated learning. Okojie, Olinzock, and Okojie-Boulder (2016) stated that technology integration should:

include the strategies for selecting desired technologies, skills to demonstrate how the selected technologies will be used, skill to evaluate such technologies, as well as the skill to customize the use of such technological skills (p. 66).

In summary, the approach of Okojie, Olinzock, and Okojie-Boulder (2016) considered the relationship between pedagogy and technologies and augmented the process of learning about the use of tools. Their approach moved towards an understanding of the pedagogical principles and the role of learning theory for the design of educative activities. By thinking about the relationship between pedagogy and technology in education, educators were encouraged to critically think about their practices and engage in reflection (Okojie, Olinzock, and Okojie-Boulder, 2016).

Foulger, Graziano, Schmidt-Crawford and Slykhuis (2017) developed twelve competencies that they believed teacher educators needed to support the integration of technology in teacher candidates' understanding and use of educational technology. The competencies proposed by Foulger, Graziano, Schmidt-Crawford and Slykhuis (2017) were:

1. design instruction that utilizes content-specific technologies to enhance teaching and learning
2. incorporate pedagogical approaches that prepare teacher candidates to effectively use technology
3. support the development of the knowledge, skills, and attitudes of teacher candidates as related to teaching with technology in their content area
4. use online tools to enhance teaching and learning
5. use technology to differentiate instruction to meet diverse learning needs
6. use appropriate technology tools for assessment
7. use effective strategies for teaching online and/or blended/hybrid learning environments
8. use technology to connect globally with a variety of regions and cultures
9. address the legal, ethical, and socially responsible use of technology in education
10. engage in ongoing professional development and networking activities to improve the integration of technology in teaching

11. engage in leadership and advocacy for using technology
12. apply basic troubleshooting skills to resolve technology issues (p. 432-433).

One of the most popular theoretical frameworks in the field of technology teacher education for the past 10 years is technological pedagogical content knowledge (TPACK). TPACK was proposed as a way to understand the knowledge and skills for technology integration and professional development around the use of technology (Mishra & Koehler, 2006). TPACK intended to identify the nature of the knowledge needed by teachers for the successful integration of technology in teaching and aimed to address the dynamic and situated nature of teacher knowledge (Mishra & Koehler, 2006). Howland (2012) described TPACK as the “knowledge of how technologies can be best employed in different pedagogies for facilitating the acquisition of content knowledge” (2012, p. 15).

Howland credited Koehler and Mishra in their focus on the affordances of technologies for teaching and saw the value in the model for demonstrating interactions around different kinds of knowledge. Nelson (2017) found that a teacher’s TPACK and the use of technology in teaching had the possibility of influencing teacher candidates’ use of technology in their future practices. However, in a different light, Archambault and Barnett’s (2010) review of the literature did not provide evidence for the claim that TPACK correlated to effective integration of technology. Borthwick and Hansen (2017) stated that despite the use of TPACK in teacher education, in-service teachers still lacked the skills to integrate technology into teaching. Further critique of the TPACK model, as noted by Borthwick and Hansen (2017), is that difficulty stemmed from defining teacher educator’s knowledge and what they needed to know related to technology to support the design of technology teacher education and guide professional development in the field.

Howland (2102) questioned Shulman’s (1986, 1987) conception of pedagogical content knowledge (PCK), and subsequently, Mishler and Koehler’s (2006) technological pedagogical content knowledge (TPACK). Howland suggested that the PCK and TPACK models made heavy epistemological assumptions and did not focus adequately on learning (Howland, 2012). Aligned with Howland’s (2012) thinking, Bullock (2013) suggested that TPACK, shaped after PCK, may be problematic as there is “little

agreement as to the specific epistemology of PCK, or how to document and analyze the development of PCK” (Bullock, 2013, p. 153) and this made it challenging to articulate professional knowledge (Bullock, 2013).

Howland (2012) argued that content knowledge is an “impoverished concept, because it does not articulate how the teacher should know, only what they should know” (2012, p. 14). Since instruction will regulate to some extent the kinds of knowledge constructed, then pedagogical knowledge cannot be uniform and a “deeper understanding of learning is essential for developing any understanding of teaching” (Howland, 2012, p. 14). Howland’s critique of TPACK is that it is “impossible to make meaningful recommendations about technology use without a clear conception of how students are supposed to learn” (Howland, 2012, p. 15). Howland (2012) suggested that TPACK be extended to TPLACK to include learning and thinking about “aspects of different disciplines employing a particular pedagogy” (p. 15). Yet, Howland (2012) noted the complexity of this recommendations by recognizing the synchronicity with the complexity of design. Howland’s (2012) main message is that the most critical elements of determining what and how one teaches is linked to how students learn.

Bakir (2016) suggested that pre-service technology integration models have followed the ISTE (2007) standards and moved towards programing that focused away from the use of technology towards critical thinking about using technology as a tool to learn with. Bakir (2016) suggested that a “new framework for teacher knowledge has emerged, one more in line with the current technological advances of the 21<sup>st</sup> century” (p. 27). The diversity of the integration approaches suggested in this section make it increasingly difficult for teacher educators to design quality programs (Elwood & Savenye, 2015) as there is little agreement in the field about the recommended approach to technology integration in teacher education.

Ertmer (1999, 2005) and Hew and Brush (2007) spoke about two layers of barriers that may explain some the different approaches and uses of technology by teacher educators. First-order barriers are for example, access to technology, environmental readiness, and teacher knowledge. Second-order barriers are intrinsic factors such as for example, anxiety and attitude about technology (Ertmer, 1999). These barriers are useful for understanding situations related to adequate technology knowledge that do not result in effective technology integration (Pily, Mims, Shepherd &

Inan, 2010). We now understand these as related to teacher beliefs about technology as predictive and reflective of teaching actions (Wilkins & Young, 2008). Pajares (1992) suggested that teacher perspectives are more persuasive than their knowledge. Kim, Kim, Lee, Spector, and DeMeester (2013) suggested that by understanding beliefs, it may give insight into why technologies are integrated differently into teaching and “would be helpful in improving technology integrations” (p. 77).

## **2.4.2. Teacher Beliefs about Using Technology**

There is considerable agreement on the definition of beliefs as psychologically held in understandings, premises, or propositions about the world that are felt to be true. Beliefs are propositions that are accepted as true by the individual holding the belief and they do not require an epistemic warrant (Richardson, 2003, p. 2-3). Beliefs about teaching and learning are pedagogical beliefs (Denessen, 2000) and inform what teachers feel about their students, the curriculum, and their roles and identities (Pajares, 1992).

Teachers' epistemologies about the nature of knowledge and knowing are the framework for their beliefs and effect what and how they will teach and the processes they take to learn their practices (Schommer-Aikins, 2004). Epistemology began as a concept by Aristotle, a Greek philosopher in 384-322 BC (Perusek, 2008). “Epistemology is the study or a theory of the nature, origin, and limits of human knowledge” (Perusek, 2008, p.1). “The mission of epistemology, the theory of knowledge, is to clarify what the conception of knowledge involves, how it is applied, and to explain why it has the features it does. And the idea of knowledge at issue here must, in the first instance at least, be construed in its modest sense to include also belief, conjecture, and the like” (Rescher, 2003, p. xiii). “Its range of concern includes not only knowledge proper but also rational belief, probability, plausibility, evidentiality and— additionally but not least—erotetics, the business of raising and resolving questions” (Rescher, 2003, p. xiii). “Epistemologists try to evaluate the commonsense idea that we (often, if not always) have knowledge and that we are (often, if not always) rationally justified in the beliefs we have” (Sober, 2009, p. 147).

Epistemology is an important aspect of understanding professional knowledge and its development in teacher education programs particularly as it relates to fostering

epistemic development of teacher candidates. Many “scholars study this symbiotic relationship of how a student understands knowledge and how a teacher uses his/ her beliefs about knowledge to teach” (Perusek, 2008, p 1). There is a growing need to understand teachers’ beliefs about the nature of knowledge as these “affect their approach to teaching and subsequently, how it is passed down to the student” (Perusek, 2008, p. 1). Yet, there is limited research that investigates teacher’s beliefs and their actions in the practice of teaching (Kane, Sandretto, Heath, 2002). The teacher’s epistemology impacts their pedagogy and the profession of teaching as does a student’s epistemology bare influence on the way they receive information. Perusek (2008) advocated for a scholarly focus on the diverse methods that teachers and students use in the acquisition and transfer of knowledge. “As teacher[s] learn more about student’s epistemological perspectives, it is imperative that teachers develop curriculum that will bridge any gaps in knowledge” (Perusek, 2008, p. 3). “In this sense, in order to design teacher preparation programs that can help preservice teachers to develop adequate understandings about teaching and their role in the classroom, teacher educators need to be aware of preservice teachers’ prior belief systems, which can jeopardize their learning experiences during the program and, hence, their future teaching practices (Yadav, Herron,& Samarapungavan, 2011, p. 26).

Epistemological worldviews influence the way that teachers make instructional decisions for the curriculum, the pedagogical approaches, and assessment methods (Schraw & Olafson, 2002). Research shows that “teacher’s personal pedagogical beliefs play a key role in their pedagogical decisions regarding whether and to integrate technology” (Tondeur, Braak, Ertmer, & Ottenbreit-Leftwich, 2017, p. 556). An indicator of teacher practices (Pajares, 1992) and teacher educator’s constructs (Kagan, 1992) can be studied through beliefs as teaching perspectives are impactful on teaching practices. Extensive research has been conducted in this area by Ertmer (1999), Ottenbreit-Leftwich (2010), and others. Researchers support the claim that pedagogical practices are influenced by beliefs (Kagan, 1992; Pajares; 1992) but more research needs to be done on the role of beliefs and the relations to technology used in teaching (Tondeur, et al., 2017). The research findings suggest that “teachers select application of technology that align with their selection of other curricular variables and methods and that also align with their existing beliefs about good education” (Tondeur, et al., 2017, p. 556). Lawless and Pellegrino (2007) raised an important point that the technological

selection does not prescribe a teaching approach and the role of technology in teaching relates to the teacher's perspectives about the nature of teaching (Tondeur, et al., 2017).

Schommer (1990) suggested that beliefs about the nature of knowledge can be specifically or circuitously connected to actions that are facilitated through cognition, attitude, and motivation. Teacher beliefs are linked to reasoning, decision making, and the development of teaching environments and strategies. Historical studies of teacher beliefs are largely epistemological (Schommer, 1990) and examined a range of things including expectations of learners, self-efficacy of ability, and beliefs about teaching strategies, to name a few (Kim, Kim, Lee, Spector, & DeMeester, 2013). Schommer's (1990) studies of multidimensional beliefs included the structure of knowledge, the source of knowledge, the stability of knowledge, the speed of learning, and the ability to learn. Deng, Chaai, Tsai, and Lee (2014) found that teachers' beliefs in educational technology are of two types: 1) teacher-centered beliefs that are linked with behaviorist approaches to learning and the role of the teacher, and 2) student-centered beliefs that are linked to constructivist approaches to learning and the role of the teacher. This binary has been criticized in the literature and contemporary researchers are more inclined to multidimensional approaches and continue their investigations to examine teachers' systems of beliefs (Tondeur, et al., 2017).

As a construct, teacher beliefs are not defined consistently in the general field of teacher education, including teacher technology integration. "It appears that researchers examined beliefs only associated with technology although there should be fundamental beliefs that are associated with teacher beliefs in relation to technology, their fundamental beliefs about what is important in student learning, and thus teaching (regardless of technology use) should be understood" (Kim, Kim, Lee, Spector, & DeMeester, 2013, p. 77). Kim, Kim, Lee, Spector, and DeMeester (2013) investigated teachers' beliefs about the nature of knowledge and how teacher's perspectives are related to their integration of technology, while not contingent on a specific technology. "It was expected that information about relationships between teacher beliefs and technology integration would suggest how to take teacher beliefs into consideration so as to facilitate technology integration" (Kim, Kim, Lee, Spector, & DeMeester, 2013, p. 77). Kim, Kim, Lee, Spector, and DeMeester's (2013) carried out a study using Schommer's (1990) Epistemological Belief Questionnaire. The Concerns-Based

Adoption model assessed the status of technology integration and was coupled with classroom observations and interviews. The results showed that

teacher's beliefs about the nature of knowledge (epistemology), beliefs about effective ways of teaching (conceptions), and technology integration were positively correlated with one another... It is noteworthy that what teachers say they do (levels of technology use) was significantly correlated with both their beliefs about effective ways of teaching (conceptions on class discussions and teacher role) and their actual practices with regard to technology integration (lesson design and lesson implementation) (Kim, Kim, Lee, Spector, & DeMeester, 2013, p. 81).

Despite the somewhat questionable psychometric properties of the Epistemological Beliefs Questionnaire (Ordoñez, Ponsoda, Abad, & Romero, 2009), other studies such as the Technology Counts research project (Ravitz & Becker, 2000) have yielded similar results, namely: there is a correlation between teachers' beliefs and their practices.

Judson's (2006) study however did not support the above conclusion and found that there is not a "significant relationship between practices and beliefs" (Judson, 2006, p. 581). Judson (2006) noted that "specific to the relationship between technology integration practices and teacher beliefs, research is limited" (p. 584). Using the Conditions that Support Constructivist Uses of Technology, Judson (2006) collected data through a self-report survey to uncover the actionable integration of technology in teaching. Judson (2006) suggested a few reasons why observed practices do not resonate with teacher's beliefs. It may be that teacher feel their use of technology paralleled their beliefs. But through empirical analysis, the teaching actions are misaligned (Judson, 2006) with their espoused beliefs or their "perception of their teaching practices is truly and markedly different from actual practice" (Judson, 2006, p. 585). Another reason why beliefs may not be aligned to practice is due to situationally constrained choices, wherein the teaching context is unable to provide the teacher with what they require to act in accordance with their belief (Smith, 2012). What remains unclear is "whether or not teachers use technology in a way that is aligned with their beliefs" (Judson, 2006, p. 583) or if there is a correlation between their attitudes towards technology and the quality of instruction (Judson, 2006). Another reason may be that teachers feel intimidated and lack the skills and confidence required to attempt technology integrations into their teaching (Okojie, Olinzock, and Okojie-Boulde, 2006), or that their perceived level of expertise with technology (novice or experienced) may be correlated to a teacher's emotional state (Judson, 2006).

This section provided overview of the history of technology and teacher education and described the varying models, strategies, and challenges in the integration of technology into teaching. Given the complexity of the field, there is an opportunity for further investigation of how to integrate technology and teacher education. Okojie, Olinzock, and Okojie-Boulde (2006) suggested that the “degree of success teachers have in using technology for instruction could depend in part on their ability to explore the relationship between pedagogy and technology” (p. 66). Cutri and Whiting (2018) suggest that “there is a need to understand general teacher educator’s experiences with technology and their pedagogical concerns, and to assist them in negotiating their own positions on the speeding train of technology integration in teacher education (p. 126). The next section will discuss one way of advancing the field of technology teacher education.

### **2.4.3. Moving Forward in Supporting Technology Integration**

Teacher educators need to understand the epistemologies of teacher candidates in order to support them with the professional knowledge required for technology integration as in-service teachers. There is lack of educational research that examines the connection between technology teacher educators’ beliefs about knowledge and their practices and actions. There is a need to make explicit the epistemologies of teacher educators and the teacher candidates to understand how to learn about learning to teach. Kane, Sandretto, and Heath (2002) argue that “university teaching is incomplete without a consideration of teachers’ beliefs about teaching and a systematic examination of the relationship between those beliefs and teachers’ practice” (p. 182).

An understanding of teacher candidates’ epistemologies in technological environments will support how the teacher educator facilitates learning about the *how and why* of educational technology required for teacher candidates to advance their understandings about the *epistemic nature of technology*. But, “learning how to think and act in ways that achieves one’s intentions is difficult, particularly if knowledge is embedded in the practice itself” (Darling-Hammond, 2006, p. 37). Therefore, a way forward is for teacher educators is to use self-study methodology to uncover their practices and actions to understand how to enact teaching and learning about technology integration with teacher candidates. Self-study methodology as educational

research provides a way to study the relationship between practices, beliefs, and actions in teacher education.

This research will support advancement of the challenges faced in the technology teacher education literature and supplement the self-studies of technology teacher education. Some self-studies of technology integration include Bullock's (2013) exploration of the "role of technology in the professional knowledge of science educators" (p. 156) and Korthagen's (2016) self-study of the impact that technological tools have on pedagogy. Other studies include Fransson and Holmberg's (2012) inquiry into the "challenges and opportunities...while working with and learning about ICT as a tool for learning," yet, they acknowledge that ICT self-studies are few. Self-studies by Hamilton and Pinnegar (2017) discussed three broad areas of the digital turn, namely: teaching about technology, improvement of learning using technology, and technology to support the study of practice. The research in this dissertation attends to teacher candidates' epistemologies and the coherence between this and a post-secondary teacher educator's epistemology in order to understand the pedagogical interdependence of purposeful technological environments with a view to narrowing the space between student and teacher epistemologies and beliefs about technology and practices with technology.

In conclusion, there is a need for a different epistemic way to understand technology integration and teacher professional knowledge that many of the technology integration approaches and models do not develop in depth. Teacher education programs need an epistemological foundation to think about how teacher candidates theorize about the nature of knowledge in technological environments. Maker pedagogy and experiential learning as educational technologies provide the catalyst to do this type of work and enable opportunities to learn-about-technology through an epistemological framework that is discussed in the next section.

## 2.5. The Study of Teacher's Professional Knowledge

Teacher professional knowledge is the knowledge required to engage in one's practice and is considered to encompass the knowledge, beliefs, and values that teachers possess and create in the course of their career as educators" (Bullock, 2011, p. 22). Bullock (2011) provided a detailed synopsis of how teachers' professional knowledge had been studied historically and in the contemporary literature. To describe teacher professional knowledge and its development, Bullock (2011) framed his work to reflect epistemological underpinnings of different research programs. Bullock (2011) categorized knowledge in certain ways to form an approach to study teacher's professional knowledge and how it develops at a meta-level. To study professional knowledge, Bullock (2011) used two epistemological frameworks: 1) an epistemology of propositional knowledge, and, 2) an epistemology of experience. Bullock's (2011) categorizations are based on groupings that study knowledge and the process of justified belief for teacher's professional knowledge.

This review will not replicate the comprehensive work that Bullock (2011) has conducted regarding the study of teachers' knowledge. Nor will this review discuss the positivist view of knowledge produced through reason, the epistemology of propositional knowledge. The epistemology of propositional knowledge holds the long-standing conception of knowledge that governed (and in some instances still governs) educational enterprises in higher education and drove the separation of theory from practice to map external realities and trap professionalization into compartmentalizing the subject matter (Raelin, 2007). Rather, the starting point of this section is the study of teachers' professional knowledge during the "practice turn in social theory that acknowledged the decentralization of knowledge production and showed that concurrent reflection on experience could not only expand knowledge but could also improve practice" (Raelin, 2007, p. 497). The practice turn shifted the landscape of epistemological ways to study professional knowledge towards looking at experiences as early as Bergson's work in 1986. The shift towards professional self-reflection (Schön, 1983) arose as a result of the events that occurred between 1963 and 1972 (Schön, 1983) that signaled a "loss of confidence in professional knowledge" (Schön, 2001, p. 184) regarding the uncertainty of professionally conceived solutions to societal concerns (Schön, 2001).

Pagano (1991) said “to act is to theorize” (p. 194) and that practice is the physical manifestation of one’s embodied experiences and theoretical understandings. This positions theory, practice, and experience in different ways and signals that there are distinct epistemic methods inherent in each place of knowledge construction. There is not ample space in this section to discuss the vast and existing undercurrents that lead to the constructionist responses to empiricism, which questioned the worth of empirical data (Raelin, 2007) and subsequently led to major movements in the study of professional knowledge. However, it was a shift in professional education models that acknowledged “knowledge or theory produced from the field” (Raelin, 2007, p. 499). This study responds to how “professionals are still criticized, and criticize themselves, for failing to adapt to changing social reality and to live up to their own standards of practice” (Schön, 2001, p. 186).

The heart of this research is in line with knowing-in-action as way to understand teachers’ professional knowledge. Some lines of research that conceptualize learning from experiences as a source of knowledge include: craft knowledge, narrative knowledge, and knowing-in-action (Bullock, 2016). The research in this study clearly addresses the critique of technical rationality (Bullock, 2016) and provides a new way for a novice teacher to understand their practice, wherein the years of craft and narrative knowledge may not have had the time to develop.

Munby and Hutchinson (1988) “abandon the view of the teacher as a technical expert and acknowledge that there was significant knowledge behind the observable behaviors of teaching” (p. 77). This points to the significance that “teacher research is revealing a form of educational knowledge which is grounded in educational practice rather than grounded with any other form of theorizing [and that] educational research is a practice rather than social science” (Laidlaw & Whitehead, 1995, p. 3). Since 1986, Munby and Russell collaborated on research about teachers’ professional knowledge and developed an epistemology of professional knowledge that was rooted in action (1992, 1994). Their work takes up Schön’s notion of professional knowledge (1983, 1987) from the standpoint of a reflective practitioner to understand experience as an epistemic source of teacher’s professional knowledge. Munby and Russell (1992) argued that research on teacher education typically progressed without attention to the nature of experience and the role it plays in knowledge acquisition.

Significant to the epistemology of experience is that Munby and Russell's (1992) specifically addressed a warrant for the study of knowledge in experiences to draw assertions for action. The warrant in Munby and Russell's (1992) work is the Schönian metaphor that enabled the study of knowledge and allowed the practitioner to label and understand knowledge in particular ways. This draws on the authority of experience in order to go beyond the story or narrative to label the assertions drawn (Loughran, 2007) and reveal tacit knowledge in an epistemic way. The focal point of Munby and Russell's (1992) work is the notion that what we know lies in actions. By adding knowing to knowledge, special attention is given to the concepts of knowledge-in-action, reflection-in-action, and the authority of experience so that one can account for the relationships between what they know and what they do in order to generate new knowledge and ways of knowing (Munby & Russell, 1992).

### **2.5.1. Epistemology of Experience**

Munby and Russell's (1992, 1994) work has a long history that is tremendously well articulated in their various articles, all well referenced in the literature. This review does not aim to repeat their ideas comprehensively, but rather draw on some of the highlights of how Munby and Russell (1992) unpack Schön's ideas for the study of experience as fundamental to teachers' professional knowledge and how it develops.

Schön's (1983) argument was that professionals often know more than they can verbalize, and he advocated that professionals have a kind of knowing in their practice. This professional knowledge is a specific type of knowledge called knowing-in-action wherein professionals in the midst of practice analyze their experiences, frame a problem, offer an action, and re-evaluate the experience that results in action as a way forward in professional effectiveness (Schön, 1983). Making sense of the experience that occurs during the present moment of action by professionals is called reflection-in-action, a term coined by Schön in 1983. Schön (1983) believed that the present moment of practice makes knowing conscious and accessible. Reflection-in-action is the 'action present' (Schön, 1983) that occurs when the professional reflects on the experience or incident whilst still in it so as to benefit that situation rather than reflecting on future actions, or after the situation, which is reflection-on-action.

Reflection-in-action is a useful method to use in disciplines where the professional reacts to an event at the time it occurs – rather than having the luxury of being able to think about what happened and make changes at a later time. The process, as described by Schön (1983), suggested that “when someone reflects-in-action, he becomes a researcher in the practice context. He is not dependent on the categories or established theory and technique but constructs a new theory of the unique case” (Schön, 1983, p.68). Reflection-in-action or reframing is a

process with nonlogical features, a process that is prompted by experience and over which we have limited control. Teachers at every level of education are familiar with the circumstance of being unable to get a point across to the whole class. Success may come suddenly and unexpectedly, through the teacher’s hearing what the students say in quite a different way (Russell & Munby, 1991, p. 164).

In this way, reflective practice is epistemic, and it is “spontaneous, intuitive, and grounded in experience” (Russell & Martin, 2017, p. 30).

Schönian metaphors as tools to study knowledge in Munby and Russell’s (1992) epistemology of experience expose tacit knowledge. Munby and Russell (1992) claimed that experiences carry tacit knowledge that can be uncovered by accessing the authority of experience. Munby and Russell (1994) argued for the authority of experience to account for the development of professional knowledge as the authority of experience “gives credence to the special force that experience has in the development experiential knowledge. This form of authority resides in experience and cannot be transferred” (Munby & Hutchinson, 1998, p. 77). The authority of experience authorizes one to make assertions about knowledge and was described by Munby and Russell (1994) as the “knowledge that resides in action” (p. 92). This is conceptually distinct from the authority of proposition or the authority of position. They introduced the term because:

our concern is that learning from experience is never mastered, during preservice programs, in a way that gives direct access to the nature of the authority of experience. If Schön is correct that there is a knowledge-in-action that cannot be fully expressed in propositions and that learning from experience has its own epistemology, then our concern is that learning from experience is never clearly contrasted with learning that can be expressed and conveyed in propositions (Munby & Russell, 1993, p. 9).

In their use of the authority of experience, Munby and Russell noted specially that the context is related to the teacher candidates’ need to confront an authority of

experience so that the “experience be brought to the surface so that it is not ignored by students (Munby & Russell, 1993, p.12). The “approach moves in the direction of having teacher education candidates give voice to their experiences” (Munby & Hutchinson, 1998, p. 78).

### **2.5.2. Practice**

Cook and Brown (1999) defined practice as “the co-ordinated activities of individuals and groups in doing their ‘real work’ as it is informed by a particular organizational or group context” (p.60). The Cambridge dictionary defines practice as “action rather than thought or ideas.” Practice is also the conceptions, propositions, assertions, philosophy, and principles that make up a professional.

The terms experience and practice draw attention to different professional identities. The term experience involves the “active and engaged participation in events or activities that lead to the accumulation of applicable knowledge and skills” (Cook & Wagenaar, 2012, p. 4). The term practice is used to reflect the work, activities, and beliefs that a professional person, artist, or craftsperson engages with that “lead to the accomplishment of goals through the use of knowledge, theories, and understanding” (Pinnegar & Hamilton, 2009, p. 16). Pinnegar and Hamilton (2009) defined practice as:

the activity or activities engaged in by a person in a particular profession or as an artist or craftsperson. Practice is a word attached to the work someone does in a particular role whether that role be personal, professional, or artistic. Practice refers to all the activities of a person engaged in that role. It includes the responsibilities, beliefs, and knowledge that informs and shapes that practice.

There is a different recognition of intentionality, professional boundary, and identification that a professional has towards a group that draws the line between experience and practice. The distinction is the professional boundary wherein practice is “special expertise or artistic, intuitive processes that the professional develops through practice” (Schön, 1983, p.49). Therefore, the notion of practice in this dissertation belongs to the profession of teacher educators versus the teacher candidates who participate in experiences.

Given the discourse about the practical knowledge that one acquires through the authority of experience, there is an opportunity to talk about the professional knowledge

that one accesses through an authority of practice. Practice is more expansive than experience because it refers holistically to the profession and draws on the authorizers of the professional. One can have experiences and an authority over those experiences, but when you self-identify and have professional affinity with a group, this becomes your practice. To gain authority of practice you make meaning of your knowledge as a professional.

Schön in his work references an epistemology of practice more frequently over an epistemology of experience. This provides an opportunity to revisit the epistemology of practice to understand how it may complement the study of teacher educator's professional knowledge and its development.

### **2.5.3. Epistemology of Practice**

An epistemology of practice is the professional knowledge formed in action in the context of professional situations and evokes assertions that count as knowledge about practice and who you are in practice as drawn from a basis for knowing. An epistemology of practice can be extended to teacher education research and the research on teacher educators' professional knowledge through the study of practice as an epistemic source to understand the development of knowledge in practice and make assertions about knowing. The epistemic study of practice makes contributions to educational research in the professional development of the teacher educator through the study of educational practice. The epistemology of practice offers methods that support educational inquiry for understanding teacher educators' knowledge.

The epistemology of practice in teacher education is fruitful to revisit as it did not seem to advance in the literature, likely due to the focal point of educational research on teacher candidates' development of professional knowledge. There is not necessarily a gap in the field about how to study professional knowledge, yet, Schönian epistemology of practice offers a lens and tools to study the epistemic source of practice. In very recent work, Russell and Martin (2017) revisited Schön and explained the disparate ways that reflective practice is used in the field of teacher education. They draw attention to the fact that "Schön's work was not recognized as requiring an epistemological shift" (p. 3). In their paper, Russell and Martin (2017) discussed the importance of an

epistemology of practice and draw heavily on the work of Raelin's (2007) conceptualizations of tacit knowledge, critical thinking, and mastery.

This part of the literature review aims to add to the discourse on the professional knowledge of teacher educators by reclaiming the epistemological underpinnings of Schön's epistemology of practice. The aim is to expand the lens of the study of professional knowledge and how professionals understand practice as an epistemic source. To be productive, an epistemology of practice needs to be able to answer questions about the study of professional knowledge, the justifications, the warrants to make assertions from the basis-of-knowing, and the following section will discuss this in detail. By reclaiming the work of Argyris and Schön (1974), warrants for the justification of professional knowledge can be understood in new ways in an epistemology of practice.

### ***Why do we need an epistemology of practice?***

There is a difference between practice and experience and the argument that follows is that teacher educators' professional knowledge would benefit from an expanded epistemological framework to study practice beyond those proposed by epistemologies of experience. Russell and Martin (2017) noted that "because teacher educators possess teaching experience that their students do not, it falls to teacher educators to introduce and model an epistemology of practice for those learning to teach" (p. 27). Further, "an epistemology of practice compels us to identify and explore our assumptions and feeling about our teaching actions and their consequences for student learning" (Russell & Martin, 2017, p. 40). The epistemic source of experience to study of professional knowledge as discussed in the literature is largely related to teacher candidates, specifically the authority of experience of teacher candidates that supports their professional development. Since there is arguably a difference between experience and practice, an epistemic way to understand professional knowledge of teacher educators that builds on the foundations in the field of professional knowledge is the authority of practice. The authority of practice will be unpacked in an upcoming section after discussing the philosophical underpinnings of Schön's epistemology of practice.

The benefit of engaging in renewed thinking about an epistemology of practice is that it expands what is thought of as epistemic. The epistemic warrants are drawn from

practice versus those drawn from experience and differ in their relationship to a professional identity. Arguably, the professional distinctiveness allows one to view their practice differently than an experience and for this reason, there are different warrants underlying the epistemic source of practice. In this way, understanding professional knowledge of teacher educators requires an epistemology of practice as an expanded lens for studying professional knowledge made accessible by the authority of practice.

### ***Aspects of an Epistemology of Practice***

An epistemology of practice can be framed as what it means to know and to learn one's profession. There is no universal theory of an epistemology of practice, as an epistemology of practice is personal, embodied, dynamic, and changes with time. Schön (2001) suggested that "some were troubled by the existence of an irreducible residue of art in professional practice" (p.185). Because art cannot be codified and it is variant (Schön, 2001), the argument is that practice includes professional artistry (Schön, 2001). After the 1972 professional education colloquium, professionals became more aware of the "intermediate zones of practice- the situations of complexity and uncertainty, the unique cases that require artistry" (Schön, 2001, p. 186). The component of professional knowledge that distinguished a positivist epistemology of professional practice that used "describable, testable, replicable techniques derived from scientific research" (Schön, 2001, p. 188) and problem-solving, and an epistemology of practice that focused on the crucial and inflexible aspects of professional practice and did not separate deciding from doing, was the concept of problem-finding (Schön, 2001). It is the problem-finding activity of professional practice that engages the practitioner to access the artistry of the profession and allows the practitioner to cope with the uncertainty and complexity of the intermediate zone of practice. These situations of indeterminacy are incommensurable with the nature of knowledge in the technical rationalist problem-solving paradigm.

Technical rationality in professional education is the "application of research-based knowledge to the solution of problems of instrumental choice" (Schön, 2001, p. 187). Technical rationalism caused discord in professional education because professionals started to understand that the competencies originally established as central to their professional practice actually "had no place in the underlying model of professional knowledge" (Schön, 2001, p. 186). The 'application of theory to the solving

of problems' view did not provide the rigor required of the curriculum in professional education (Schön, 2001). Ackoff (1979) described that professionals recognized the limits of formal models in their application to situations of complexity and uncertainty and clearly a shift was needed to understand and study professional knowledge. Schön (2001) proposed an "alternative epistemology of practice grounded in observation and analysis of the artistry competent practitioners sometimes bring to the intermediate zones of practice" (p.189). He also suggested that the artistry of professional knowledge "is not only in the deciding but also in the doing" (Schön, 2001, p.189).

A knowledge excluded from the technician model, Schön (1983) offered an alternative epistemology of practice that valorizes the "special expertise" or "artistic, intuitive processes" that professionals develop through practice (p. 49) that responds to dilemmas of rigour. "Rigorous practice depends on well-formed problems of instrumental choice to whose solution research-based theory and technique are applicable" (Schön, 2001, p. 189). Issues of rigour recognized the complexity in problem-setting as often issues of practice are not clearly shaped, as such, are messy and indeterminate (Rein & Schön, 1977). During problem-setting, the professional makes countless decisions about the issues that require attention, how to frame these in a contextual manner, and sets the actions to be taken in order to translate the problem into a resolution (Schön, 2001). The framing process inherent in the problem-setting requires the professional to engage in professional inquiry that draws on professional artistry. Professionals often describe their method as "experience, trial and error, intuition or muddling through" (Schön, 2001, p. 192). These methods allow them to seek problems of professional practice and address those that are "messy and confusing and incapable of technical solution" (Schön, 2001, p.191) and concurrently the most relevant in the situation. In order to work on problems in the swampy lowlands (Schön, 1983) of one's profession, Schön offered epistemic tools to study professional knowledge that "takes full account of the competence practitioners sometimes display in situations of uncertainty, complexity, and uniqueness" (Schön, 2001, p. 193).

The philosophical underpinnings of Schönian epistemology of practice are shaped by reflection-in-action and theories of action that Argyris and Schön (1974) worked on together to develop implications for professional education and organizational learning. The premise rests on the spontaneity of actions wherein the professional often "cannot say what [they] know" (Schön, 2001, p. 194) and involves knowledge which is

“tacit, implicit in our patterns of actions and in our feel for the stuff with which we are dealing. It seems right to say that our knowing is in our action” (Schön, 2001, p. 194). Tacit knowledge should not be confused with knowing, which is dynamic, relational, and a concrete part of action; tacit knowledge is a tool to action, but not a part of the action itself (Cook & Brown, 1999). “Knowing requires present activity. Tacit knowledge does not. Knowing is that aspect of action (or practice) that does epistemic work” (Cook & Brown, 1999, p. 388). It is the interactions between tacit knowledge and action that enables knowing and knowing-in-action can be transformed into knowledge-in-action.

There is often thinking before acting and “much of the spontaneous behavior of skillful practice reveal[s] a kind of knowing which does not stem from prior intellectual operation” (Schön, 2001, p. 194) and remains tacit. Tacit knowledge allows professionals to skillfully execute complex tasks without being able to verbalize their performance and is anchored in action (Polanyi, 1958). Yet, Schön (2001) said that “in spite of their tacit complexity and virtuosity, however, our spontaneous responses...do not always work. Sometimes our knowing-in-action yields surprises, and we often react to the unexpected in a kind of on-the-spot inquiry which I shall call reflection-in-action” (p. 196).

Schön coined the term reflection-in-action in 1983 to describe the rethinking process that occurs as the professional aims to understand how their action contributed to the outcome. Schön (2001) further described reflection-in-action as:

ordinarily, we might call such a process “trial and error.” But it is not a series of random trails continued until a desired result has been produced. The process has a form, and inner logic according to which reflection on the unexpected consequences of one action influences the design of the next one... In the course of such a process, the performer “reflects”, not only in the sense of thinking about the action he has undertaken and the result he has achieved, but in the more precise sense of turning his thought back on the knowing-in-action implicit in his action. He reflects “in action” in the sense that his thinking occurs within the boundaries of what I call an action-present—a stretch of time within which it is still possible to make a difference to the outcomes of action. (p. 197).

When reflection-in-action become embedded in performance and there is no ‘stop-and-think,’ the process is described as artistry and may involve improvisation in the production of collective meaning formation (Schön, 2001). But it is one thing to engage in reflection-in-action and another to reflect and describe it as professional knowing-in-

action. This involves the professional having the ability to “make decisions and carry out action in the moment, without necessarily being able to articulate either their reason for taking such action or how they learnt to carry out such actions in the first place” (Bullock, 2011, p. 29). This suggests that there are distinct types of reflection with the aim being to know what you are doing so that you can analyze it and improve future actions and avoid the narrowness of perspective that may make a professional inattentive to their tacit patterns of errors (Schön, 2001).

Reflection-in-action and knowing-as-action are also the cornerstones of Munby and Russell's epistemology of experience. However, the way the epistemology of practice enables the substantive epistemological plinth (Munby & Russell, 1993) of reflection-in-action and takes professional knowledge a step further is by engaging the epistemic source of practice through the study of one's theories of action. Drawing on the work of Argyris and Schön (1974), who conceptualized that people act in situations based on their mental maps, they conceived that personal theories, or one's mental maps, do not have much explanatory power. Yet, these mental maps have utility when used in the examination of one's actions in planning, implementation, and review. Argyris and Schön (1974) made the assertion that people have maps in their heads that include planning, implementation, and assessment of their actions, yet for the most part, they are unaware of the mental maps that are used to take action and frequently do not relate them to theories they explicitly espouse.

Based on this, Argyris and Schön (1974) proposed two theories of action to explain how humans act in their environments. The first is *theories-in-use* (tacit knowledge): those we champion and are inherent in our performance and are implicit, and these can be thought of as values or world views and are the beliefs about the things that govern our behavior. The second is *espoused theories*: those that are used to describe actions and are the values and world views, or mental maps, that are explicit and can be articulated to guide behaviors and are used to take action. Argyris and Schön (1974) describe the theories of actions as more than a distinction between what people say and what people do and assert that there is a theory at play that is consistent with what people say and do. Argyris (1987) proclaimed that action has theoretical elements because action is not haphazard and has design aspects for which professionals are accountable. The discrepancy is not between theory and action but rather the difference between the theories of action (Argyris, Putnam, & McLain Smith,

1985). The mental maps serve to create models of different contexts and within those models, humans have theories about action that they use to create action for the achievement of their goals. Humans “learn a repertoire of concepts schemas, and strategies, and they learn programs for drawing from their repertoire to design representations and actions for unique situations” (Argyris, Putnam, & McLain Smith, 1985, p. 81).

Argyris and Schön (1974) suggested that professionals are largely oblivious to the fact that their theories-in-use are misaligned to their espoused theories and this further suggested that professionals do not have a good handle on their theories-in-use generally. Argyris (1987) felt that theories can be understood through action and through the observation and study of practice and that professionals can construct their theories-in-use. “Action science suggests that a lack of correspondence, that is, a gap between espoused theory and theory-in-use, is the norm for human behavior and that the use of tacit or untested assumptions to diagnose or explain inconsistencies is common” (Menges & Rando, 1989, p. 57). “Like most assumptions that support theories-in-use, these are untested and possibly inaccurate. If not made explicit and tested against real events, they may leave teachers with invalid theories of action and ineffective behaviour” (Menges & Rando, 1989, p. 54). The two theories provide access to the study of action and professional knowledge and allow the professional to attend to their practices, particularly where there is incongruence “with the understandings and know-how implicit in [their] patterns of action” (Schön, 2001, p. 201).

There are some studies that have integrated Argyris and Schön’s (1974) theories of action, for example, studies of professionalism in university teaching (Blackwell & McLean, 1996), lecturer’s views of their teaching (Gow, Kember, & Sivan, 1992), and the improvement of teaching (Menges & Rando, 1989). These studies signalled the need to study espoused theories and theories-in-use. Thompson (1992) noted that

any serious attempt to characterize a teacher’s conception of the discipline he or she teaches should not be limited to an analysis of the teacher’s professed views. It should also include an examination of the instruction setting, the practices characteristic of that teacher, and the relationship between the teacher’s professed views and actual practice (p. 134).

Argyris (1980) argued that professional effectiveness was achieved by aligning the two theories of action. Argyris and Schön (1978) offered models to support

professional effectiveness with the aim to support professionals with decision-making in the design of their actions. The main elements of the model (Argyris & Schön, 1978) that aim to align thought and action are:

1. Governing variables (in-use and espoused)- personal values that are influenced by action, which may trigger a shift in one's governing variables.
2. Action Strategies- approaches used by professionals to maintain their governing variables.
3. Intended and unintended consequences for the self and others.
4. Action strategy effectiveness.

One's governing variables are typically tacit and critical to the study of professional knowledge to support professional effectiveness and develop a basis for knowing to make informed decisions as a professional. Part of the process in the model is that in the midst of action, the professional can "turn thought back on itself, surfacing, criticizing and restricting the thinking by which they have spontaneously tried to make the situation intelligible to themselves" (Schön, 2001, p. 201). The inquiry into action may present as problem-solving in the action-present, formulation of theory, or revisiting the problem (Schön, 1983) but the "systems of intuitive knowing are dynamically conservative, actively defended, and highly resistant to change. They tend not to go quietly to their demise, and reflection-in-action often takes on a quality of struggle" (Schön, 2001, p. 202). The process is also "dialectal in the sense of a coming to understand through a process of questions and answers" (Laidlaw & Whitehead, 1995, p. 3). In examining the situation and prior experiences, the professional may generate new learnings about the situation and develop processes to change it (Schön, 1983). The key is that each situation is local and so espoused theories may need to be re-examined. In the process of reflecting-on-action, after a situation occurs, the professional thinks about their actions and draws on the entire phenomenon of the experiences to question their theories-in-use to develop their repertoire during this practice (Schön, 1983).

In the view of Argyris and Schön (1978), the actions that required improvement or correction called attention to the process of learning. When errors arise, most people begin to seek corrective strategies through methods of operationalization that draw on their governing theories-in-use in the pursuit of efficiency, commonly referred to as

*single-loop learning* (Argyris & Schön, 1974). Single loop learning involves the action planning, carrying out the action, and evaluating the action in an aim to learn from the previous stages (Argyris & Schön, 1974). Alternatively, if one seeks corrective measures to their theories-in-use through a process of self-assessment and questioning in the search for effectiveness, then they are engaged in *double-loop learning* (Argyris & Schön, 1974). Double-loop learning as an action has the potential to alter one's governing dimensions and can result in a perspective shift, but it may be challenging to unearth if it remains an individual pursuit, wherein the knowledge remains tacit.

The sense making during profession inquiry draws on one's repertoire and similarities are evaluated, and distinctions are drawn in the theories-in-use. The familiar places of overlap may function as metaphors to serve the understanding of the unfamiliar (Schön, 1983). "Metaphoric constructions serve as warrants for epistemic claims about teachers' professional knowledge and how teachers learn from experience because they are used almost unconsciously to describe situations, hence revealing more about tacit, unexamined knowledge" (Bullock, 2011, p. 33). This is a potential explanation of how professionals encounter professional learning, so while there may not be complete understanding before action, the thought is that massive failure is avoided by drawing on one's repertoire. By looking at the repertoire of professional performance, these can be routinized and support the development of new theories to serve the situation at hand (Schön, 1983). This resonates with the importance of being present and aware of ontology so that the professional can reflect on what is happening in the moment with the aim to improve the future.

In summary, the epistemology of practice as described in this section through Schön's (1983) and Argyris and Schön's (1974) work involves on-the spot experimentation, analysis of the theories of actions, understanding the repertoire of practice through exemplars, and the framing of problematic situations. Relevant specifically to teacher education is Schön's (1983) recommendation that professional educators build their artistry of coaching and develop methods to support upcoming professionals in their reflection-in-action abilities.

#### **2.5.4. A Framework for an Epistemology of Practice for Teacher Educators**

As one aims to draw assertions from epistemology, they are arguing for a conceptual framework and tools to study knowledge. Epistemic understanding is a question of authenticity and for this reason, epistemology requires authenticity, which involves making transparent the connections between practice and the knowledge of that practice to better inform it in the future. An epistemology of practice is a way to study teacher educators' professional knowledge and its development and it has a conceptual framework and tools to answer questions about teacher educator's professional knowledge that go beyond labelling kinds of knowledge.

The tools to study professional knowledge in practice are drawn from the philosophical foundation of Schön's epistemology of practice and Argyris and Schön's (1974) theories of action. These foundations help to reveal and uncover tacit knowledge and knowing-in-action and provide the warrants used to make assertions about actions and what it means to know one's professional knowledge in order to improve practice. The theories of action allow the professional to attend to practice and see practice differently as a result of studying it. The justification is that practice offers an epistemic source to understand professional knowledge through the access to the authority of practice.

The authority of practice calls for a different type of authority than is presented in the literature. It is different from the authority of experience, proposition, and position (Munby & Hutchinson, 1998). An authority of practice provides a lens to refract a new way of doing things and resides in knowing-in-action as understood through the study of the two theories of action (Argyris & Schön, 1974) of the professional. The authority of practice is the nexus between agency and self-identity within a professional affinity group. When professional identity is formed, this epistemic mindset can be accessed. To have authority of one's practice means that the professional has made meaning of practice and this authorizes the professional to draw assertions about knowledge from a basis of knowing. An authority of practice is the warrant that leads to professional identity and understanding of professional knowledge, how it develops, and is reframed.

The conceptual framework in an epistemology of practice is predicated on the teacher educator's understanding of their practices in their pedagogy. This feature of the

conceptual framework is only accessible to teacher educators, as teacher candidates may not have formed a personal pedagogy as they do not have the requisite practice. To understand one's practice means that the professional identifies their authorizers. Authorizers are viewed as the things that one interacts with that shape, authorize, and create one's professional knowledge. Authorizers are not authoritative, rather authorizers are personal and come from: practice; experience; knowledge; framing positions; values and beliefs; assumptions; relationships with people or technology; moral debts; life history and/or personal biography; and/or, the examination of one's teaching and tasks (Griggs & Muchmore, 2014) as they reveal motivations, priorities, and pedagogies.

Authorizers are introduced here to capture the diverse ways in which teachers' cognition has been historically studied, namely: there is no agreement on the aspects that influence teachers' beliefs and the development of professional knowledge. Pajares (1992) suggested that teachers' beliefs

travel in disguise and often under alias—attitudes, values, judgements, axioms, opinions, ideology, perceptions, conceptions, conceptual systems, preconceptions, dispositions, implicit theories, explicit theories, personal theories, internal mental processes, action strategies, rules of practice, practical principles, perspectives, repertoires of understanding, and social strategy, to name but a few (p. 309).

The conceptual framework in an epistemology of practice attends to the professional's theories-in-action to study action and reveal tacit knowledge and incongruencies between espoused theories and theories-in-use through a process of reframing. The characteristic of knowing in an epistemology of practice is largely tacit and not easily describable thus it necessitates a methodology that supports access to the practice of the professional in order to study, analyze, and draw assertions from practice that are often tacit. Knowing-in-practice supports teacher educators' knowing-in-order-to and knowing-what-for (Heidegger, 1977).

An epistemology of practice is a conceptual framework that also has utility for naming "what is" in the ontological moments of practice. An epistemology of practice, unlike for example, pedagogical content knowledge, allows the teacher educator to document and analyze (Bullock, 2011) the development of professional knowledge. An epistemology of practice is amorphous as a universal because it is personal and

temporal and the authorizers are a moving target, as is professional knowledge. An epistemology of practice is realized and embodied in the profession of teaching and underscores the ontological philosophy that truth is a fluid construct and there is a need to recommit to it constantly to understand professional knowledge and its development. It is useful to study teacher educators' professional knowledge and its development in this way because practice is more holistic than an isolated experience. In this way, the associations between the authorizers that constitute practice are flattened in a manner that the teacher educator can trace through access to the authority of practice.

Kane, Sandretto, and Heath (2002) provide a comprehensive overview of some methods "adopted by researchers studying the beliefs and conceptions, or the espoused theories of action, of teachers" (p. 183). These range from concept mapping, to interview, life history, and reflective practice (Kane, Sandretto, & Heath, 2002). Kane, Sandretto, and Heath (2002) advocate that "a great deal can be learned about teaching at the tertiary level by examining the coherence of teachers' theories of action and exploring the factors that encourage or discourage agreement. These questions expose a vast sea of uncharted research" (p. 184). However, to my knowledge, there are no studies that advocate for a research methodology to study teacher educators' professional knowledge in an epistemology of practice. The next chapter describes a qualitative research methodology that facilitates the study of practice and action in an aim to understand a teacher educators' professional knowledge, its development, and the improvement of practice.

## **Chapter 3.**

# **Research Design, Methodology, and Analytical Framework**

### **3.1. Introduction**

This study aims to tease out the complexity (Donnell, 2010) in my process of becoming (Dinkelman, Magolis & Sikkenga, 2006) a technology teacher educator through an understanding of the theories of action in my teaching practices and actions (Loughran, 2007). Self-study of teaching and teacher education practices (S-STTEP) is the educational research methodology used to uncover my teaching practice in order to understand the relationship between teaching and learning in teacher education and improve my practice. S-STTEP, also referred to in this research as self-study methodology, is unlike other qualitative research in that the researcher comes to understand oneself “by looking more clearly at personal understanding and practice rather than attempting to remove the self from the study” (Pinnegar & Hamilton, 2009, p. 58). Understanding of the self in S-STTEP involves the arduous process of self-discovery and “the adoption of a rather special attitude toward yourself and observation of yourself in action” (Perls, Hefferline, & Goodman, 1965, p. 3-4).

#### **3.1.1. Context for the Research**

This study was carried out during the Summer of 2017 in a special topics course in the Faculty of Education at a large research-intensive and comprehensive university in British Columbia, Canada, where I am a teacher educator. The course was called ‘Making Experiences in Science and Technology Education.’ The purpose of the course was to provide opportunities for the 17 registered teacher candidates to think about and practice the ways in which one learns from experiences in science and technology. In the course, teacher candidates gained hands-on experience with science and technology projects that were selected for secondary science and technology teachers. The educative approaches in the course emphasized the relevance and implications of maker pedagogy and experiential learning as educational technologies for the development of teacher candidates’ pedagogy and identity as science and technology

teachers. The course had in-class and off-campus opportunities for teacher candidates to engage with the educational technologies of maker pedagogy and experiential learning.

### **3.1.2. Design of the Course**

The course was designed as a blended model meaning that there were face-to-face and online components. The semester schedule at the University is 13-weeks in length. Of the 13-weeks, the course met face-to-face for 11-weeks, and two weeks were dedicated to off-campus activities, that included the teacher candidates' site visits at a Maker Faire, as well as to experiential learning sites of their choosing (e.g., Botanical Gardens, Art Gallery, Science World).

I used a PowerPoint presentation as a lesson framework to guide the class through discussions, questions, and activities. In preparation for each in-class meeting, the teacher candidates participated in online discussions and completed the course readings. The online discussions had metacognitive prompts that aimed to engage teacher candidates to think about the course readings and to formulate questions, extend their thinking, and/or share ideas about applications of their learning with their peers. The online discussions provided me with insight into the teacher candidates thinking, beliefs, assumptions, questions, areas of interest, and views. Each week, I summarized the online discussions and synthesized the teacher candidates' questions and ideas, which were used in subsequent classes. The teacher candidates completed four assignments for the course, including two reflective papers, an individual paper, and a group project. The course assignments that are a part of this study can be found in Appendix A, B, and C.

During the first class, the teacher candidates completed a Q-sort activity to support my understanding of their subjective perspectives related to their theories of knowledge about technological environments. This activity provided a starting place for me to understand the teacher candidates' epistemologies, which involved more than knowing about their prior experiences and course work. I analyzed the teacher candidates' perspectives to gather information about how teacher candidates might construct knowledge in a technological environment. This data provided me with information that could be used to signal changes and shifts in teacher candidates'

theories of knowledge. The data was used to deepen the self-knowledge of my pedagogy of technology teacher education and support how I may enhance my practices for the design of educational technologies in post-secondary environments to support teacher candidates with technology integration.

### **3.1.3. About the Teacher Educator as Researcher**

I am a doctoral candidate in the Faculty of Education specializing in Educational Technology and Learning Design at a large research-intensive and comprehensive university in British Columbia, Canada. I am the researcher in the study and a teacher educator, which refers to “someone who provides instruction or who gives guidance and support to [teacher candidates], and who thus renders a substantial contribution to [their] development into competent teachers” (Koster, Brekelmans, Korthagen & Wubbels, 2005, p. 157). As a novice teacher educator, I had taught three undergraduate courses in the teacher education program. Two courses focused on experiential learning and one course focused on maker pedagogy and experiential learning. I do not have a teaching certificate, nor had I taught in the elementary or secondary school setting before higher education. I have a strong background in higher education pedagogy and have taught for over ten years as an online instructor. I identify as a maker and experiential learner and am an active member of the maker community. In my professional career, I am a curriculum designer for the work-integrated learning program (experiential learning) at a large research-intensive and comprehensive university in British Columbia, Canada. As well, I am a research assistant for experiential projects within the University’s student services area, and a research assistant in the University’s maker pedagogy lab. In the lab, teacher candidates construct and expand their professional knowledge about teaching through maker activities. Maker activities such as applied physics, computer programming, and robotics support teacher candidates to think about their pedagogy while working with technological artifacts. As a research assistant, I study how teacher candidates create knowledge from experiences, develop professional knowledge, and learn to teach.

### 3.1.4. Research Questions

This study of teaching and teacher education practices aims to understand my practices and actions as a technology teacher educator through the lens of maker pedagogy and experiential learning as educational technologies. The specific research questions guiding this study are:

1. How do students' theories of knowledge drive the ways in which they construct knowledge in technological environments?
2. What, if any, degrees of coherence exist between how teachers and students view the nature of knowledge in technological environments?  
and
3. How might my personal pedagogy of technology teacher education be influenced by my perceptions of students' changing theories of knowledge for the design of educational technology within a post-secondary environment?

## 3.2. Methodological Framework of the Research

### 3.2.1. Overview

This section describes the methodology, the data collection methods, the study design and analytical framework, and concludes with a discussion about trustworthiness and ethics. Self-study is a research approach that incorporates the *self* in research, including the *self* in relationship with others, to reflexively study the space between one's practice and actions (Loughran, 2007). "Self-study methodology works from the postmodernist assumption that it is never possible to divorce the self from either the research process or from educational practice" (Cochran-Smith & Lytle, 2009, p. 607). There are some debates in educational research on the place of self-knowledge as an epistemic source of information, and Gertler (2012) argued that:

[s]elf-knowledge, even if not absolutely certain, is especially secure, in the following sense: self-knowledge is immune from some types of error to which other kinds of empirical knowledge—most obviously, perceptual knowledge—are vulnerable. Some theorists who take this line maintain that there is a causal gap between a perceptual state and its object, and this gap introduces sources of error that are absent in direct introspective apprehension of a sensation (para. 10).

Self-study of teaching and teacher education practices is a type of educational research methodology that is concerned with the understanding and improvement of one's practice and the relationship between teaching and learning in teacher education. S-STTEP is situated in the hub of research on teaching and teacher education and arose at a time when other methodologies did not answer questions about teacher and teacher education practices; specifically, questions about how practitioners could "understand their experiences in ways that counted as knowledge" (Pinnegar & Hamilton, 2009, p.1). Shifting perspectives in the field of research and educational practice about the value of learning from experiences (Berry & Hamilton, 2013) advanced S-STTEP methodology. This was exciting given the crisis of representation (Denzin & Lincoln, 2005) surrounding the inability of qualitative researchers to present the lived experience of those they studied. Self-study methodology provided teacher educators with a way to study their own practice and contribute to the development of the scholarship in the field of teacher education.

Russell (2004) contributed to the development of S-STTEP by positioning the methodology within reflection and reflective practice, and alongside other qualitative research traditions. Self-study research supports a way to see one's thinking, to understand one's tacit knowledge as embedded in teacher actions, and to attend to the role of becoming a teacher educator. The 'act of becoming' is the philosophical orientation of S-STTEP methodology in ontology, which is the study of one's reality as context-dependent and shaped by a constructed world view. Having an ontological research stance supports the recognition and ontological difference between practice and action in order to narrow the space in one's practice where there may be "dis-juncture between our belief and our action" (Bullough & Pinnegar, 2001, p. 15) in order to improve the educational outcomes for the benefit of student learning. The self is central in self-study methodology wherein the "focus on neither the self nor the other but both as well as the place between them" (Pinnegar & Hamilton, 2009, p. 77). Self-study looks at practice at the same time that one is acting it, so the methodology studies what one does, how they do it, and how one can improve, in order to advance one's professional practices (Cochran-Smith, 2005). A fulsome historical and developmental synopsis of self-study in educational research can be found in Loughran (2004). The methodological pillars of S-STTEP are detailed in an upcoming section.

### **3.2.2. Methodological Fit**

This self-study provides an account of my practices and actions as a technology teacher educator to understand the espoused theories (Argyris & Schön, 1974) and the theories-in-use (Argyris & Schön, 1974) in my pedagogy of technology teacher education. My moral commitment is to support teacher candidates' achievement of the course goals and to understand and improve my practice as a teacher educator in service of teacher candidates. This study aims at discovery of: my teacher identity, changes in my practice, my views on learning how to teach about teaching, and my perspectives about how teacher candidates' changing theories of knowledge influence my personal pedagogy of technology teacher education.

The methodological framework of S-STTEP supports this self-initiated and improvement-aimed (LaBoskey, 2004) study of my teacher-educator-research self and is justified as the best methodology for answering the research questions. Self-study methodology is a rigorous and effective educational research methodology that supports the study of my pedagogy and my capacity to access the authority of experience (Munby & Russell, 1993) in my practices to investigate how my practices align with my actions (Loughran, 2007). The methodology has affordances for “making the practices of teacher educators explicit, valued, and visible – particularly when such practices are subject to change in response to academic scrutiny” (Bullock & Madigan Percy, 2018, p.23). Further, the methodology allows the teacher-researcher to achieve nuanced insight through the rigorous and systematic (Vanassche & Kelchtermans, 2015) study of one's practice to make tacit knowledge (Polanyi, 1958) explicit in order to support and sustain the complexity of teacher educators' professional development (Hordvik, 2018; Bullock & Madigan Percy, 2018).

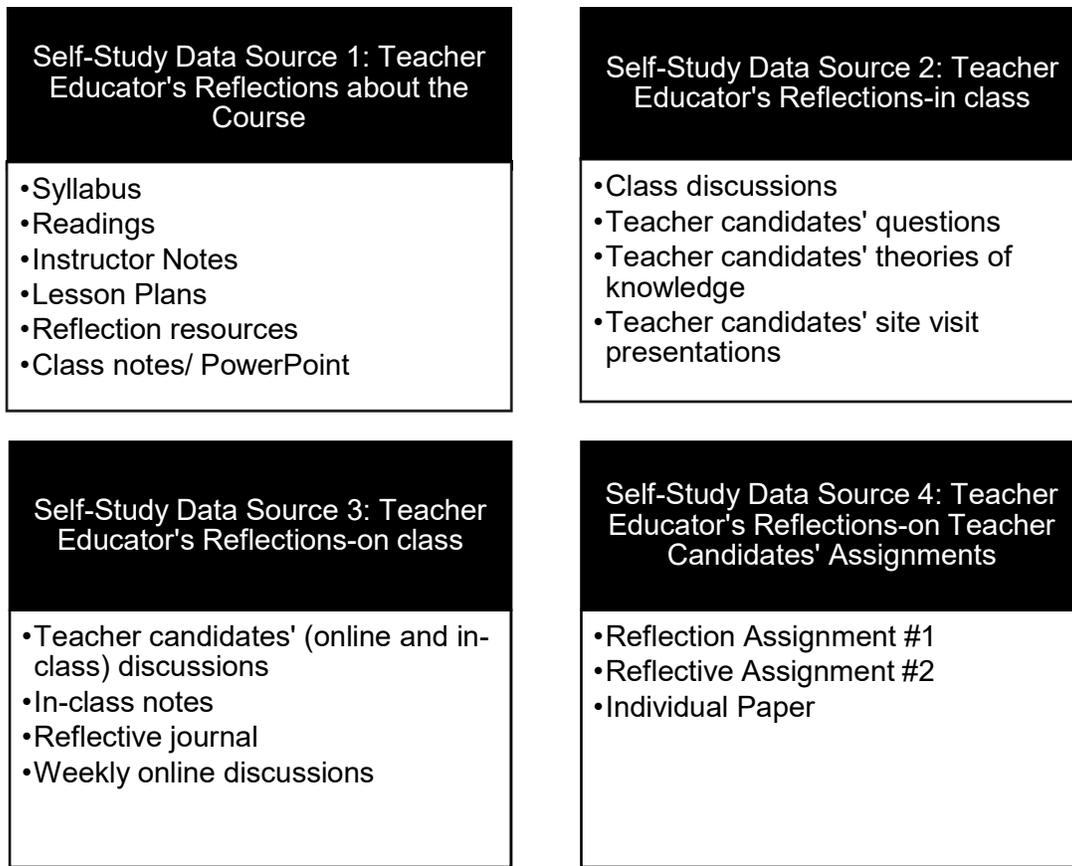
### **3.2.3. Data Collection and Methods**

Ethical approval was granted by the University to conduct this research. There were 17 secondary science teacher candidates registered in 'Making Experiences in Science and Technology Education'. An invitation to join the study was sent to the entire class after the last day of the course once I had submitted the final grades and the Faculty of Education had approved them. Thirteen teacher candidates agreed to participate in this study.

S-STTEP methodology is a research framework that allows for a multiplicity of qualitative methods (LaBoskey, 2004) to collect and analyze data. This study used multiple data sources to support the assertions drawn from the study (Hubbard & Power, 1993) while balancing the accumulation of far more information than there are analytic possibilities for (Miles & Huberman, 1984). It is through multiple data sources that I build assertions of what I discovered. I was cautious in the data collection process to be mindful of Miles and Huberman (1984) who stated that if you

self-consciously set out to collect and double-check findings, using multiple sources and modes of evidence, the verification process will largely be built into the data gathering process, and little more needs to be done than to report on one's procedures (p. 235).

The duration of this research paralleled the length of the course and throughout the process, "data collection-data analysis-data interpretation occur[ed] in a recursive process from the onset of a study's research design" (Pinnegar & Hamilton, 2009, p. 147). Self-study data recorded my assumptions (Brandenburg, 2008), beliefs, practices as a teacher of teachers, teaching actions, and observations of teacher candidates' reactions to my teaching. The focus of the self-study data is on my practice, not on the teacher candidates' practices, learning, or the achievement of the course goals. Graphic 1 below provides an overview of the self-study data.



**Figure 1. Overview of the Self-Study Data.**

As Hubbard and Power (1993) noted, “sometimes it is hard to take notes intensively and still maintain a role as a teacher in the class. For this reason, many teacher-researchers rely on brief, intensive periods of note taking during their teaching day (p. 13)”. My brief jotted notes included “little phrases, quotes, and key words that were recorded during observations and intended to direct [my] mind to specific points” (Hubbard & Power, 1993, p. 23).” “One thing I will note is that it is hard to write detailed reflections in class while one is teaching. I seem to record phrases, key words, or simple things that trigger moments in my memory that I then use to write my reflection-on each class within a day or two after the class” (Sator, Data Source 3 Teacher Reflection-on Week 3, 2017). As a teacher-educator, I extended on my in-class notes by engaging with extensive reflective writing in my teacher educator journal after each class. My teacher educator reflective journal was as detailed as possible and focused on the particulars in the context, and well as my reflections on specific thoughts related to the research questions.

My recorded reflections entailed an iterative process of collection and analysis, likened to the processes that Hubbard and Power (1993) call 'cooking the notes' as a method to identify missing information in my data set. "Cooking notes is the process of reflecting upon what you are seeing shortly after you first write your notes" (Hubbard & Power, 1993, p.17). The cooking process was very useful because it helped my note-taking skills as well as trained my eyes to "look for incidents that delight, jar, confound, or confuse" (Hubbard & Power, 1993, p. 17). As I cooked my notes, I theorized about my perspectives and contemplated my observations alongside the data collected. Hubbard and Power (1993) reminded me that the Greek root of theory means 'to complete' and 'to see' and Jorgensen (1989) suggested that theorizing allowed me to assemble or reconstruct the data in ways that are meaningful.

Other self-study data sources included the course syllabus, course readings, lesson plans, class notes, and field notes taken during my readings of the online course discussions. Further self-study data included notes on in-class teacher candidates' presentations about their site visits to experiential learning sites and the Maker Faire. The data for this study also includes the Q-sort activity and 3 assignments (that were completed as a designed part of the course) of the 13 teacher candidates that approved the use of these artifacts. This meant that I used the Q-sort activity of 13 teacher candidates to understand their beliefs about the nature of knowledge and how they thought about and conceptualized knowledge in technological environments to establish a baseline understanding of teacher candidate epistemologies. The course assignments and discussion (in-class and online) were the data used to understand teacher candidates' shifting theories of knowledge.

#### **3.2.4. Q-Methodology**

Part of this self-study research is understanding teacher candidates' theories of knowledge to support my ontological commitment as a technology teacher educator that fosters teacher candidates' understandings about knowing in technological environments for the integration of technology in their in-service practice as teachers. As a tool to understand the subjective perspectives of teacher candidates' and my theory of knowledge, S-STTEP as a hybrid methodological framework for this study was combined with Q-methodology. Q-methodology offers a way to systematically study subjectivity of a belief, opinion, viewpoint, or attitude (Brown, 1993). "The power of Q

methodology lies in its ability to gain insight into the self-understanding of the participants in the study” (Madoc-Jones & Gajdamaschko, 2006, p. 65). I selected Q methodology because it allowed for the interpretive investigation of subjective individual and group perspectives (Madoc-Jones & Gajdamaschko, 2006) related to the conceptions of knowledge in technological environments. The methodology supported me to answer research questions one and two and offered a technique that was distinct from prior learning assessments and survey methods.

In Q-methodology, the participants are provided a set of statements about a topic, which is called the Q-set. The Q-set is developed from the discourse in the field, which is the flow of communicability surrounding (Brown, 1993) the research area. At the heart of Q-methodology is the development of the discourse which is “the array of ideas, attitudes, feelings, values and perceptions” (Madoc-Jones & Gajdamaschko, 2006, p.65) about the topic in question. I engaged in an extensive literature review, as presented in Chapter 2, in order to generate the discourse about the conceptions of knowledge in technological environments to ensure it was inclusive of the things that people were saying about the subject. The discourse was then reduced to a series of statements, the Q-set, and it is up to the research to “draw a representative sample from the discourse at hand” (Van Exel & de Graaf, 2005).

The Q-set is the research tool that the participants, referred to as the P-set, are asked to rank-order on a Likert scale based on their individual feelings. This process is called the Q-sort, and represents the method used to elicit subjective meaning that the P-set attributes to the Q-set to reveal their subjective perspectives (Van Exel & de Graaf, 2005). The “Q-sort is the vehicle of Q-methodology, the means by which the data are collected” (Wilson, 2005, p. 75). The Q-set aims to draw out personal reactions to the discourse statements (Chen, Chen & Chen, 2015). The 35 Q-sort statements that teacher candidates rank-ordered on a Likert scale (from -4 to +4) are in Appendix D. The Q-sort provides the data about teacher candidates’ theories of knowledge and serves as a catalyst for understanding my practice as a technology teacher educator for the design of educational technology in post-secondary environments.

The rankings on the Likert scale represent a quasi-normal distribution and are subject to factor analysis. “Q-methodology is an inversion of conventional factor analysis in the sense that Q correlates persons instead of tests” (Van Exel & de Graaf, 2005,

p.1). The P-set's Q-sorts are processed in PQ Method, a statistical software tool that uses factor analysis to determine variability and correlated variability to impose groupings on the data (Brown, 1980), namely: identify factors, which are the world views or perspectives of the P-set. The factors are operant segments of subjectivity that demonstrate how the concourse statements are understood by the participants and get sorted in relation to one another. The factors present people with similar world views and perspectives (Van Exel & de Graaf, 2005) as taken from the PQ Method correlational matrix of statistically significant and distinct world views. The strength of the connection to a factor depends on the correlation. The correlation matrix is rotated in PQ Method until every participant has a distinct world view and loads on a factor. Q-methodology does not focus on discovering numbers of participants that share a perspective. The methodology seeks to determine discrete perspectives that the P-set embraces and for this reason the methodology does not require randomized sampling of large populations.

PQ Method is used to carry out the factor analysis, however, the researcher makes meaning of each factor and answers the research questions using the computational outputs from the software. The outputs include: the distinguishing statements of the factors (the statements in the factor that are ranked significantly distinct based on how they loaded in other factors); the correlation matrix; the z-score of statements within a factor; the clarifying statements (those ranked most positively and negatively); participants' affinity towards a factor; and, statements of convergence and divergence across the factors. The self-reference of participants is maintained (Stephenson, 1993) in the

factors that result from a Q study... in a very real sense are the results of behavior—that is, they exist as the consequence of a group of respondents having responded in the same fashion... Factors in Q technique studies arise from actual concrete operations of persons as they model their attitudes; a factor is the result of behavior. The factor-categories are genuine, as opposed to *ad hoc* categorical, and reflect true attitudinal segmentation. They are more genuinely “operational definitions” of this-or-that attitude, since whatever they are definitions of has been made manifest by virtue of behavioral operations expressed through the medium of Q technique. (Brown & Unga, 1970, p. 519).

The outputs from PQ Method support my interpretation of the teacher candidates' and my theories of knowledge about knowledge in technological environments and are presented in Chapter 4.

The factor analysis shows the correlation between the P-set with comparable viewpoints, and when “significant cluster of correlations exist, they could be factorised, described as common viewpoints” (Van Exel & de Graaf, 2005, p.1). The factors that results from the analysis in Q-methodology are the segments of operant subjectivity and are functional categories (Brown, 1993). The premise of Q-methodology is that “subjectivity is communicable, because only when subjectivity is communicated, when it is expressed operantly, it can be systematically analyzed, just as other behaviours” (Van Exel & de Graaf, 2005, p. 2).

Q-methodology does aim at generalizations and does not require a large P-set because it reveals perspectives (behaviours) that are independent of distributions relative to other behaviours (Van Exel & de Graaf, 2005). The P-set represents a sample of participants that are “relevant to the problem under consideration” (Van Exel & de Graaf, 2005, p.6), and the “number of persons associated with a factor is of less importance than who they are” (Van Exel & de Graaf, 2005, p.6). Due to the small number of participants in a Q-study, replicability becomes the most important form of reliability. Replicability states that given the same set of instructions, the factors will be schematically reliable (Van Exel & de Graaf, 2005) and “represent similar viewpoint on the topic- across similar structured yet different Q samples and when administered to different sets of persons” (Van Exel & de Graaf, 2005, p.3).

Some proponents of Q-methodology suggested that it offered some answers to the criticism of qualitative/quantitative dualist traditional methods and provided a way to study subjective perceptions (Ward, 2009). Q-methodology provides a systematic way to study emergent subjectivity and perspectives regarding a given subject and is very different from positivist frameworks such as surveys or questionnaires (Brown, 1980, 1993; Stephenson, 1953). For example, survey data would not be adequate in this study to report on patterns of responses from participants as it imposes categories for selection on potential responses. Willis, Thompson and Sadera (1999) suggested that educational research relies too readily on surveys and they do not always provide an important method of advancing a field.

The examination of personal constructs permits some understanding of a person’s views and perspectives. There are various construct elicitation methods (e.g.: interviews, narratives, focus groups, needs analysis, Q-sorts, concept sorting), however,

there is limited research comparing the elicitation procedures (Caputi & Reddy, 1999) and the nature and types of knowledge the procedures produce. Some historical research suggests that the elicitation of personal constructs is method-dependent, and that the elicitation of constructs taken on two separate occasions may be similar, even through the use of different methods (Fjeld & Landfield, 1961). However, Caputi and Reddy's (1999) findings do not suggest this, and they suggest that there is not a high level of similarity in constructs between separate elicitations when using different methods. This suggests that "qualitatively different kinds of constructs" (Caputi & Reddy, 1999, p. 264) are elicited by different methods and that the nature of elicitation is time sensitive. The implications for researchers is to understand that elicitation methods allow insight into the different nature and type of constructs and that, for example, some methods may allow for less cognitive complexity. This points to limitations and issues in the use of construct elicitation methods, the context and time specific nature of their use, as well as the type of construct the methods provide insight about, and the validity of the representations. As such, the constructs elicited through Q-methodology are understood through the lens of the complexity inherent in the Q-sort method and aim to provide understanding and insight for the teacher educator about the nature of teacher candidates' knowledge within the timeframe of the research context.

"Q is neither fully qualitative nor fully quantitative, Q research can draw upon components and values of both" (Ward, 2009, p.75). Q ensures a level of operant subjectivity and "a systematic approach for identifying clusters of people who carry common viewpoints" (Pruslow & Red Owl, 2012, p. 375). The researcher then interprets each of the factors (clusters of people) to determine the perspectives represented and proposes related discourses. As I aim to uncover deeply held subjective perceptions, Q-methodology was selected as appropriate for eliciting these, and potentially revealing new viewpoints.

Watts and Stenner (2005) suggested that Q-methodology can "bring coherence to research questions that have many, potentially complex and socially contested answers" (p.75). However, as with any methodology, Q faces criticism and some limitations. Cross (2005) noted that the methodology raised questions about reliability and questions if the same perspectives of a participant can be elicited on different occasions using the same Q-sort. However, Stainton Rogers (1995) in earlier work noted that social psychology does not place expectations that participants will respond similarly

on different occasions. Another limitation of the methodology is the bias that the researcher brings, particularly in the preparation of the Q-set and in the interpretation of the factors. The number of statements limits the perspectives that can be elicited (Cross, 2005) and Cross (2005) suggested that researchers conduct focus groups and interviews to ensure the Q-statements are representative of the opinions on a subject. Finally, Stainton Rogers (1995) suggested that like concerns in other methodologies the interpretations arise from a place that the researcher practices within and this influence or bias may be eased through discussions with other researchers and the P-set.

### **3.2.5. Study Design and Procedures**

The procedures for the research include:

1. Analyze and interpret the teacher candidates' Q-sorts about their theories of knowledge in technological environments using Q-methodology to understand their subjective perspectives.
2. Analyze and interpret my Q-sort about my theory of knowledge in technological environments using Q-methodology to understand my subjective perspective.
3. Answer the first and second research questions, which are presented in Chapter 4.
4. Analyze and interpret the self-study data to examine my practices and actions in my pedagogy of technology teacher education.
5. Analyze and interpret my perceptions of teacher candidates' shifting theories of knowledge and examine these influences on my personal pedagogy of technology teacher education.
6. Answer the third research question, which is presented in Chapter 5 and 6.

### **3.2.6. Self-Study of Teaching and Teacher Education Practice Methodology**

This section provides an overview of self-study of teaching and teacher education practice (S-STTEP) methodology through a description the pillars and warrants for making assertions for action from self-study. This section also discusses how this research adheres to issues of trustworthiness and ethics.

S-STTEP is “used in relation to teaching and researching practice in order to better understand: oneself, teaching, learning, and, the development of knowledge around these” (Loughran, 2004, p.9). “Self-study can be a powerful resource for teacher educators and classroom teachers who are interested in using critical approaches to systematic reflection” (Hostetler, 2012, p. 64) and in taking an inquiry stance (Cochran-Smith, 2005) in an aim to improve practice (Cochran-Smith & Lytle, 2009). Practice is defined as the work, activities, actions, and beliefs that a professional person, artist, or craftsperson engages with that “lead to the accomplishment of goals through the use of knowledge, theories, and understanding” (Pinnegar & Hamilton, 2009, p. 16). Practice is the physical manifestation of one’s embodied experiences and theoretical understandings because “to act is to theorize” (Panago, 1991, p.194). The methodology allows one to theorize about practice and gain profound understanding about the why of teaching and learning, but this

is not an easy task for, as has been highlighted throughout the research on teaching literature, much of one’s knowledge of practice is tacit, so attempting to define and articulate such knowledge can be a difficult and frustrating process. However, overcoming, rather than succumbing to such difficulties and frustrations is important in demonstrating scholarship in self-study (Loughran, 2007, p. 17).

There are many reasons that teacher-researchers carry out a self-study as Berry (2004) and others have noted. I would like to argue that my reasons are similar to Loughran’s (2004) position in that:

although instances of being “a living contradiction” (Whitehead, 1993) may well be at the heart of beginning a self-study, it is this overarching desire to better align theory and practice, to be more fully informed about the nature of a knowledge of practice, and to explore and build on these “learnings” in public ways that appears to be an underlying common purpose in self-study—a tacit catalyst for self-study (p.14)

S-STTEP methodology takes seriously the study “inside the experience of practice” (Pinnegar & Hamilton, 2009, p. 3) of educating teachers. This positions the researcher in an ontological orientation wherein the “basic question is actually more about *what is* than about claims to know (Pinnegar & Hamilton, 2009, p. 2). The theory-experience-practice relationship is critical to S-STTEP research and studies are “constructed from our place within that experience with a commitment to shaping what is real to conform more closely with what we value” (Pinnegar & Hamilton, 2009, p. 5). S-

STTEP methodology challenges the dominant binaries in educational discourse about practice and theory and as Loughran and Northfield (1998), LaBoskey (2004), and Russell (2004) suggested, S-STTEP offers solutions to the dichotomy by aligning practices, intentions, and beliefs.

Self-study methodology is the systematic and rigorous study of the self-in-enactment of practice through the questioning of the space that occurs amid one's actions, practices, and intentions with others (Pinnegar & Hamilton, 2009). In this way, self-study methodology examines the space between one's practice, wherein the focus is attending from what we know, and one's action, wherein we attend to how we respond. Self-study research intensifies one's awareness and tenacity towards findings solutions to the tensions that occur between intent and action (Loughran, 2007).

In S-STTEP methodology, the researcher's authority as engaged in practice allows one to document their learning about teaching and teacher education and is a powerful tool for understanding professional knowledge. Self-study methodology proposes a way to go beyond technical rationality and involves a more productive understanding of professional knowledge that is grounded in socially constructed understandings (Bullock, 2016). The methodology encourages researchers to state explicitly the "tacit and personal practical knowledge they possess that contributes to [their] knowledge and understanding of teaching" (Pinnegar & Hamilton, 2009, p. 3). This attention to practical knowledge focuses on what is revealed in practice through knowing and knowing-as-action, which occurs through interactions in the process of arriving at assertions for action and understanding (Berry & Loughran, 2002) and how it can improve practice.

### ***Pillars and Warrants of S-STTEP Methodology***

One challenge of S-STTEP methodology is that there is not one agreed upon parameter for carrying out a self-study, and this potentially makes the methodology more complex (Loughran, 2004; Samaras & Freese, 2006). There are, however, characteristics evident in self-studies that serve as "markers for this research paradigm" (Brandenburg, 2008, p.23) within the scholarship. This section describes three pillars of self-study methodology that underpin the value of self-study methodology for aligning teacher educators' theory and practice to advance professional knowledge and its

development. The three pillars are: 1) attention to the self, 2) critical others, and 3) alternative ways of knowing.

These pillars serve as the warrants in self-study research that maintain the “momentum towards too much focus on the self-as-a learner” (Bullough & Pinnegar, 2001) and underpin the basis for knowing (Bullock, 2009) in drawing assertions from the research. A warrant is the adhesive or logical statements (Toulmin, 1964) that bridge the evidence and assertions to clamp the argument together. The connection between the evidence (meaning derived from analytical descriptors) and the assertions (the interpretations) in a study are bonded by a warrant.

### **Pillar 1: Attention the self**

Self-study methodology focuses on practice and studies of one’s self-initiated action with an improvement-aimed (LaBoskey, 2004) focus in the present moment of practice. This positions self-study methodology in an ontological orientation, which means that the study focuses on what is real in the practice (and its improvement), rather than in an orientation that aims to make epistemological claims to know (Pinnegar & Hamilton, 2009). This “asserts publicly who owns the responsibility for both the practice and the research on it” (Pinnegar & Hamilton, 2009, p. 13). Ontology as a warrant for assertions for actions in self-study methodology justifies a course of action in the entire research process, particularly in the evidence and methods for gathering it. Ontology embraces the researcher’s moral debt, the intention to improve one’s current practice, the belief in growth and making change, and attention to the present moment.

Pinnegar and Hamilton (2009) stated that an ontological stance:

directs the researcher to capturing clear, defensible, and compelling accounts of the contexts and experiences from which understanding emerges. The researcher attends to providing enough contextual depth to enable others to see the practice or experience in the same way the researcher sees it (p. 56).

Munby and Russell (1994) noted that an ontological stance recognized the contexts that shape a study in a moment-in-time, including social, political, and economical movements. An ontological warrant also means that one goes beyond the story (Loughran, 2010) of one’s practice, does not linger on what they found personally valuable, and connects the study to the broader field (Munby & Russell, 1994) of

research in teacher education. The intent should not be a hero story, rather it should expose and challenge the researcher to not focus on the egotistical self (Loughran, 2007) and move towards self-improvement (LaBoskey, 2004).

Self-study research happens in the spaces between, for example, the spaces between practice and intention, the self and other, and life history and autobiography. Attention to the self in these spaces between requires that self-study 'turn back on itself' and a

study turns back on itself when the teacher educator reveals and supports with empirical evidence the new understandings of and assertions for practice that emerged as the teacher educator questioned again the practices being used and what they revealed about what the teacher educator now knew (Pinnegar, Hamilton, & Fitzgerald, 2010, p. 205).

One's command over the practice they are studying and intending to improve means they have the ability to frame a problem (Schön, 1983). This serves as a tool for developing understanding and describing the situation and implications. An attention to the self acknowledges the practical knowledge gained through experiences, and the knowledge of phronesis versus the theoretical or propositional knowledge of episteme. Schön (1983) argued that institutions have a propensity towards the belief that episteme exists only in the 'ivory tower,' and this thinking led to technical rationalism and placed less value the knowledge of phronesis. Schön (1983) advocated that professional knowledge requires attention to the knowledge gained through knowing-in-action, which draws attention to the self in ways that are unique to S-STTEP. LaBoskey (2004) extended Schön's (1983) concepts of framing and reframing, wherein a practitioner reflects while in-action on the problematization of their situation and acts on it to transform the self in practice with others.

S-STTEP requires attention to the self that is balanced through reflective practice and reflexive methods that help manage the momentum of the research from focusing too much on the self as a learner (Bullough & Pinnegar, 2001). "Self-study research provides an enhanced understanding of the conceptual underpinnings and pragmatic necessities of reflective practice, and that reflective practice requires one to be truly present within the crucible of practice" (Bullock & Madigan Percy, 2018, p. 22). Reflection is a very important tool in self-study and is used to understand the assumptions and beliefs and the impact of those on practice (Dinkelman et. al, 2006).

However, Loughran and Northfield (1989) remind us that self-study demands action be taken on the outcomes and that this type of research is more than a reflection on practice.

Finally, self-study focuses on the self as doing good work versus egotistical and self-serving work. In this way, good work is a warrant for the improvement of one-self (Sator, Bullock, MacKinnon, 2017) and draws attention to the self as a pillar of self-study. Therefore, while the self is the focus of the study, it is not the way of carrying out the study (Loughran and Northfield, 1989). As discussed in this section, self-study methodology turns back on itself and this process leads to the reframing of one's practice. The reframing of practice means that the situation is seen through multiple eyes to gain diverse perspectives, which is a second pillar of S-STTEP and is described in the next section.

## **Pillar 2: Critical Others**

Self-study is not carried out in isolation and the methodology simultaneously considers the involvement and role that *the other* (e.g., a film, an article, an aesthetic experience, teacher candidates) plays in the process of coming-to know and arriving in S-STTEP research (Pinnegar & Hamilton, 2009). The pillar of critical other in S-STTEP methodology supports the researcher to see beyond the self because "being personally involved in experiences can limit one's ability to recognize oneself as a living contradiction and therefore impact the self-study" (Loughran, 2004, p. 19). The value of the critical other is to illuminate in a detached manner (Loughran, 2004) what may not be noticeable due to the bias that occurs in situations of personal relevance. "Self-study reports make clear the importance of seeking disconfirming data, acting on such data, and reconsidering what might normally be easily overlooked (Loughran, 2004, p.17).

Different types of critical others exist and the interactive (LaBoskey, 2004) characteristics of S-STTEP methodology is about encountering these. Critical others include the literature, prior experiences, the research community, teacher candidates, and current experiences, to engage in critical dialogue with all of those things to "draw authority for making assertions about action and understanding" (Pinnegar & Hamilton, 2009, p. 14). A type of critical other that Schuck and Russell (2005) discussed is a critical friend -- someone who works with the researcher, but is not part of the research,

yet shares common goals for the success of the research. The critical friend demonstrates commitment to a relationship and advocates for the advancement of the practice the researcher aims to improve.

The personal journey of arriving in self-study engages the researcher in understanding their practices and identity in relation to the other through illuminating their actions by using methods of reflexivity. Reflexivity can be understood to mean the commonplace mental capacity that one uses to consider oneself in relation to others. Encountering the self in conversation with another can support the consideration of beliefs, assumptions, and experiences in different ways than individual interpretation allows, and this includes reflexive practices that seek the self as the other as Ricoeur (1992) posited.

Inherent in reflexivity is the method of dialogue, which S-STTEP researchers use in the process of coming to know (Pinnegar & Hamilton, 2009) for reframing one's practice. "Dialogue is a method through which we examine our practice in our self-study work for the purpose of improving our practice" (East, Fitzgerald, & Heston, 2009, p. 55). Through dialogue and interactivity with others, the researcher can frame and reframe an inquiry (Hamilton, 1998) they have about their practice from diverse perspectives" (Samaras & Freese, 2009). Loughran (2007) said that the:

need to actively pursue understandings from alternative perspectives, or to reframe situations (Schön, 1983), is important in a self-study report to demonstrate that different perspectives on teaching and learning situations have been sought and considered and to (again) minimize possibilities for self-justification or rationalization of existing practices and behaviors (p.16).

The back and forth conversations afford the generation of new knowledge situated in the evolving context of conversation and is a way to disentangle the nuanced interactions. Reframing encourages the researcher to think about their practice differently, make alterations in their teaching, and ultimately shift their practice (Samaras & Freese, 2009). Critical others have a temporal nature as the present moment of practice is the recipient of the supports for reflexivity that influence the researcher's ability to reframe a problem (Schön, 1983) through multiple and diverse perspectives. Dialogue with critical others is a warrant for assertions in self-study methodology as it empirically fortifies the analytical processes for coming-to-know. In dialogue with critical others, the researcher examines meanings ascribed to their self in practice with others

and this supports the improvement-focused goals of the methodology. Further, the process opens the third space, wherein the researcher's tacit knowledge, personal practice, and explicit knowledge are explored alongside the exposure of implicit actions (Pinnegar & Hamilton, 2009). The dialogue is validated through an approach that uses exemplar-based evidence to represent assertions and is described in more detail in section 3.2.8.

### **Pillar 3: Alternative ways of knowing**

Self-study methodology draws a nuanced insight that supports alternative ways of knowing and is a warrant for drawing assertions from self-study research. To achieve an alternative way of knowing, self-study research investigates tacit knowledge in the present moment, and knowing (as action) provides the authority of experience (Munby & Russell, 1993) in S-STTEP research. To make explicit the tacit knowledge in the action-present (Schön, 1983), the other pillars of S-STTEP are engaged. For example, the process involves dialogue with critical others to unpack, shift, and reassemble tacit knowledge and reframe it for the purpose of improving practice. The adoption of a critical reflexive position, or the reflexive turn to the self, is crucial in the analytical process as it is the turning back on one's understanding that propels the way. The reflective turn is facilitated by understanding the present moment through reflection-in-practice (Bullock, 2014) to "turn on its head the problem of constructing an epistemology of practice" (Schön, 1991, p. 5). Bullock and Ritter (2011) offered the following four criteria for identifying turning points in self-study data:

1. There is an affective (e.g., emotional or motivational) element to the data.
2. The data frame a problem of practice.
3. The author of the data is implicitly or explicitly asking for help from a critical friend.
4. The data are bounded by the action-present; there is still time to take action on the problem (p. 175).

The alternative ways of knowing in S-STTEP methodology require that the researcher goes beyond the description of evidence and moves towards rendering assertions. Assertions in self-study are the statements or proclamations that the researcher has uncovered throughout the study and are not thought of as outcomes or

epistemological claims to know, which are conclusion-based and misaligned with postmodern ways of thinking. The research aims to bring the totality of the lived experiences into the discourse (Lyotard, 1984). Lyotard (1984), known for his formulation of postmodernism, posits the movement as 'incredulity towards metanarratives.' The metanarratives capture total historical narratives and the goals of the society as foundational for the legitimization of knowledge and cultural practices. Self-study methodology is postmodernist because assertions drawn from a study are not predictable or linear (Wilcox, Watson, & Paterson, 2004). The hinge for self-study methodology is on the teacher-researcher providing evidence of assertions (Hamilton & Pinnegar, 1998) that are embedded in the context of practice and the scholarship of the field, and explicitly link the basis for knowing (Bullough & Pinnegar, 2001) to these contexts (Clandinin & Connelly, 1992). This involves extending the study context to support others who may want to apply the learning to their own work (Loughran & Northfield, 1998).

### **Summary**

This section described the pillars of self-study methodology as attention to the self, critical others, and alternative ways of knowing. In the pillars of S-STTEP, warrants for the methodology and arriving at assertions for actions hinge on drawing from an authority of experience in the action-present. In the next section, the pillars and warrants of self-study methodology are drawn together in a framework that will be used to analyze the self-study data.

### **3.2.7. Analytical Framework**

There are various methods, traditions, and orientations to data analysis. Data analysis is

the process of breaking down something with a desire to make sense of it...We might say that researchers deconstruct data to reconstruct them in ways that make meaning from what we think we see and what others seem to say" (Pinnegar & Hamilton, 2009, p. 148).

Hubbard and Power (1993) suggested that data analysis

is a way of "seeing and then seeing again." It is the process of bringing order, structure, and meaning to the data, to discover what is underneath the surface.... In seeking to explain the material you are collecting, you

enter into a dialogue with it, questioning it further, finding newer meanings and different rhythms (p. 65).

Taking inspiration from Morgan and Krueger (1997), I examined the plethora of possibilities (Blair, 2015) for working with the data because S-STTEP methodology offers scarce details about how to approach analysis and interpretation (Pinnegar & Hamilton, 2009). This research has specific goals and the purpose is not to judiciously describe all the data collected in the study or make “evidence-based pronouncements” (Chenail, 2012, p. 249) that generalize to other contexts through grand narratives (Lyotard, 1984). The orientation to data analysis described in this section is a way of thinking about the research process, the data, the analysis, how interpretations are drawn, and the warrants for drawing assertions for action.

### ***Researcher’s Paradigm***

My researcher paradigm is detailed here for the purpose of providing clarity and transparency in the analytical and interpretative processes that I engage with. A research paradigm “is a set of beliefs about the world and about gaining knowledge that go together to guide your actions as to how you’re going to go about doing research” (Wilson, 2001, p. 175). This philosophical stance defines what you do with the data (Guest, MacQueen, & Namey, 2012) and similarly provides the rationale for making “decisions about approaches to analysis and interpretation” (Pinnegar & Hamilton, 2009, p. 148).

Wilson (2001) stated that a research paradigm is comprised of four aspects:

One is ontology or a belief in the nature of reality. Your way of being, what you believe is real in the world: that's your ontology. Second is epistemology, which is how you think about that reality. Next, when we talk about research methodology, we are talking about how you are going to use your ways of thinking (your epistemology) to gain more knowledge about your reality. Finally, a paradigm includes axiology, which is a set of morals or a set of ethics (p. 175).

I believe that a singular reality does not exist, neither fixed or fluid, and that multiple realities are socially constructed (Wilson, 2001). Blair (2015) labelled that as an interpretivist view and suggested this is an understanding of the world that occurs through interactions with others. Blair (2015) recognized the changing nature of relationships in the interpretivist view and with the data and the acceptance of one's place within the research. This participatory consciousness (Heshusius, 1994) identifies that I am not distinct from the world in which the data are formed and recognizes that it

is not the realities in and of themselves that are important, it is the relationship that I share with reality. It is not necessarily an object that is important, it is my relationship with that object that becomes important [and] because this relationship is shared and mutual, ideas or knowledge cannot be owned or discovered (Wilson, 2001, p. 177).

This represents a holistic epistemology (Blair, 2015) that “replaces the traditional relationship between truth and interpretation through recognizing the productive relationship between all the players” (Blair, 2015, p. 15). Blair (2015) makes an insightful statement whereby he suggested that in an interpretivist paradigm

where a person's relationship with the world creates meaning and understanding, means that epistemology is a less tangible term, perhaps one that is connected to the relationship between the researcher and the object under research (Bettis & Gregson, 2001). Ontology in this instance becomes a question about how I use my reflections to construct my understanding. Such a process is validated by the central facets of reflexivity—constant internal scrutiny and questioning (p. 15).

Table 1 summarizes the researcher paradigm I used throughout the study and provides foundational information that guided the choices (Pinnegar & Hamilton, 2009) I made in this study. The paradigm provides defensible reasons for the analysis and interpretations and reinforces that “key to this choice is matching the [research] question to the ontological stance to the data collection-analysis-interpretation process” (Pinnegar & Hamilton, 2009, p.149).

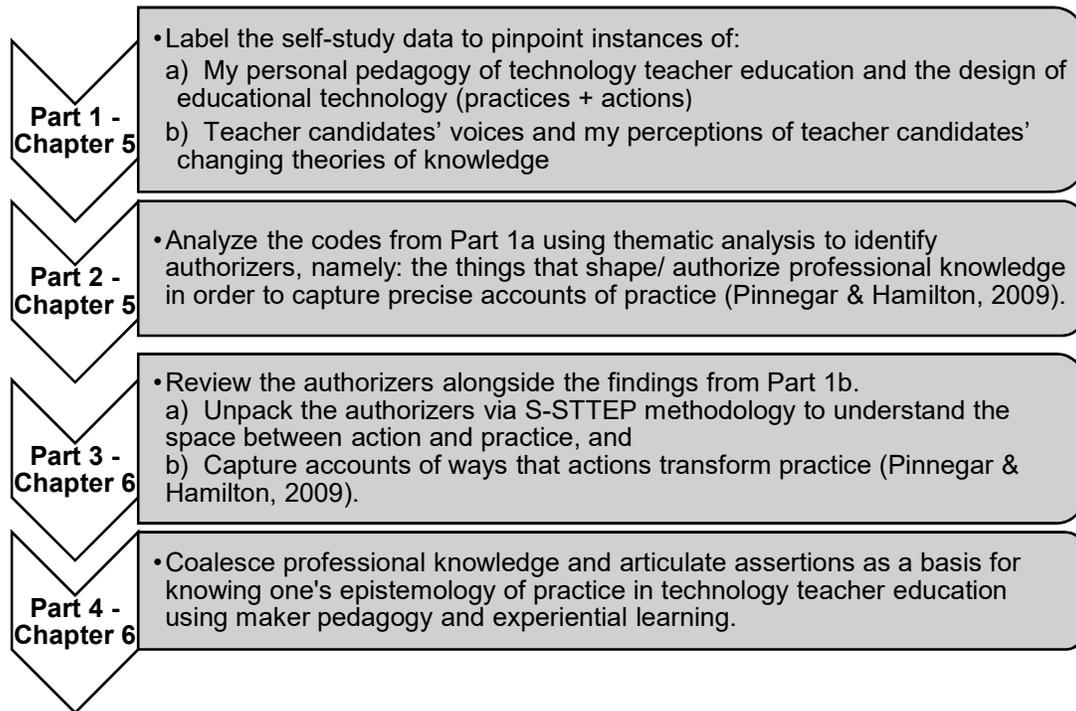
**Table 1. Researcher's Paradigm Summary**

<b>Ontology</b>	My belief is that conceptions of truth and moral values are not absolute and are relative to persons or groups, therefore is interpretivist. I consider my relationships to others and believe that "it is not the realities in and of themselves that are important, it is the relationship that I share with reality" (Wilson, 2001, p. 177).
<b>Epistemology</b>	My epistemological position is based in constructivist theory that seeks to understand knowledge that is generated in practice and not make predictions or generalize knowledge. "Constructivists believe that there is not just one reality (be it fixed or fluid), but that there are multiple realities. Different realities exist that are socially constructed" (Wilson, 2001, p. 176).
<b>Methodology</b>	The methodology is self-study research of teaching and teacher education practices (S-STTEP) for the study of practice and its improvement.
<b>Axiology</b>	My moral obligation of this research is to do "something beneficial in the world" (Wilson, 2001, p. 175). "The axiology or moral need to be an integral part of the methodology so that when I am gaining knowledge, I am not just gaining it in some abstract pursuit; I am gaining knowledge in order to fulfill my end of the research relationship" (Wilson, 2001, p. 177) and offer assertions that are useful to teacher education and being accountable in my support of educative relationships with teacher candidates for the achievement of student learning.

### ***Analytical Framework***

This section describes a comprehensive four-part analytical framework that supports me to answer the third research question and to arrive at assertions for understanding my epistemology of practice as a technology teacher educator using maker pedagogy and experiential learning as educational technologies. The third research question predicates an understanding of my practice as a technology teacher educator prior to the articulation of assertions for understanding and action. Part 1 of the analytical framework involves the identification of my practices and actions in the self-study data. The labelling of actions and practices in Part 1 of the framework is not an analysis or critical examination of my pedagogy. Part 2 of the framework utilizes the labels from Part 1 to identify my espoused theories and theories-in-use (Argyris & Schön, 1974). The process in Part 2 supports the identification of my authorizers of professional knowledge that I have accessed in an authority of practice. Part 3 of the analytical framework uses the findings from Part 2 and S-STTEP methodology for "coming to terms with the self-reproof associated with the incongruence between by intentions and actions" (Donnell, 2010, p. 227). This component of the analysis allows me to tease out the complexity of my pedagogy of technology teacher education and offers a critical examination of tensions (Loughran, 2007) in my pedagogy of technology teacher education. Finally, Part 4 of the analytical framework coalesces my professional knowledge in an epistemology of practice and supports the articulation of

assertions for actions to improve my practice as a technology teacher education using maker pedagogy and experiential learning. A high-level overview of the analytical framework and the corresponding chapters of this dissertation are presented in Figure 2 below:



**Figure 2. Summary of the Analytical Framework**

### **Part 1: Code Self-Study Data Sources for Practices and Actions**

In the first part of the analytical framework, I will code the self-study data for instances of my practices and actions. As a self-conscious (Blair, 2015) methodologist, I investigated different coding traditions to support the analytical processing of the type of data collected. A careful investigation of coding traditions suggested that an a priori coding technique that is descriptive and exploratory (Guest, MacQueen, & Namey, 2012) would best fit the analytical process. The coding tradition and methods used to pinpoint instances of practices and actions in the self-study data sources of technology teacher education are described in the next section.

## Coding Tradition

This research collected self-study textual data as a proxy for experience, which places the study in a sociological orientation (Tesch, 1990) and positions the analyst to understand the data through free-flowing text analysis (Bernard & Ryan, 1998). A starting place to derive understanding of the data is to code the data, and coding traditions within qualitative research are commonplace and valuable. Yet, I am mindful of St. Pierre and Jackson's (2014) comment that

[t]here is something nonsensical in this practice of coding if one thinks about it, because in the logic of coding, words can be both *data*—brute, waiting to be interpreted—and *code*—meaningful. Even if one accommodates that incommensurability— which coders do—such a project is thinkable only in logical positivism that presumes that language can, indeed, be brute and value-free. To restate, it is logical positivism that claims a word can be brute data. Other social science approaches such as interpretive, critical, and “post” approaches assume that language is always already entirely contaminated by meaning, exploding with meaning deferred. In those approaches, language cannot be and never has been brute, and so, as Popkewitz (2004) explained, “there are no data without theory that orders and gives classification to the things of the world” (p. 72).

“There is no recipe for this kind of analysis- for thinking with theory- because one has to read, and study theory carefully and then put it to work in a particular project” (St. Pierre & Jackson, 2014, p. 717), making the coding process particularly complex. St. Pierre and Jackson (2014) recognized that many analysts “do not follow a particular analytic method, rather, they borrow concepts, invent approaches, and create new assemblages that demonstrate a range of analytic practices” (p. 717).

To construct a robust analytical framework, I examined my research paradigm and the things that framed seeing the data (Drake, 2010). During this reflexive approach, I returned to Popkewitz's (2004) explanation that “there are no data without theory that orders and gives classification to the things of the world” (p. 72). To remain true to my philosophical orientation in interpretivism and a constructivist epistemology, I reconciled that the analysis was “not a neutral pursuit but was infused with my epistemological and ontological assumptions” (Mauthner & Doucet, 2003). For this reason, I carefully selected the template coding method (a priori) versus the open coding method for the analysis of the self-study data in Part 1 of the analytical framework. Open coding was incommensurable with my philosophical position, namely: in emergent coding and

drawing from grounded theory methodology (Glaser & Strauss, 1967), there is the implication that a truth exists awaiting discovery.

Template coding is an a priori method wherein the codes are defined by the researcher prior to the analysis and are drawn from literature, research, and theory specifically related to the research question (Crabtree & Miller, 1992; King, 1998). The template coding in this study relies on post-coding as an analytical technique that

can be thought [of] as non-technique and non-method that is always in a process of becoming as theories interlink, intensify, and increase territory—spreading out and “overturning the very codes that structure [them] . . . putting them to strange new uses” (Deleuze & Guattari, 1987, p. 11, 15).

Template coding is orientated towards interpretivist thinking rather than the positivism of open coding. Template coding is “skeptical of the existence of real internal states which can be discovered through empirical research” (King, 1998, p. 119). I felt that template coding was conducive to my research paradigm and that the data could “speak through me rather than at me” (Blair, 2015, p. 19). I adopted a similar opinion to Blair (2015) who stated that:

[t]emplate coding also meant that my reflexivity during the process would be addressed (Roberts, 1997) and that the analysis would embrace my position within the study and my personal “code of conduct” (Watts & Ebbutt, 1987, p.33). Here I claim validity of method—not by offering a faultless technique but through constant self-scrutiny, reflexivity and the analysis of any conclusions I draw (p.19).

Coding line by line was not used in the analysis as there is inefficiency in breaking things into component parts and the purpose of the present study is not a complete taxonomy of all the data collected or to develop theory from the data set. The coding process followed the fundamentals proposed by Ryan and Bernard (2000) who stated that coding:

is the heart and soul of *whole-text analysis*. Coding forces the researcher to make judgments about the meanings of contiguous blocks of text. The fundamental tasks associated with coding are sampling, identifying themes, building codebooks, marking texts, constructing models (relationships among codes), and testing these models against empirical data (p. 780).

In summary, Part 1 of the analytical framework uses a priori codes to analyze the data sources to label “the parts of materials that contain pertinent information” (Pinnegar & Hamilton, 2009, p. 149). The coding process pinpoints instances of practices and actions that correspond to the tenets of technology integration in teacher education and issues that designers of educational technology should attend to as drawn from the literature review. The a priori coding method brought “empirical data into conversation with these theoretical constructs” (Cutri & Whiting, 2008, p. 131) and served as the method for the coding of samplings of practice and action in NVivo, a qualitative and mixed method software analysis tool (QSR International's NVivo 12 software, 2018). I am mindful of Ryan and Bernard’s (2000) point that while literature reviews are crucial, other valuable sources for a priori themes are the “investigators’ own experience with subject matter” (p.780). This reinforces the importance of post-coding analytical techniques and the reflexivity required in the examination of the position of oneself in the study and during the analytical process.

## **Part 2: Identify and Trace Authorizers**

Part 2 of the analytical framework is the thematic analysis of my accounts of practice (Pinnegar & Hamilton, 2009) from Part 1 to identify authorizers of my personal pedagogy of technology teacher education. Authorizers are viewed as things that one interacts with that shape, authorize, and create one’s professional knowledge. In this sense, authorizers are not authoritative, rather authorizers are personal and come from: practice; experience; knowledge; framing positions; values and beliefs; assumptions; relationships with people or technology; moral debts; life history and/or personal biography; and/or, the examination of one’s teaching and tasks (Griggs & Muchmore, 2014) as they reveal motivations, priorities, and pedagogies.

### Thematic Analysis

Authorizers are identified through the thematic analysis of the codes in Part 1 and are researcher imposed heuristic labels on the kinds of knowledge evidenced in the self-study data. Thematic analysis brings “together components or fragments of ideas or experiences, which often are meaningless when viewed alone” (Leininger’s, 1985, p. 60). Braun and Clarke (2006) defined thematic analysis as “a method for identifying, analyzing and reporting patterns (themes) within data” (p. 79). Pinnegar and Hamilton (2009) described the process as “the organization, classification, and categorization

along with a search for patterns and a synthesis of patterns in the recursive research process” (p. 148). Guest, MacQueen, and Namey (2012) added to the definition to say that thematic analysis goes “beyond counting explicit words or phrases and focuses on identifying and describing both implicit and explicit ideas within the data, that is, themes” (p. 10).

Guest, MacQueen, and Namey (2009) proposed four guiding steps that are followed in this study:

1. Become familiar with the data. “For exploratory study, the researcher carefully reads and rereads the data, looking for key words, trends, themes, or ideas in the data that will help outline the analysis, before any analysis take place” (Guest, MacQueen, & Namey, 2009, p. 8).
2. Search for themes by sorting the codes into various themes.
3. Review themes: refine the codes by collapsing and separating themes into subthemes.
4. Define and name themes by using visual maps and links between themes and subthemes. (Guest, MacQueen, & Namey, 2009, p. 87-93).

To theme the data in this study, the above guiding steps and Burke’s (1969) notion of metaphor as a “device for seeing something in terms of something else were used. It brings out the thisness of a that, or the thatness of a this” (p.503). The metaphoric process of data analysis uses the “qualitative codes (i.e., the “this”) to bring out a quality in the unit (i.e., the “that”) (Chenail, 2012, p. 251). Chenail (2012) suggested that Burke’s (1969) “definition also accepts that the two things being compared are different yet connectable; if they were the same then there would be no perspective of difference between them for seeing something in terms of something else” (p. 249). By using metaphor as a technique, a descriptive posture rather than an interpretive or conceptual one (Sadelowki & Barroso, 2013) supported the labelling in a way that is “slightly apart from the concrete data to epitomize the qualitative differences being suggested via the qualitative code. In other words, the code provides a perspective on that which is being coding” (Chenail, 2012, p. 249). This technique of noticing the data is the abstraction required in qualitative analysis that moves the outcomes of the abstraction process and allows the analysts to see “something in terms of a qualitative something else” (Chenail, 2012, p. 250).

Braun and Clarke (2006) developed a notion of thematic analysis that “involves searching across a data set...to find repeated patterns of meaning” (p. 86). The aim is to notice patterns and to reflect upon the relationship of the patterns and think about what is learned from the data (Chenail, 2012) “within the context of the original data source” (Chenail, 2012, p. 251). The patterns are segments of text that mirror a single theme that Krippendorff (1980) labelled “thematic units” (p.62). Chenail (2012) drew on the Collins English Dictionary definition of a unit to suggest that in “qualitative data analysis a unit would be a single undivided entity upon which you direct your analysis and express the qualities you perceive in that element” (p. 266). A useful metaphor that describes the analytical process is that of a *bricoleur* as a collector who brings representations together to represent the curated montages into new representations (Denzin and Lincoln, 2005). Braun and Clarke (2006) suggested that a researcher works through the whole text systematically to keep the complete extract intact within the context and to be mindful that statements may be coded simultaneously with different themes. Through the searching and noticing of metaphors, re-occurrence of codes, and co-occurrence of codes (Guest, MacQueen, & Namey, 2012) the researcher gains confidence in making proclamations about the themes.

In summary, throughout the process of thematic analysis in this study, pattern matching (Yin, 2009) was used to notice findings that related to the theme and were traced across data sources. Pattern matching provided an opportunity to trace patterns across the different data sources in an independent and aggregate manner. This form of data source integration aimed to enhance the trustworthiness of the findings (Curti & Whiting, 2018). The process of tracing authorizers and exploring how an authorizer is represented across the data supports the identification of things (“the what”) that comprise my practice and pedagogy of technology teacher education.

A fundamental and critical parallel process that occurred alongside thematic analysis was writing about the themes and reflexively encountering the data through the lens of self-study research. Writing as a method has affordances for providing authority over one’s ideas and empowered my reflective thinking during the understanding of themes as possible authorizers. Through sustained and continued writing, S-STTEP methodology supported me to trace the themes across all the data sources, and it is this process that supported the articulation of my authorizers. Writing about the authorizers

enabled the recursive part of the analysis and enhances the trustworthiness of the assertions.

### Trustworthiness in Thematic Analysis

Issues of trustworthiness may arise with thematic analysis, yet, Guest, MacQueen, and Namey (2012) felt that the method is “still the most useful in capturing the complexities of meaning with a textual data set” (p. 11). To establish the trustworthiness of the analysis, this study embraced the 1) three concepts proposed by Lynch, Pelletier, and Fish’s (cited in Hubbard & Power, 1993) to support processes of data analysis, 2) recorded decisions in a codebook, 3) was embedded in reflexivity, and 4) used multiple data sources.

The first adherence to trustworthiness in the analysis of the self-study data is that it incorporates Lynch, Pelletier, and Fish’s (cited in Hubbard & Power, 1993) concepts of “patience, a willingness to make mistakes, and playfulness [to] lead to a deep “seeing” of the underlying patterns beneath surface appearances” (p. 66). The second adherence to trustworthiness in the analysis of the self-study data is established through using a robust codebook. The codebook detailed the descriptors, exemplars, and the inclusion and exclusion criteria. The codebook serves as an audit trail throughout my many passes of the data and it is a place for me to document the decisions that I made to convince the reader about the quality of the analysis.

The third adherence of trustworthiness in the analysis of the self-study data is the deep and immersive engagement with the data through reflexive and recursive processes. Because “the data do not speak for themselves” (Chenail, 2012, p. 251), recursive processes are critical in that the “qualitatively distinct code must draw upon and include the distinct qualities of that which is being coded in order to create a meaningful code” (Chenail 2012, p. 251). During the analysis, I simultaneously used memos and reflection to enhance the rigour of the analytical tradition. Memo writing attends “to issues of trustworthiness in self-study research by providing a tangible record of systematic meaning making” (Cutri & Whiting, 2018, p. 131). The adoption of a reflexive position is crucial in my analytical process, as it is the turning back that propelled me forward in a self-critical manner (Feldman, 2003). I was reflexive in my analysis, and this involved the “constant scrutiny of the relationship between the researched and the researcher” (Blair, 2015, p.15) via “immediate, continuing, dynamic

and subjective self-awareness” (Finlay, 2003, p. 108). Further, I reflected continually and “reflection serves as a mechanism for turning experiences into knowledge about teaching” (McAlpine & Weston, 2000, p. 364). It is the co-occurrence of reflexivity and multiple reflective experiences that enable people to distinguish patterns that lead to knowledge (McAlpine & Weston, 2000). The importance of reflexivity cannot be overstated in its value for pulling together the codes into themes and confirming that what I noticed was actually in the data, namely: there is evidence to support the themes.

The fourth position of trustworthiness in the analysis refers to Blair’s (2005) strong argument against the need for inter-coder reliability in the coding and thematic analytical process. Blair (2005) stated that:

[t]here is very little guidance on how researchers can work together to form inter-coding groups (Campbell, Quincy, Osserman & Pederson, 2013) and there is no clear evidence that the inter-coding of qualitative data is ever truly dependable (Zhao, Liu & Deng, 2013). Therefore, upon reflection, I was not convinced that having a second (or third) researcher co-code the transcripts would improve the validity of the codes developed. In the end, I felt that my coding methods were validated by my constant attempts to establish causal inference that would best capture the data’s “imageric meaning” (Glaser, 2002) and by Kvale’s (1994, pp. 166-167) suggestion that, “validity pertains to whether a method investigates what it purports to investigate”—in this regard I can claim my methods to be valid as I have set out clearly what I have done and, throughout, I have focused my methods on assessing whether either coding system has the ability to produce analyses that are in keeping with my reflexive perspective (p. 22).

In conclusion, Leininger (1985) stated that the “coherence of ideas rests with the analyst who has rigorously studied how different ideas or components fit together in a meaningful way when linked together” (p. 60). By establishing trustworthiness in the analytical process, the “presence of the qualities of the unit of analysis in the product of the qualitative analysis [is] evidence of the quality of the analysis itself” (Chenail, 2012, p. 248).

### **Part 3: Professional Knowledge**

Part 3 of the analytical framework reviews the authorizers and my teacher educator practices and actions to articulate my professional knowledge of technology teacher education and answer the third research question. In this part of the analytical framework I unpack the authorizers via S-STTEP methodology and examine the space between practice and actions to understand the epistemic development of professional

knowledge and to reframe my practice. The epistemic warrant that allowed me to attend to the self-study data and reveal tacit knowledge and draw assertions about my professional knowledge is my theories of action taken from the work of Argyris and Schön (1974). The first is *theories-in-use*: those we champion and are inherent in our performance; are implicit; and, can be thought of as values or world views, and are the beliefs about the things that govern our behavior. The second is *espoused theories*: those that are used to describe actions and are our values, world views, or mental maps, that are explicit and can be articulated to guide behaviors and are used to take action.

The examination of practices and actions draws on methods of reflective practice such as reflection-in-action; reframing through turning points (Bullock & Ritter, 2011); and, reflexivity, constant scrutiny, and self-critique. Another important method is interactivity “in the understanding that engaging with others will help us more accurately develop and uncover the practice in which we participate (Pinnegar & Hamilton, 2009, p. 154). Interactivity includes interactions with teacher candidates and engaging with the literature and scholarship of the field; and, dialogue in the “process of coming-to-know” (Pinnegar & Hamilton, 2009, p. 154).

Accessing an authority of practice is more than just knowing what you are doing, it is a process of understanding the things in the repertoire of what you are doing that facilitate the examination of the space between the self-in-practice and practice-and-action to test how one lives their authorizers via S-STTEP methodology. Self-study methodology allowed me to access my authority of practice because S-STTEP flattened the associations and interactions of the authorizers and facilitated the examination of my professional knowledge. Throughout the analytical process, I accessed the authority of practice to understand changes to my ontological position in the reframing of who I am in the moment as informed by my past and present relations to critical others. S-STTEP methodology makes “certain that voices from the self and the other are both present in the data and that we have identified ways in which we will engage others to provide alternative interpretations and multiple perspectives” (Pinnegar & Hamilton, 2009, p. 155). This is a critical phase in the analytical framework for examining bias and the consideration that

[h]ere researchers must interrogate with alacrity the bias they bring- looking under and around the lives they think they lead for disconfirming evidence...living contradictions, notions of marginalization, and false consciousness can be made explicit and researchers should demonstrate that such attempts have been undertaken (Pinnegar & Hamilton 2009, p. 152).

This analytical process supports me to attend in an authentic way to my practice and action of technology teacher education and capture accounts of ways that my actions transform practice (Pinnegar & Hamilton, 2009). It is this methodology that supports the improvement of my practice. In summary, the examination of knowing-in-action enables my understanding of my teacher educator professional knowledge and its epistemic development. As my authorizers will change, herein lies the ontological commitment and acknowledgement of “what is” as a result of my authority of practice. By using exemplars that detail the reasons that my professional knowledge is constructed in a particular way, I go beyond the story or narrative to labels the assertions I draw (Loughran, 2010) and this reveals my tacit professional knowledge. As Pinnegar and Hamilton (2009) suggested, this opens the research against the bonds of modernity (Bhadha, 1994) and serves to capture diverse perspectives that live in the local and situated context of the work of teacher education.

#### **Part 4: Epistemology of Practice**

As one works through the analytical framework, they move from ontology to epistemology. An epistemology of practice is professional knowledge about practice and who you are in practice. In Part 4, I distill the analysis from Parts 1 to 3 of the analytical framework into an epistemology of practice to answer the questions:

- How did a self-study of authorizers help me to understand the nature of my professional knowledge differently as a result of engaging in this process?
- What are my assertions for understanding and action as a technology teacher educator?
- What assertions do I have about professional knowledge and how it develops?

S-STTEP condenses all the meaning drawn from the authority of practice to articulate an epistemology of practice and this has utility in the mobilization of teacher educator professional knowledge.

### **3.2.8. Trustworthiness, Credibility, and Quality in S-STTEP Methodology**

Adherence to trustworthiness and quality in self-study methodology enhances the utility of assertions drawn from the research. “The process of establishing the trustworthiness of any study comes down to the quality of the relationships built between the researcher and the community of readers and critics who examine the study (Atkinson, Heath, & Chenail, 1991). It is through a transparent articulation of the research choices made along the way that I build trust in my work and enhance the validity for the reader. The key issues related to trustworthiness in self-study methodology that this research adheres to are: philosophical orientation and context, interactivity, and sharing stories through exemplars (Pinnegar & Hamilton, 2009), and these are detailed below.

#### **Philosophical Orientation and Context**

A first keystone for upholding trustworthiness is that the study be philosophically oriented in ontology. The ontological obligation in self-study methodology is the moral authority (Pinnegar & Hoban, 2005) of the tradition for the improvement of practice and to enhance the “lives of children and young people” (Pinnegar & Hamilton, 2009, p.55). This ontological stance adheres researchers to the purposes of self-study methodology as a way to improve current practices, rather than deliver knowledge outcomes as the final product. To uphold this keystone for trustworthiness, self-study methodologists include detailed descriptions of “contextual frames that inform and shape our experiences” (Pinnegar & Hamilton, 2009, p. 9). Further, as Loughran (2004) reminded us, in order to challenge the individual paradox, researchers need to be clear about the context they are studying. This includes both the practice context that the research is situated, as well as where the study is positioned within the scholarly context (Pinnegar & Hamilton, 2009). This warrants that the researcher’s declarations come from their authority of experience (Munby & Russell, 1994). This bedrock “lies at the heart of the action and performance that constitute knowing about practice” (Pinnegar & Hamilton, 2009, p. 153) and avoids the epistemological traps of the politics of knowledge.

Quality of the research is also framed by the scholarship that came before it. Therefore, what the researcher selects for inclusion in the study’s theoretical framework, how the researcher interprets overlaps and gaps in this literature, and finally how the

researcher weaves the theoretical framework throughout the study is crucial for trustworthiness. Bullock and Madigan Percy (2018) noted that S-STTEP methodology faces critiques due to the “degree to which self-study work engages with the wider fields of educational research” (p. 19). By positioning the work in adequate scholarly contextual details and crossing boundaries between and across qualitative methodologies (Bullock & Madigan Percy, 2018), researchers are positively supporting their S-STTEP research community to not isolate their inquiries (Zeichner, 2007). Further, by making “explicit links between what was learned by conducting the self-study that is of value to others” (Bullock & Madigan Percy, 2018), teacher educators can use the assertions for action to understand their own practices.

### **Interactivity**

Another keystone for trustworthiness in self-study methodology draws on the pillar of critical others and the process of dialogue in the methods and analysis. By “engaging in dialogue across every aspect of our studies, [it] will lead to the development of rigorous understanding and trustworthy representations” (Pinnegar & Hamilton, 2009, p. 154). The method of critical others draws attention to places in the study where misinterpretation of claims or bias may surface so that they can be checked and searched (Bullough & Pinnegar, 2001). Loughran (2004) suggested that by evoking a data and interpretation check for professional scrutiny and challenge, it will make the context clearer and reduce the limits inherent in the recognition of living contractions. The dialogue process uncovers alternative ways of knowing and enhances the quality of the study as it serves as a touch-base or check-in to triangulate the evidence and interpretations.

### **Stories and Exemplars**

Self-study methodology relies heavily on verbal data and the stories in the research should be represented as exemplars or vignettes to enhance the trustworthiness of the study. Mishler (1990) suggested that the “visibility of the work” (p.429) is made available through explicit examples-of and discussion-about the data as critical to the creation of the exemplars. The use of exemplars assures one is grounded in ontology due to the meaningful units that recount experience and re-construct the experience of the research (Pinnegar & Hamilton, 2009). LaBoskey (2004) asserted that

the use of exemplars will “advance our understanding and practice of teacher education” (p. 853).

Stories in self-studies are commonplace and are more than narratives, namely: they serve as dialogues to organize and communicate assertions for understanding and maintain the present moment. Craig (2009) discussed at length the trustworthiness that the use of exemplars and narratives bring to self-study research. Craig (2009) drew on the work on Schön (1983) to suggest that thinking with exemplars and presenting these as assertions in self-study research is more powerful than the rhetoric of conclusions (Schwab, 1969). “Concrete examples of actual practices fully elaborated so that members of a relevant research community can judge for themselves” (p. 20) is the case that Lyons and LaBoskey (2002) made for the use of exemplars for research in teaching and teacher education. The quality of these representations requires careful consideration to uphold the aesthetic value and maintain the materiality of research that illustrate and bring life to the interpretations. Chenail (2012) suggested that researchers share abundantly the wealth of the data to invite others to continue the inquiry and conversation.

In the content of the exemplars, Loughran (2004) reminded self-study methodologists that success is largely glossed over and that researchers need to be comfortable with the sense of vulnerability. Self-studies are not egocentric and should expose perceived failures and areas of challenges in one’s teaching and teacher education practices. Attention to areas of vulnerability in self-study are re-focused on the management of the dilemma rather than a search for the correct response. While the use of story is a meaningful unit to recount experiences and make order of our and others behaviours, Bullock and Madigan Peercy (2018) remind us that “self-study researchers need to move beyond individual stories in which they have made a reflexive turn and toward an explanation of how such a turn changes their practice and contributes to research more broadly” (p. 21).

These guidelines for trustworthiness and quality presented above are adhered to in this research. This study embraces Bullough and Pinnegar’s (2001) call to “provoke, challenge, and illuminate rather than confirm and settle” (p. 20). Further, this study situates the research in the broader field where it will be subject to public scrutiny. This attention to trustworthiness and quality need to go beyond the story (Loughran, 2010) of

the self, particularly “if the outcomes are to genuinely affect understandings of practice beyond the individual self” (Loughran, 2007, p.12) and move the research conversations forward in the field.

### **3.2.9. Ethical Considerations**

Mitchell’s (2004) discussion of ethics in self-study research provided a wealth of important ethical considerations for my work despite the difference in my context of higher education and Mitchell’s context of primary and secondary education. The ethical considerations that are important to this study include the balance between my role as an educator and researcher and the management of harm. I draw on Mitchell’s (2004) ethical considerations of self-study methodology as warrants for this study.

The first ethical issue is balancing my role as a teacher of teachers and as a teacher-researcher. Ethical boards often voice concerns about teacher research regarding the

conflict between the role of teaching and the role of researching...the danger of teaching, learning and hence students’ best interests being compromised because of the teacher’s extra research role” (Mitchell, 2004, p. 1400).

Mitchell (2004) suggests that teacher-researchers are typically in a space of experimenting that is much different than a pure researcher or outsider focus. “The practice of teacher research is inextricably intertwined with the act of teaching” (Mitchell, 2004, p. 1404). To balance the possible tensions between my “teaching role and the researcher role” (Mitchell, 2004, p. 1397), I did not spend lengthy amounts of time in class reflecting-in the present moment and there was no “lessening of the teacher’s attention to teaching” (Mitchell, 2004, p. 1402). Rather, I made short memos in my teacher educator journal that were used as triggers to evoke my thinking during the long periods of reflective writing that I engaged with outside of the classroom.

Also, in this study, all course activities were within the zone of accepted practices (Zeni, 2001) and ceded to my ethical and moral authority (Pinnegar & Hoban, 2005) as a teacher educator. While I do not have a professional development designation as a K-12 teacher, I have care and commitment, competence, respect, and integrity for my work as a teacher and for my learners. Within the profession of teaching, and in my course, I

taught that “new interventions are a constant feature” (Mitchell, 2004, p. 1407) as “teachers are typically interested in improving their classrooms” (Mitchell, 2004, p. 1407). “Teachers who are trying something new are continually monitoring the outcomes and adjusting what they do against a desire to maximise learning (Mitchell, 2004, p. 1411). My teaching role is “pre-eminent over the research role” (Mitchell, 2004, p. 1402) and my primary obligation is to the teacher candidates.

The second issue is the management of harm to my participants. Self-study methodology does not require the same type of protocol that bio-medical research ethics boards rely on to determine harm. Self-study presents minimal risk by way of the intervention that occurs, rather the perceived risk comes from issues of consent and the potential for the participant to be identified (Mitchell, 2004). Mitchell’s (2004) guidance related to issues of consent are critical to this study. I used due care and attention to obtain informed consent from the adult-aged teacher candidates in my course (Mitchell, 2004). At the beginning of the course, I informed teacher candidates that I will be conducting a self-study of my practice as a teacher educator. I was clear with teacher candidates that I will not be studying them throughout the research, yet, they understood that their voice as participants in the learning environment was important to the understanding of my teacher practice.

The teacher candidates were informed that their participation in my research will only be requested after the conclusion of the course once their grades were submitted and accepted by the Faculty of Education. The teacher candidates were aware that the study was minimal risk, that there was no potential harm to them if they voluntarily chose to participate or drop out of the study, even after they had agreed to participate. There was no “coercion, unethical or unprofessional behavior” (Mitchell, 2004, p. 1395) in getting teacher candidates to participate in the study. The consent asked participants for agreement to include content from their course assignments as “evidence of understanding” (Mitchell, 2004, p. 1406). By using activities that are a regular part of the course, there was “minimal disturbance to the environment being studied” (Mitchell, 2004, p. 1422). Additionally, the data collected was only being used for the purposes as outlined to participants (Mitchell, 2004). There was no “exploitation of the students by teachers to gain benefits from the research that are of no benefit to the students” (Mitchell, 2004, p. 1422). Mitchell (2004) stated that if

one accepts that there is commonly a convergence of purpose in the teaching and research roles, then using data that has been collected (solely) for a teaching purpose for a research agenda that is aimed at assisting this teaching purpose, involves a low level of ethical conflict (p.1423).

Finally, participants were assured that they would not be identifiable (Mitchell, 2004) in the final report of the study. The final report presents the evidence in an aggregate manner (Mitchell, 2004) to mitigate the risk of exposing participants' details and raising ethical issues in educational research.

## **Chapter 4.**

### **Theory of Knowledge in Technological Environments**

This chapter presents the analysis and interpretations of data pertaining to the first and second research questions and uses Q-methodology to understand the teacher candidates' and my theories of knowledge in technological environments. The chapter opens with an overview of the theoretical models that are drawn on to support the interpretations of teacher candidates' theories of knowledge. The chapter then moves to describe the teacher candidates' responses to the Q-set in the Q-sort about their theories of knowledge. The Q-set was generated from the literature review in Chapter 2 about the conceptions of knowledge in technological environments. This is followed by my interpretations of factors present in the teacher candidates' theories of knowledge and my perceptions of how their theories of knowledge drive the ways in which they construct knowledge in technological environments. The chapter concludes with a discussion about my perceptions of areas of coherence between my views and those of teacher candidates with regard to the nature of knowledge in technological environments.

#### **4.1. Epistemologies**

Teacher candidates have complex and diverse backgrounds and differing apprenticeships of observation (Lortie, 1975) due to the time they have spent as students in classrooms prior to beginning a teacher education program. Teacher candidates' also have beliefs about teaching and learning, which are

robust, idiosyncratic, sensitive to the particular experiences of the holder, incomplete, familiar, and sufficiently pragmatic to have gotten the teacher or student to where they are today (Clark, 1988, p. 7).

The varied experiences and beliefs of teacher candidates bring forth unique perspectives about knowledge and consequently, their approaches to teaching.

As Kane, Sandretto and Heath (2000) noted, there is limited research that investigates teacher's beliefs and their actions in the practice of teaching. Because

epistemology impacts pedagogy, and epistemology bears influence on the way information is received, there is a need for a scholarly focus on the diverse methods that teachers and students use in the acquisition and transfer of knowledge (Perusek, 2008). “In this sense, in order to design teacher preparation programs that can help preservice teachers to develop adequate understandings about teaching and their role in the classroom, teacher educators need to be aware of preservice teachers’ prior belief systems, which can jeopardize their learning experiences during the program and, hence, their future teaching practices (Yadav, Herron, & Samarapungavan, 2011, p. 26). Further, “as teacher[s] learn more about student’s epistemological perspectives, it is imperative that teachers develop curriculum that will bridge any gaps in knowledge” (Perusek, 2008, p. 3). For these reasons, this part of the study does not intend to investigate teacher candidates’ view of themselves as learners. As such this study does not conflate learning and knowledge; a typical flaw of some psychological studies of personal epistemology is that they combine ideas about learning and views about knowledge to “infer that expressed beliefs about how to best learn reflect epistemological beliefs, as opposed to other beliefs or motives” (Sandoval, 2005, p. 636). In my aim to design educational technologies within post-secondary environments, Q-methodology provided a catalyst to understand my perceptions of clusters of thinking in the teacher candidates’ views about knowledge in technological environments. The clusters of thinking are my perceptions of teacher candidates’ views about theories of knowledge in technological environments and it is the groupings that are informative to understanding my practice and its improvement.

The study of personal epistemology commonly stems from two main positions as described by Yadav, Herron and Samarapungavan (2011). The first line of research in personal epistemology is psychological stage-based development and the second is the study of beliefs about the nature of knowledge and knowing. Samarapungavan, Westby, and Bodner (2006) described four conceptual models of epistemology in detail, namely: epistemological development (Perry, 1970; Kuhn, 1991; King & Kitchener, 1994; epistemological beliefs (Hofer 2000; Schommer, 1990); epistemological theories (Bendixen & Rule, 2007; Schraw & Olafson, 2008); and epistemological resources (Hammer & Elby, 2002). The aim of this section is not to detail each model but to note that the models are associated with different lines of thinking and each model has a place and relevance based on the purpose of the research question. “Personal

epistemological theories, as described throughout the existing literature, are made up of somewhat discrete, but perhaps interrelated dimensions” (Hofer, 2000, p. 380).

For the purposes of the analysis in this dissertation, the epistemological belief models of Schommer (1990) and Hofer (2000) were informative in the interpretations of teacher candidates’ epistemologies. The research on epistemological beliefs by Schommer (1990) and Hofer (2000) recognized “two central components of personal epistemological theories, the nature of knowledge (what one believes knowledge is) and the process of knowing (how one comes to know)” (Hofer, 2000, p. 386), which resonates with the research questions. “Under nature of knowledge, there are the dimensions of *certainty of knowledge* and *simplicity of knowledge*, and within the area of nature of knowing, two other dimensions exist, the *source of knowledge* and *justification of knowledge*” (Hofer, 2000, p. 380). “It is hypothesized that these four dimensions should be considered the core of an individual’s epistemological theory, while the other beliefs about learning, teaching, and intelligence may be related to the core dimensions, but are peripheral to an individual’s conception of epistemology” (Hofer, 2000, p. 381). It is the epistemological beliefs that provide me with a window into understanding: 1) how teacher candidates may make meaning in technological learning environments, 2) their ideas about knowledge and knowing, and 3) how my practice may influence teacher candidates’ exposure to ways of knowing with educational technologies. This research does not aim to draw relationships between epistemologies and teacher candidate learning.

## **4.2. Correlation Matrix**

As described in Chapter 3, section 3.2.4, the P-set’s Q-sorts are processed in PQ Method. PQ Method is a statistical software tool that uses factor analysis to determine variability and correlated variability to reduce the data and impose groupings on the data (Brown, 1980), namely: identify factors, which are the world views or perspectives of the participants in the study. Table 2 shows the correlation matrix for teacher candidates’ theory of knowledge, which was used to extract factors from the sorts. A factor is the closeness of the Q-sorts and provides information about the clustering of the world views.

**Table 2. Correlation Matrix Between Sorts**

Sorts	1	2	3	4	5	6	7	8	9	10	11	12	13
1	100	49	59	58	76	63	56	52	48	75	57	49	50
2	49	100	66	58	43	18	63	71	24	61	66	65	35
3	59	66	100	51	44	47	73	60	45	61	55	81	56
4	58	58	51	100	46	37	73	47	19	47	52	61	49
5	76	43	44	46	100	26	52	47	22	54	56	34	49
6	63	18	47	37	26	100	43	26	57	54	33	46	29
7	56	63	73	73	52	43	100	57	33	63	62	65	51
8	52	71	60	47	47	26	57	100	27	73	77	69	45
9	48	24	45	19	22	57	33	27	100	55	30	37	25
10	75	61	61	47	54	54	63	73	55	100	74	60	44
11	57	66	55	52	56	33	62	77	30	74	100	57	59
12	49	65	81	61	34	46	65	69	37	60	57	100	63
13	50	35	56	49	49	19	51	45	25	44	59	63	100

The initial centroid extraction in PQ method resulted in participants loading significantly onto only one world view. The X beside the loadings as shown in Table 3 below indicate statistical significance in PQ Method.

**Table 3. 1<sup>st</sup> Factor Matrix with an X Indicating a Defining Sort**

Q-Sort	Loadings		
	1	2	3
1	0.84 X	-0.46	-0.20
2	0.72 X	0.31	0.04
3	0.82 X	0.13	0.18
4	0.69 X	0.18	-0.23
5	0.65 X	-0.15	-0.48
6	0.55 X	-0.38	0.17
7	0.81 X	0.16	-0.05
8	0.76 X	0.20	0.06
9	0.51	-0.43	0.39
10	0.85 X	-0.17	0.13
11	0.70 X	0.11	-0.02
12	0.82 X	0.33	0.26
13	0.63 X	0.17	-0.24

Because the initial centroid extraction resulted in only one world view, the factors were rotated in PQ Method to identify other possible world views. Rotations are important for the purposes of interpreting the extracted factors and do not change the positions of the Q-sorts relative to each other or their position to the factor. This rotation of the factors revealed three statistically significant world views. Table 4 shows the three

statistically significant factors (statements that clustered together). This means that three discrete world views exist in teacher candidates' epistemologies that I could interpret.

**Table 4. 2<sup>nd</sup> Factor Matrix with an X Indicating a Defining Sort**

Q-Sort	Loadings		
	1	2	3
1	0.8017X	0.1982	0.5204
2	0.2168	0.7089X	0.2668
3	0.2516	0.6327X	0.5013
4	0.4492	0.5900X	0.1229
5	0.7560X	0.3185	0.0791
6	0.3544	0.0691	0.5881X
7	0.3888	0.6526X	0.3181
8	0.2642	0.6488X	0.3552
9	0.1968	0.0143	0.7437X
10	0.4399	0.4299	0.6174X
11	0.3836	0.5958X	0.3558
12	0.1002	0.7828X	0.4715
13	0.4257	0.5409X	0.0888

### 4.3. Research Question 2: The Factors and Interpretations

This section presents the results of each factor from the PQ Method output including the:

1. Distinguishing Statements – the statistically significant statements that give insight into the view. ( $P < .05$  ; Asterisk (\*) Indicates Significance at  $P < .01$ ). Both the Factor Q-Sort Value (Q-SV) and the Z-Score (Z-SCR) are shown.
2. Factor scores for each factor – identified by the z-scores as strongly agree or strongly disagree with the statement.

This section presents my interpretation of the three world views and summarizes the teacher candidates' perceptions about the Q-set presented to them in the Q-sort. The interpretations represent my understandings of how teacher candidates think about theories of knowledge and what this potentially means for how they construct knowledge in technological environments. My interpretations were presented as an activity for discussion with teacher candidates in Week 3 of the course. As a class, we unpacked the findings of the Q-sort in a collaborative activity and discussed the nuanced ways that epistemological theories manifested in our class and the teacher candidates validated

my interpretations of their Q-sorts. The interpretations are not claims about teacher candidates' epistemologies, rather, they describe my view about tendencies I see in teacher candidates' thinking and how these may cluster around a view of knowledge in technological environments, which is informative to my practice as a technology teacher educator.

### 4.3.1. Factor 1

**Table 5. Factor 1: Distinguishing Statements**

No.	Statement	Q-SV	Z-SCR
29	I can teach myself almost anything as long I have access to the right resources.	4	1.64
28	Experts can sometimes change their theories.	3	0.99
10	I can shape the purposes of the technology I use irrespective of how it was designed.	2	0.93*
23	I feel that truth and knowledge are personal and private, subjectively known or intuited.	1	0.71*
32	I believe that the nature of knowledge is an individual pursuit.	-2	-1.35*

**Table 6. Factor 1: Strongly Agree**

No.	Statement	Z-SCORES
18	I believe it is possible for experts to hold opposing opinions and that there can be multiple perspectives on an issue.	1.641
29	I can teach myself almost anything as long I have access to the right resources.	1.641
30	Teachers sometimes state incorrect facts.	1.209
28	Experts can sometimes change their theories.	0.993
15	I develop my knowledge when I create something, for example through the process of design and problem solving.	0.962
10	I can shape the purposes of the technology I use irrespective of how it was designed.	0.931
13	Knowing about historical and philosophical developments in technology enhances my knowledge about technology.	0.931

**Table 7. Factor 1: Strongly Disagree**

No.	Statement	Z-SCORES
9	Technology cannot be altered and should be used the way it is designed.	-2.065
19	I accept knowledge from authorities (e.g., teachers or supervisor) without question.	-1.848
26	Several scientists analyzing the same data will reach the same conclusions.	-1.601
22	I feel that I can receive and reproduce ideas but that I am not able to create new knowledge.	-1.385
14	My knowledge is bound to the context where it was developed, and I do not feel that it is useful elsewhere.	-1.385
32	I believe that the nature of knowledge is an individual pursuit.	-1.354
27	The information I find on the internet is trustworthy.	-1.324
5	Knowledge can be gained from doing something in context only if you know a lot about what you are doing first.	-1.138
6	I reflect about my knowledge while I am practicing and/or doing something.	-0.922

***Interpretation: Epistemological World View 1: Practical Knowledge***

Based on the teacher candidates' ranking of the Q-set, the teacher candidates in Epistemological World View 1 appear to share the belief that information should be evaluated, and that experiences are a source of knowledge. This world view recognizes that teachers sometimes state incorrect facts, that experts can change their theories, and that it is possible for experts to hold opposing opinions, which suggests to me that teacher candidates are evaluating knowledge. The teacher candidates holding this world view seem to recognize the difference between opinion and fact, do not believe in one truth or objective knowledge, nor feel that information on the internet is trustworthy. Further, the way they ranked the Q-set seemed to indicate that they do not rely on or accept information passively from positions of authority (teachers or experts) or believe in absolutes without questioning the information (Schommer, 1990). The ranking of the statements suggests that the teacher candidates may believe that there can be multiple perspectives on an issue and that truth is relative. Their theory of knowledge seems to resonate with concepts around the uncertainty of knowledge (Hofer, 2000) and that time is required to formulate a viewpoint.

The ranking in this world view suggests to me that these teacher candidates may be self-creators of knowledge and producers of knowledge (Hofer, 2004). It may be likely that teacher candidates with this world view believe in knowledge as contextually situated yet constructed in a manner that is useful in other contexts. This may suggest a belief that knowledge is not bound to the context that it was gained, and this is indicative

of an awareness for the transfer of knowledge. Teacher candidates that hold this world view may believe they can teach themselves things in technological environments as the Q-sorts indicate a strong disagreement with the sentiment that they are merely recipients and reproducers of ideas. There is evidence of the teacher candidates' agreement with the statement that truth and knowledge are personal and private, subjectively known or intuited (Schommer, 1990),

The way teacher candidates ranked the Q-set suggests to me that the epistemic sources of knowledge for teacher candidates holding this world view include experiences. It is likely that these teacher candidates resonate with the view that knowledge is constructed out of experience and is a "justification for the basis of knowing" (Hofer, 2000, p. 378). The statements suggest to me that teacher candidates may feel they can develop their knowledge when they create something, or engage with design and problem solving, as they indicated that propositional knowledge is not the primary source of their knowledge. It may be likely that the process of knowledge creation is viewed as dynamic, relative, and collaborative, as the teacher candidates generally disagreed that the nature of knowledge is an individual pursuit. This may also suggest a constructivist lens to how these teacher candidates construct knowledge in technological environments. They feel that they can teach themselves almost anything as long as they have access to the right resources. But, teacher candidates in this world view did not indicate that reflective practice or reflection-in-action was a part of how they theorize about knowledge.

It is likely that teacher candidates feel that technology is not a means to an end and that social construction of outcomes is possible. They indicate a belief that technology is multi-purpose, that they can shape the purposes of the technology irrespective of how it was designed, and that it can be altered. As such, it does not appear that teacher candidates' beliefs resonate with ideas of technological determinism. Proponents of this world view indicated that they look to historical and philosophical approaches in their explorations with technology as it enhances their knowledge about technology. Based on the clusters of statements in this world view, the way that teacher candidates may construct knowledge in technological environments embraces the social shaping of technology (Bijker, Hughes, & Pinch, 2012). This means that teacher candidates likely recognize the relationship between technology and society (Bijker, Hughes, & Pinch, 2012).

### 4.3.2. Factor 2

**Table 8. Factor 2: Distinguishing Statements**

No.	Statement	Q-SV	Z-SCR
1	Knowledge is gained through experiences, for example doing or making something.	4	1.79*
31	I believe that new knowledge can be developed by working in collaboration with others.	4	1.50
7	I reflect on my knowledge and think about how I can use it in another context.	3	1.41*
6	I reflect about my knowledge while I am practicing and/or doing something.	3	1.18*
29	I can teach myself almost anything as long I have access to the right resources.	1	0.74
28	Experts can sometimes change their theories.	0	-0.06*
13	Knowing about historical and philosophical developments in technology enhances my knowledge about technology.	-1	-0.62*

**Table 9. Factor 2: Strong Agree**

No.	Statement	Z-SCORES
1	Knowledge is gained through experiences, for example doing or making something.	1.786
31	I believe that new knowledge can be developed by working in collaboration with others.	1.497
7	I reflect on my knowledge and think about how I can use it in another context.	1.410
2	I use my experiences to develop my knowledge.	1.296
6	I reflect about my knowledge while I am practicing and/or doing something.	1.183
18	I believe it is possible for experts to hold opposing opinions and that there can be multiple perspectives on an issue.	1.139
15	I develop my knowledge when I create something, for example through the process of design and problem solving.	1.024

**Table 10. Factor 2: Strong Disagree**

No.	Statement	Z-SCORES
9	Technology cannot be altered and should be used the way it is designed.	-1.840
14	My knowledge is bound to the context where it was developed, and I do not feel that it is useful elsewhere.	-1.801
19	I accept knowledge from authorities (e.g., teachers or supervisor) without question.	-1.452
5	Knowledge can be gained from doing something in context only if you know a lot about what you are doing first.	-1.390
22	I feel that I can receive and reproduce ideas but that I am not able to create new knowledge.	-1.332
26	Several scientists analyzing the same data will reach the same conclusions.	-1.300
23	I feel that truth and knowledge are personal and private, subjectively known or intuited.	-1.272

### ***Interpretation: Epistemological World View 2: Reflection and Experience***

Based on the teacher candidates' ranking of the Q-set, the teacher candidates in Epistemological World View 2 share the belief that reflection and experience support the construction of knowledge. The manner in which teacher candidates ranked the Q-set indicates to me a belief in experiential and reflective knowledge. The teacher candidates view knowledge as gained through the experience of doing or making something, which may indicate a belief that knowledge can be produced and created versus reproduced or reiterated. Teacher candidates disagreed with the statement that knowledge can be gained from doing something in context only if you know a lot about what you are doing first. Based on the way they ranked the Q-set, a hefty part of teacher candidates' theory of knowledge in this world view is based in reflective practices, such as reflection-in-action (Schön, 1987). The teacher candidates may believe in the authority of experience (Munby & Russell, 1992) and use their experiences to develop their knowledge based on how they ranked procedural knowledge. It may be likely that teacher candidates in this world view feel that they can create knowledge from design and problem-solving processes.

The way in which teacher candidates ranked the Q-set suggests to me that this world view recognizes the difference between opinion and fact. They believe that it is possible for experts to hold opposing opinions and that there can be multiple perspectives on an issue. It does not seem likely that teacher candidates in this world view believe in the authority of position or objectivity as they disagree with the statement that "several scientists analyzing the same data will reach the same conclusions." It is likely that teacher candidates in this world view have a tendency towards self-direction, self-teaching, and independent knowing wherein one is required to formulate their own viewpoints (Schommer, 1990).

The way that teacher candidates ranked the statements suggests to me that they may have a world view that believes that knowledge can be developed and created by working collaboratively with others or working in groups or as teams. This resonates with concepts related to knowledge sharing and the construction of shared understandings. The way they ranked the statements also suggests to me that these teacher candidates believe in metacognition and the transfer of knowledge, in that they stated that knowledge is useful outside of the context where it was gained. This is likely

related to their belief in reflective practice, as the teacher candidates agreed that: “I reflect on my knowledge and think about how I can use it in another context” and “I reflect about my knowledge while I am practicing and/or doing something.” The statements also suggest that teacher candidates may not believe that their knowledge is bound to the context where it was developed and that is useless elsewhere.

The way the teacher candidates ranked the statements suggests that this world view is not associated with the belief that historical and philosophical developments to enhance their knowledge about technology. Yet, the teacher candidates did appear to suggest that they believe that technology can be used in ways different from those it was designed for, and it is likely that they are not proponents of technological determinism. Based on how the statements were ranked in this factor, it is likely that teacher candidates in this world view approach educational technology from a place of exploration and novelty, rather than seeking historical information about technological integrations and outcomes.

### 4.3.3. Factor 3

**Table 11. Factor 3: Distinguishing Statements**

No.	Statement	Q-SV	Z-SCR
30	Teachers sometimes state incorrect facts.	4	2.18
28	Experts can sometimes change their theories.	4	1.89
3	Before I make things or have an experience, I develop my knowledge by reading about it.	3	1.52*
4	Knowledge comes from things that I read in books or articles and/or learn from lectures.	3	1.33*
24	My knowledge can be applied objectively to procedures for obtaining and communicating things.	2	0.92*
18	I believe it is possible for experts to hold opposing opinions and that there can be multiple perspectives on an issue.	1	0.44
29	I can teach myself almost anything as long I have access to the right resources.	0	-0.06
26	Several scientists analyzing the same data will reach the same conclusions.	0	-0.09*

**Table 12. Factor 3: Strongly Agree**

No.	Statement	Z-SCORES
30	Teachers sometimes state incorrect facts.	2.181
28	Experts can sometimes change their theories.	1.890
3	Before I make things or have an experience, I develop my knowledge by reading about it.	1.518
4	Knowledge comes from things that I read in books or articles and/or learn from lectures.	1.330
2	I use my experiences to develop my knowledge.	0.973
24	My knowledge can be applied objectively to procedures for obtaining and communicating things.	0.917

**Table 13. Factor 3: Strongly Disagree**

No.	Statement	Z-SCORES
19	I accept knowledge from authorities (e.g., teachers or supervisor) without question.	-2.181
9	Technology cannot be altered and should be used the way it is designed.	-1.788
14	My knowledge is bound to the context where it was developed, and I do not feel that it is useful elsewhere.	-1.753
23	I feel that truth and knowledge are personal and private, subjectively known or intuited.	-1.192
5	Knowledge can be gained from doing something in context only if you know a lot about what you are doing first.	-1.090
6	I reflect about my knowledge while I am practicing and/or doing something.	-1.069

### ***Interpretation: Epistemological World View 3: Propositional Knowledge First***

Based on the teacher candidates' ranking of the Q-set, the teacher candidates in Epistemological World View 3 share the belief that propositional knowledge is a primary epistemic source that supports the construction of knowledge. The teacher candidates in this world view appear to have strong beliefs that before one makes things or has an experience, that they first develop their knowledge by reading about it. This knowledge comes from things that they read in books or articles and/or learn from lectures, a view which aligns with omniscient authority (Schommer, 1990). Despite a belief in propositional knowledge, teacher candidates did indicate a belief that experiences develop their knowledge and disagreed with the statement that "knowledge can be gained from doing something in context only if you know a lot about what you are doing first." It is plausible that the logic in this world view is that propositional knowledge is sought as a foundation or sought as a primary source for the development of knowledge from experiences.

It is likely that the teacher candidates with this world view also believe that their own knowledge can be applied objectively to procedures for obtaining and communicating things in a manner that demonstrates their certainty of knowledge (Schommer, 1990). Yet, they contradict themselves as the teacher candidates holding this world view do not seem to believe in objective knowledge as they disagreed with the statements that several scientists analyzing the same data will reach the same conclusions. For example, the way teacher candidates ranked the statements suggests they believe that teachers sometimes state incorrect factors and that experts can sometimes change their theories. This may indicate a tendency towards independent thought that resonates with a world view that does not accept knowledge from authorities (e.g., teachers or supervisor) without questioning it first.

Based on the statements in this factor, it is likely that teacher candidates in this world view are not technologically deterministic in their beliefs as they disagreed that “technology cannot be altered and should be used the way it is designed.” However, it is possible that they engage with propositional knowledge before they approach activities and tend to construct knowledge in technological environments in specific ways. The teacher candidates in this world view appear to be inclined towards structure, such as building on the knowledge they gain in demonstrations, through watching and listening to the instructor, reading articles, learning through instructional videos, and/or seeking reference materials prior to engaging with technology in the learning environment. Additionally, because teacher candidates aligned with this world view did not indicate a belief in reflective practice, it is likely that they will evaluate their experiences against propositional knowledge.

#### 4.3.4. Summary of the Factors

The table below shows the summary of the three factors and indicates areas of similarity and difference.

**Table 14. Summary of the Factors**

Factor 1		Factor 2		Factor 3	
Agree	Disagree	Agree	Disagree	Agree	Disagree
18- shared by Factor 1, 2	9- shared by Factor 1, 2, 3	*1	9- shared by Factor 1, 2, 3	30- shared by Factor 1, 3	19- shared by Factor 1, 2, 3
29	19- shared by Factor 1, 2, 3	31	14- shared by Factor 1, 2, 3	28- shared by Factor 1, 2, 3	9- shared by Factor 1, 2, 3
30- shared by Factor 1, 3	26- shared by Factor 1, 2, 3	*7	19- shared by Factor 1, 2, 3	*3	14- shared by Factor 1, 2, 3
28- shared by Factor 1, 2, 3	22- shared by Factor 1, 2	2- shared by Factor 2, 3	5- shared by Factor 1, 2, 3	*4	23 - shared by Factor 2, 3
15- shared by Factor 1, 2	14- shared by Factor 1, 2, 3	*6-different form Factor 1 and 3	22- shared by Factor 1, 2	2- shared by Factor 2, 3	5- shared by Factor 1, 2, 3
*10	*32	18- shared by Factor 1, 2	26- shared by Factor 1, 2, 3	*24	6- shared by Factor 1, 3
13- shared by Factor 1, 2	27	15- shared by Factor 1, 2	23- shared by Factor 2, 3		*26- shared by Factor 1, 2, 3
*23- different from Factor 2, 3	5- shared by Factor 1, 2, 3	*28- shared by Factor 1, 2, 3			
	6- shared by Factor 1, 3	*13- shared by Factor 1, 2			

**\*Statistically significant distinguishing statements**

Based on the teacher candidates' ranking of the Q-set, the teacher candidates across all the world views appear to similarly believe that:

- technology can be altered and does not need to be used the way it was designed
- knowledge from authorities (e.g., teachers or experts) should be questioned
- knowledge is not bound to the context where it was developed
- knowledge can be gained from doing something in context despite not knowing a lot about what you are doing first
- several scientists analyzing the same data will not reach the same conclusions
- experts can sometimes change their theories

Some shared beliefs occur between World Views 1 and 2 and include the acceptance that it is possible for experts to hold opposing opinions and that there can be multiple perspectives on an issue. These two world views also appeared to incorporate the belief that one can develop their knowledge when they create something, for example through the process of design and problem solving. All world views appear to share the belief that the epistemic source of experience supports the development of their knowledge.

#### 4.4. Research Question 2: Coherence in Theories of Knowledge

Tables 15 and 16 demonstrates the statements that I strongly agreed and disagreed with. Table 17 summarizes the similarities and differences between the teacher candidates' and my Q-sort.

**Table 15. Teacher Educator's Factor: Strongly Agree**

No.	Statement
1	Knowledge is gained through experiences, for example doing or making something.
2	I use my experiences to develop my knowledge.
7	I reflect on my knowledge and think about how I can use it in another context.
13	Knowing about historical and philosophical developments in technology enhances my knowledge about technology.
15	I develop my knowledge when I create something, for example through the process of design and problem solving.
30	Teachers sometimes state incorrect facts.
29	I can teach myself almost anything as long I have access to the right resources.
31	I believe that new knowledge can be developed by working in collaboration with others.
10	I can shape the purposes of the technology I use irrespective of how it was designed.

**Table 16. Teacher Educator's Factor: Strongly Disagree**

No.	Statement
14	My knowledge is bound to the context where it was developed, and I do not feel that it is useful elsewhere.
5	Knowledge can be gained from doing something in context only if you know a lot about what you are doing first.
27	The information I find on the internet is trustworthy.
22	I feel that I can receive and reproduce ideas but that I am not able to create new knowledge.
9	Technology cannot be altered and should be used the way it is designed.
3	Before I make things or have an experience, I develop my knowledge by reading about it.
26	Several scientists analyzing the same data will reach the same conclusions.
19	I accept knowledge from authorities (e.g., teachers or supervisor) without question.

**Table 17. Summary of the Differences in Teacher Candidates' and Teacher Educator's Q-Sorts**

Factor 1		Factor 2		Factor 3	
Agree	Disagree	Agree	Disagree	Agree	Disagree
18- shared by Factor 1, 2	9- shared by Factor 1, 2, 3	*1	9- shared by Factor 1, 2, 3	30- shared by Factor 1, 3	19- shared by Factor 1, 2, 3
29	19- shared by Factor 1, 2, 3	31	14- shared by Factor 1, 2, 3	28- shared by Factor 1, 2, 3	9- shared by Factor 1, 2, 3
30- shared by Factor 1, 3	26- shared by Factor 1, 2, 3	*7	19- shared by Factor 1, 2, 3	{*3}	14- shared by Factor 1, 2, 3
28- shared by Factor 1, 2, 3	22- shared by Factor 1, 2	2- shared by Factor 2, 3	5- shared by Factor 1, 2, 3	*4	23 - shared by Factor 2, 3
15- shared by Factor 1, 2	14- shared by Factor 1, 2, 3	*6-different form Factor 1 and 3	22- shared by Factor 1, 2	2- shared by Factor 2, 3	5- shared by Factor 1, 2, 3
*10	*32	18- shared by Factor 1, 2	26- shared by Factor 1, 2, 3	{*24}	{6}- shared by Factor 1, 3
13- shared by Factor 1, 2	27	15- shared by Factor 1, 2	23- shared by Factor 2, 3		*26- shared by Factor 1, 2, 3
{*23}- different from Factor 2, 3	5- shared by Factor 1, 2, 3	*28- shared by Factor 1, 2, 3			
	{6}- shared by Factor 1, 3	*13- shared by Factor 1, 2			

**\*Statistically significant distinguishing statements | {Different}**

My interpretation of World View 1 suggests to me that my theories of knowledge and how I construct knowledge in technological environments closely resonates with the teacher candidates in World View 1. I believe in the social shaping of technology and feel that I can teach myself almost anything as long as I have access to the right resources. Additionally, my interpretation of World View 1 appears to be comparable with my own view about the nature of knowledge in technological environments, in that the purpose of the technology can be shaped irrespective of how it was designed.

My interpretation of World View 2 suggests that I share similarities in thinking with these teacher candidates as I believe in reflective practice, reflect on my knowledge, and think about how I can use my knowledge in other contexts. Further, my Q-sort parallels with World View 2 in that I believe strongly in experiences and in the knowledge gained from the experience of doing or making something. This view of reflection as an epistemic source of knowledge is unique to World View 2 and different from my interpretations of teacher candidates in World Views 1 and 3; World Views 1 and 3 do not indicate a belief that reflection about knowledge while practicing and/or

doing something is pertinent to their epistemologies. Finally, in alignment with my interpretation of World Views 1 and 2, I believe that new knowledge can be developed by working in collaboration with others.

Similar to my interpretation of World Views 1 and 2, I feel that knowing about historical and philosophical developments in technology enhances my knowledge about educational technology. As well, I feel that knowledge is developed through creating something, for example through the process of design and problem solving. My interpretations of World Views 1 and 2 suggests that that both myself and the teacher candidates tend to draw on experiences when theorizing about the nature of knowledge in technological environments. Further, based on my interpretation of both World Views 1 and 2, I feel affinity with their belief that knowledge is created from exploration and experimental play with technology.

My Q-sort indicates a belief that experiences can be used to develop knowledge, a sentiment that is shared by my interpretations of teacher candidates in World Views 1 and 2. However, a point of divergence in my belief from World View 3 is in the order of knowledge development, namely: my interpretation of World View 3 suggests that teacher candidates believe that before something can be made or an experience can be had, that there is a need to first develop their propositional knowledge about it. As well, my Q-sort differs from World View 3 in that I do not believe that knowledge can be applied objectively to procedures for obtaining and communicating things. For example, my technology integration strategy cannot merely be told as a series of step by step facts to teacher candidates with the expectation that they can successfully implement it into their practice.

In summary, my epistemological world view most closely aligns with my interpretation of World View 2. Having said that, there are many shared sentiments and areas of overlap between my epistemological theories and those of World Views 1 and 3. The shared epistemologies are encouraging as I move forward in the analysis of my pedagogy of technology teacher education, as it highlights areas for me to notice in the teacher candidates' changing theories of knowledge.

## Chapter 5.

### Identification of Authorizers in the Self-Study Data

#### 5.1. Part 1: Coding

This chapter presents the authorizers of my professional knowledge as identified in Parts 1 and 2 of the analytical framework and provides exemplars as evidence to label my practices and actions (See Figure 2). Practice focuses on attending from what we know, and action focuses on attending to how we respond. Authorizers are viewed as things that one interacts with that shape, authorize, and create one's professional knowledge. Authorizers are not authoritative, rather authorizers are personal and come from: practice; experience; knowledge; framing positions; values and beliefs; assumptions; relationships with people or technology; moral debts; life history and/or personal biography; and/or, the examination of one's teaching and tasks (Griggs & Muchmore, 2014) as they reveal motivations, priorities, and pedagogies.

To remind the reader, Part 1 of the analytical framework involves the labelling of:

- a) My personal pedagogy of technology teacher education and the design of educational technology (practices + actions)
- b) Teacher candidates' voices and my perceptions of teacher candidates' changing theories of knowledge

The third research question predicates an understanding of my practice as a technology teacher educator prior to being able to examine the space between my practice and actions and articulate my assertions for understanding and action. As such, Part 1 of the framework is not a critical examination of my pedagogy as a technology teacher educator, it involves labelling my practices and actions. Part 2 of the framework then utilizes the labels from Part 1 to identify my espoused theories and theories-in-use (Argyris & Schön, 1974). Furthermore, Part 2 of the analytical framework analyzes the codes from Part 1a using thematic analysis to identify the things that shape my professional knowledge in order to capture precise accounts of my practices (Pinnegar & Hamilton, 2009). The process in Part 2 supports the identification of the authorizers of

my professional knowledge that I have accessed in an authority of practice and will support the critical analysis of my pedagogy of technology teacher education, which will be presented in Chapter 6.

Before the analysis began, I read all the raw data and memoed thoughts, big ideas and wonderings about the data as a whole as it related to my personal pedagogy of technology teacher education. The process of writing and using research memos is an important tool “to begin to think things through” (Hubbard & Power, 1993, p. 82) prior to and during the analytical process (Birks, Chapman, & Francis, 2008). Memoing supported my ability to make thematic leaps from the raw data to explain things I was noticing. Through memoing, “[d]ata exploration is enhanced, continuity of conception and contemplation is enabled, and communication is facilitated” (Birks, Chapman, & Francis, 2008, p. 68).

The self-study data were prepared as documents and imported into NVivo (QSR International's NVivo 12 software, 2018). In the first pass, I labelled the self-study data to pinpoint instances of my practices and actions in a personal pedagogy of technology teacher education. Some initial inquiries I had of the data included looking for evidence of: learning to teach; examining teaching moments that I know that I found challenging; examining the types of activities and tasks I used to understand what these revealed about my teaching about teaching; and, looking for confirming or disconfirming (Loughran, 2004) evidence for the success of different pedagogical approaches. I also looked at the data for evidence of failures, especially things that did not work out the way I had hoped for, or something that was absent, so that I could uncover the learning in that situation and analyze it in Part 3 of the framework. Approximately one week after the first pass through the self-study data looking for evidence of my practices and actions, I reviewed the raw data again and memoed further impressions.

### **5.1.1. Versions of the Codebook**

Following the a priori coding technique as outlined in Chapter 3, units in the raw data were labelled in a manner that retained adequate detail to be understood independently of the embedded context (Gall, Borg, & Gall, 1996). The units were of variable length and included phrases within a sentence, the entire sentence, multiple sentences, or paragraphs. The data were also coded to pinpoint evidence of my

practice, which are my intentions, assumptions, beliefs, values, and intended activities in my practices of technology teacher education. The data were coded for my actions as a technology teacher educator and for perceptions of teacher candidates' changing theories of knowledge. The first version of the codebook is shown in Table 18 below and lists the codes according to the nature of their relationship (not listed alphabetically).

**Table 18. Codebook Version 1.**

<b>CODE: PRACTICE / ACTION</b>	<b>DEFINITION</b>
<b>Abilities for a Technological World</b>	design and other abilities that teacher candidates should develop with educational technology such as using technology to solve problems
<b>Technological Competence</b>	getting to know and use technology; ability to change or mirror evolving cultural traditions; understand what is needed for technology; what must be known about systems
<b>Definition of Technology</b>	how technology is defined
<b>Nature of Technology</b>	encompasses the understanding that technology extends human potential; considers historical movements: knowledge, process, and artifacts
<b>Philosophy of Technology</b>	a theory (or attitude) that serves as guiding principles for behavior
<b>Design</b>	design with technology; realistic, appropriate and achievable designs; planning process: identify, manage and use appropriate resources; choosing appropriate resources; processes of making an artifact
<b>Evaluation</b>	what is needed for educational technology; how resources are processed and used; evaluate processes, products, effect of designs and technological activities
<b>Learning Design</b>	the design of pedagogy for the teaching and learning of educational technology; facilitation of learning
<b>Experiential and Maker Pedagogy</b>	make things via hands-on learning; experience things through doing something
<b>Collaborative</b>	provide opportunities for learning with and from peers
<b>Reflective Practice</b>	thinking about or reflecting-in-and-on what you do; learning from experience
<b>Relationship with Technology</b>	indicators of technology interests, decisions, and choices; technology and identity; confidence
<b>Technology and Society</b>	how technology affects people and the environment; focus on the influence, role, and effects of technology; social construction of technology

After using the first code book briefly, an additional code was immediately added to label learning theory, leading to Version 2 of the codebook. Moving from the Self-Study Data Source 1 to the Self-Study Data Source 2 (see Figure 1), I reflected on the nature of my relationship to the data. The Self-Study Data Source 1 includes my reflections about the course including the syllabus, readings, my instructor's notes,

lesson plans, reflection resources, and the class notes/ PowerPoints. The Self-Study Data Source 2 includes my reflections-in class about the class discussions, teacher candidates' questions, teacher candidates' theories of knowledge, and teacher candidates' site visit presentations. The data in Self-Study Data Source 1 revealed a great deal about my self-in-practice as signaled through the activities I created for the course, as these are embedded with my assumptions, beliefs, and values. The self-study data from Source 1 also exposes my self-in-practice with others, namely: my actions as identified through doing, enacting, carrying out the practice, and responding to teacher candidates.

Moving into the Self-Study Data Source 2, the teacher candidates' voice surfaced in my practices and actions and led to the Version 3 of the codebook. The third version of the codebook included the teacher candidates' voices to allow me to identify evidence of my self-in-practice with others, which supports the understanding of my practices and facilitated further reflection (Brooksfield, 1995). During the coding of the Self-Study Data Source 3 documents, which were my reflections-on the teacher candidates' discussions (online and in-class), my in-class notes, my reflective journal, and weekly online discussions, two additional codes were added. The two additional codes were: 1) pedagogical shift, and 2) perceptions of teacher candidates' changing theories of knowledge and this led to Version 4 of the codebook that is presented in Table 19.

**Table 19. Codebook Version 4.**

<b>CODE: PRACTICE / ACTION</b>	<b>DEFINITION</b>
<b>Abilities for a Technological World</b>	design and other abilities that teacher candidates should develop with educational technology such as using technology to solve problems
<b>Technological Competence</b>	getting to know and use technology; ability to change or mirror evolving cultural traditions; understand what is needed for technology; what must be known about systems
<b>Definition of Technology</b>	how technology is defined
<b>Nature of Technology</b>	encompasses the understanding that technology extends human potential; considers historical movements: knowledge, process, and artifacts
<b>Philosophy of Technology</b>	a theory (or attitude) that serves as guiding principles for behavior
<b>Design</b>	design with technology; realistic, appropriate and achievable designs; planning process: identify, manage and use appropriate resources; choosing appropriate resources; processes of making an artifact
<b>Evaluation</b>	what is needed for educational technology; how resources are processed and used; evaluate processes, products, effect of designs and technological activities
<b>Learning Theory</b>	understand and integrate learning theory into pedagogical decisions and the design of the learning environment
<b>Learning Design</b>	the design of pedagogy for the teaching and learning of educational technology; facilitation of learning
<b>Experiential and Maker Pedagogy</b>	make things via hands-on learning; experience things through doing something
<b>Collaborative</b>	provide opportunities for learning with and from peers
<b>Reflective Practice</b>	thinking about or reflecting-in-and-on what you do; learning from experience
<b>Pedagogical Shift</b>	my responses to teacher candidates' changing theories of knowledge; changes in my approaches to pedagogy and the design of educational technology
<b>Relationship with Technology</b>	indicators of technology interests, decisions, and choices; technology and identity; confidence
<b>Technology and Society</b>	how technology affects people and the environment; focus on the influence, role, and effects of technology; social construction of technology
<b>Teacher Candidate Voice</b>	teacher candidates' comments and explicit expressions about the course activities, reading, assignments, project, etc.
<b>Perceptions of Changing Theories</b>	teacher candidate changing perspectives on their theories of knowledge in technological environments

Throughout the coding process in NVivo, I used memoing to make connections and draw relationships observed between and across the data sources. The memoing and reflexive approaches in coding the data supported the theming of the codes in Part 2 of the analytical framework.

## 5.2. Part 2: Analysis

Part 2 of the analytical framework is the thematic analysis of my practices as identified in Part 1a to identify authorizers of a personal pedagogy of technology teacher education. NVivo supported my noticing of the volume of ideas and areas of salience in the codes as I searched for patterns that formed the themes. As a starting place, I grouped the codes according to prevalence to offer a productive line of thinking about possible themes. The frequency of a code signalled how often or seldom that practice surfaced and provided a starting place to notice things at the edges of my pedagogy of technology teacher education. The following list shows the ordered list of codes according to frequency of occurrence:

- Reflective Practice
- Experiential and Maker Pedagogy
- Learning Design; Evaluation; Teacher Candidate Voice
- Philosophy of Technology; Learning Theory; Abilities for a Technological World; Collaborative; Design
- Relationship with Technology; Nature of Technology; Technological Competence

After reading the coded data in the grouping presented above, I collapsed some codes into others. Then, I began to write about the areas using exemplars from the data to reveal my practices of technology teacher education. The process of writing and reviewing my research memos supported the processing of my reflections and observations about the data. Writing as a method afforded me the opportunity to draw on my authority of practice and engage in reflexive thinking during the identification of possible themes as authorizers. “Theorizing write-ups about codes and their relationships as they strike the analyst while coding” (Glaser, 1978, p. 43) supports connection-making in the data.

The patterns that recurred in the groups, across the groups, and across the different data sources were identified as themes to further investigate. The initial themes in the data were: technology and educational technology; learning design and design thinking; technology education, pedagogy, and teacher education; and, identity development and personal pedagogical knowledge.

After writing about the themes and collapsing them further, I felt justified in the final themes I arrived at. The justification of my authorizers is the way in which they surfaced consistently in-and-across the data sources, and in an interconnected way and inseparable manner throughout my practice as a technology teacher educator.

Five authorizers are identified below that represent my practices and actions in my pedagogy of technology teacher education:

1. **Epistemic Learning in Experience:** This authorizer describes the use of the educational technologies of maker pedagogy and experiential learning, and experience as an epistemic source of knowledge.
2. **Reflective Practice:** This authorizer describes the use of reflecting-in-and-on experiences and learning from experience.
3. **Framing Position of Technology:** This authorizer describes how I think about technology through the definition of technology and educational technology; a philosophy of technology; the nature of technology; and, technology and society.
4. **Learning Design:** This authorizer describes the design of pedagogy for the teaching-with and learning-about educational technology. The facilitation of learning is a part of the learning design authorizer and includes considerations about evaluation, the learning environment, abilities for a technological world and technological competencies, relationship with technology, and collaboration.
5. **Learning Theory:** This authorizer describes how understanding is brought to pedagogical decisions (e.g.: learning design) using scholarly literature and learning theory.

The subsequent sections in this chapter provide the evidence of framing my practices of technology teacher education in particular ways. Each authorizer is described through exemplars to capture accurate accounts of my practice (Pinnegar & Hamilton, 2009).

## **5.3. Authorizers**

### **5.3.1. Epistemic Learning in Experience**

This section presents the evidence for my practice of epistemic leaning in experience as an authorizer of my pedagogy of technology teacher education and how it is observed across the data sources and intertwined with the other authorizers. An epistemic leaning in experience is the explicit and intentional approach in my pedagogy teaching about the value of phronesis. My practice focuses on how knowledge is studied, justified, and the degree to which it is validated through having experiences and/or making something.

Evidence of this authorizer surfaces in my Q-sort about my theory of knowledge in technological environments. I indicate in my Q-sort that: 1) I feel strongly that knowledge is gained through experiences, for example doing or making something, and 2) that I use my experiences to develop my knowledge. Other evidence for the utility of phronesis and being mindful about epistemology in my teaching is evident in how I enact my teaching goals and actions with teacher candidates. Early in the course planning phase, there are signals in my practice for an epistemic leaning in experience. As the two exemplars below show, I voice clearly the role and place of experience in the development of knowledge.

I spent a great deal of time planning the course over many months, after a great number of conversations with my supervisor. From understanding the position of this course in teacher candidates' academic trajectory, attending local school and community makerspaces, engaging in literature reviews, and experience in teaching other courses. Reviewing the multitude of great information and articles, my goal was to develop a course that really supported teacher candidates in their epistemology of experience - how they think about, value, and learn to justify their beliefs from their experiences. There are two different approaches in this course, one maker pedagogy, the other, experiential pedagogy, that are the nexus to the goal of developing teacher candidates' ability to value and maximize their practical knowledge (Sator, Data Source 1 Pre-Course Thinking 2, 2017).

The meta-level or course competency, and my beliefs and assumptions are that too much of education is parsed into the content and theory and divided from the practice. If the practice is included, it is often as a concrete reinforcement of conceptual and theoretical understanding. I aim to disrupt this practice and move teacher candidates towards an epistemology that promotes learning through making things and having experiences. My belief is that education needs to blur the lines, and this does not just mean flipping the classroom. Yes, I think teacher candidates should come prepared to class by completing their readings, but if the in-class time is spent discussing the readings, the experience/ practice/ making aspect is lost. It is more than just discussing the readings, it is about getting that experience/ practice/ making, and this challenges teacher educators to be creative. It changes the authority of position, and proposition for that matter; and empowers the teacher educator as a facilitator that gives the learner the voice they need to make sense of the experience/ practice/ making (Sator, Data Source 1 Pre-Course Thinking 2, 2017).

Further to my notes in the planning of the course, there is evidence in my teacher educator journal that I reflect-in and reflect-on each class regarding epistemology and the value of practical experiences. An orientation towards an epistemology of experience is also apparent in my teacher educator weekly lesson notes, which serve to document my thinking and weekly planning of the course. Finally, an epistemic leaning in experience is visible in the manner in which I plan the weekly lessons. The structure of the lessons indicates to me that my beliefs are based in providing experiences for teacher candidates to construct knowledge and make-meaning from contexts and situations in a personal, collaborative, and authentic way.

Epistemic leaning in experience as a core value and belief in my pedagogy of technology teacher education is evident in the activities I design throughout the weekly lessons and in the course assignments. My practice is to provide opportunities, time, and space for teacher candidates to have an experience, and often the experience comes before the discussion of theory or relevant literature. Yet, I do not champion experiential learning exclusively as an epistemic source, as the exemplar below shows.

Brandenburg (2008), as I do, feels that rather than posing a dichotomy, intertwined and co-constructed epistemic bases are critical, namely: experiences and reasoning shape the nature of knowledge (Sator, Data Source 1 Teacher Notes Week 3, 2017).

My practice shows evidence that I draw connections between epistemology, phronesis, and actions through the artifacts I design for the course. For example, the lesson for Week 3 offers a tool, as shown in Figure 3, for teacher candidates to

understand how their epistemologies influence their teaching actions and the design of learning.



**Figure 3. An Image from a Course Lesson in Week 3.**

Figure 3 also demonstrates the linkages I draw to scholarly references that support thinking about epistemology and its connection to teaching goals through teaching actions. As Figure 3 shows, I draw on the authorizer referred to as learning theory, which references the integration of literature, learning theory, and/or relevant scholarship in my pedagogical decisions. This demonstrates the intertwined nature of the authorizers.

A great deal of my practice is dedicated to drawing linkages from the literature to bring forward robust, current, and scholarly ideas to teacher candidates about epistemological issues and debates, and the role they play in pedagogy. The exemplar below from my teacher educator weekly lesson notes shows that deep consideration and consultation of the literature is taken to support the lesson and activities around the topic of epistemology.

Epistemological debates can present as a dichotomous argument in that knowledge can rest on empirical (based in experience) or rational (reasoned, logical thought) knowledge. Yet, Confrey (1990) states that theory limits human knowledge and as we construct understanding through experiences, it is influenced by our cognitive lens (Sator, Data Source 1 Teacher Notes Week 3, 2017).

A final exemplar of my epistemic leaning in experience as an authorizer in my practice is presented below. The exemplar is particularly interesting as it shows the associations between the other authorizers, namely: 1) reflective practice, and 2) learning theory.

Reflection is a key component which stimulates the development of phronesis [the knowledge gained from experiential, practical approach], and hence is at the core of the learning process and the moral and ethical dimensions of teaching and learning about teaching. Knowledge as phronesis is based on a blending of theory and practice arising within the context of particular experience (Brandenburg, 2008, p. 16). (Sator, Data Source 1 Teacher Notes Week 3, 2017).

The exemplar above provides evidence that tracing associations between and across the themes and across all data sources strengthens the assertion of epistemic leaning in experience as an authorizer of my practice as a technology teacher educator.

### **5.3.2. Reflective Practice**

All the self-study data sources reference reflective practice as an authorizer in my practice of technology teacher education. In my planning of the course, my journal shows the importance I place on reflective practice for learning and making sense of learning experiences. I state that:

I realized how important reflective practice is now because I was not typically the type of student who wrote a lot. I wrote a lot of notes. But I never wrote down and actually thought about my own thinking (Sator, Data Source 1 Pre-course Thinking 1, 2017).

During the course lessons, I engage reflective practice as an authorizer and link this authorizer to an epistemic leaning in experience. For example, in the lesson for Week 4, I said “learning from experience is not obvious or intuitive. It is difficult to learn from experiences without the opportunity to critically analyze them (Sator, Data Source 1 Lesson Week 4, 2017). You need to “understand how you learn through experience, and as a result, you might be better able to design or develop courses, programs, or activities that help others learn that way as well (Sator, Data Source 1 Lesson Week 4, 2017). In this way, you can see the “intentionality in experiential learning so that you can make the most of those types of learning opportunities when they arise” (Sator, Data Source 1 Lesson Week 4, 2017).

I understand my practice to use methods of dialogue, guided open-ended questions, and online and face-to-face discussions to foster reflective practice, as the exemplar below demonstrates.

My personal pedagogy involves asking questions in class to engage teacher candidates to gain authority over their experiences, then weave these experiences and teacher candidates' needs into what unfolds in the classroom. My learning design strategy is underpinned by reflection and more than that, frequent and guided reflection....Further to that, I provide reminders alongside the reflections I ask of teacher candidates so that they are writing reflectively and not just descriptively, and these reminders come by way of resources and semi-structured writing prompts (Sator, Data Source 3 Teacher Reflection-on Week 1, 2017).

In my practice of technology teacher education and evident in the data sources, I made references to specific reflective methods, discuss methodologies for studying reflective practice, and incorporate critical thinking techniques to assess reflective learning. For example, in the lesson for Week 4, the course activities focus on "self-study methodology as a research approach that incorporates understanding and research of the self in practice" (Sator, Data Source 1 Lesson Week 4 Teacher Identity, 2017). My practice in Week 4 also engages teacher candidates with methods of critical thinking and asking searching questions to foster reflective learning. This practice references Bourner's (2003) scholarship that says,

when we assess student work and we spot evidence of the use of these sorts of questions we can reasonably conclude that the student has developed the capacity for reflective thinking (p. 270).

The strategy of dialogue through verbal and written methods is a critical part of my reflective practice authorizer. My practice indicates that I believe in the method of dialogue to support teacher candidates' engagement with knowing-in-action (Schön, 1983), as dialogue is the warrant for accessing one's authority of experience (Munby & Russell, 1994). In my journal, I reference Munby and Russell (1994), who said that "authority of experience as a valid source of knowledge is a type of authority that lies at the heart of action and performance" (p.92). This demonstrates that I believe in the value of reflection for learning from experiences and engage teacher candidates with dialogue to support their access to the authority of experience. By drawing on Munby and Russell's (1993) work, I find evidence in my practice that I value and support teacher candidates to access their authority of experience and learn from it.

Evidence in the self-study data indicates that my practice of technology teacher education intentionally integrates reflective practice in the course assignments. I make

clear to teacher candidates that reflective practice is at the core of the assignment as I ask them to:

look back at your reflections as a whole and share how your views on learning and your views on the nature of knowledge may have shifted through your changing understandings of maker pedagogy and experiential learning. Discuss pedagogical insights afforded by doing things, having experiences, and/or making things in a technological environment. (Sator, Data Source 1 Course Assignment Individual Reflection #2, 2017).

In uncovering my practice in this authorizer, I see evidence of drawing on another authorizer, specifically, the learning theory authorizer, and this is observed in many of the exemplars I provide above. Other evidence in the data sources show that I draw on the work of Kolb and Kolb's (2005) experiential learning, Moon's (2004) reflective practice, Schön's reflection-in-and-on action (1983, 1987), and Lave and Wenger's (1991) community of practice in my practice of reflection with teacher candidates, who read and discuss scholarly ideas and articles as part of the course.

I can also trace reflective practice to other authorizers, specifically, the epistemic leaning in experience. The exemplar below demonstrates the intertwined and dependent nature of the authorizers and supports the assertion for these as evidence of my practice. As I note in my teacher educator journal:

Brandenburg (2008) chapter was so informative and timely, largely from the standpoint of ensuring every reflective activity included had a very specific purpose and was outlined clearly. I took a step back to reflect on the learning design so far. I wanted to identify if the content (know) and curricular competency (do) aligned to the core competency, fostering an epistemology of learning through making/experiences. Were the assignments and activities purposeful? (Sator, Data Source 1 Pre- Course Thinking 2, 2017).

Bullock (2013) suggested that the professional knowledge that is required for teacher candidates needs "considerable effort to develop than casual thought might suggest. Although people who have attended school have an important starting point- namely, their prior experience as students- with which to initially approach their practice, it is critical that new teachers move beyond their prior experiences as students to develop disciplined ways of examining new teaching experiences" (p. 121). The self-study data in this authorizer indicates that my practice evokes reflection in teacher candidates as a method to support them to unpack the knowledge gained through

learning from experience. Further, my espoused theory aligns to my beliefs in the Q-sort, as I state that I value and reflect on my knowledge and think about how I can use it in another context. The reflective practice authorizer supports a disciplined view of teaching and learning in my practice of teacher education, which aims to enhance the ways teacher candidates think about their experiences.

### **5.3.3. Framing Position of Technology**

This authorizer pulls together my practices related to a frame of reference for how I think about technology. This authorizer is comprised of my practices related to: how I think about maker pedagogy and experiential learning as educational technologies; definition of technology; philosophy of technology; nature of technology; and, technology and society.

Evidence in my practice for how I perceive maker pedagogy and experiential learning as educational technologies is noted in the course syllabus. In the syllabus, I write that maker pedagogy and experiential learning are educational technologies that facilitate the opportunity for teacher candidates to consider (or re-consider) the idea of learning from experiences in science and technology education. I state that:

first, students will gain hands-on experience with small science and technology projects appropriate for secondary school students, with a particular view toward considering the implication of the “maker movement” for their own pedagogical development. Second, students will develop their understanding of experiential pedagogy by visiting several off-site locations (Sator, Data Source 1 Course Syllabus and Readings, 2017).

My practice is to integrate the educational technologies and draw on the unique epistemic affordances of these educational technologies to support teacher candidates’ development of pedagogy, experiential learning, and maker approaches for teaching and learning. This practice is also evident in the underpinnings and rationale for the course as presented to teacher candidates in Week 1. I state that the course will give:

teacher candidates an opportunity to consider alternate pedagogies of both making and of experiential learning because schools are not typically places where teacher candidates are encouraged to “make things” and research links these approaches to powerful learning (Sator, Data Source 1 Teacher Notes Week 1, 2017).

In summary, my practice frames the educational technologies as integral to the practical experiences, and this moves beyond mere discussions about educational technologies.

My framing position of technology authorizer also integrates practical and theoretical knowledge. I seamlessly design the learning experiences so that teacher candidates will consider:

the value of using the theoretical frameworks of maker pedagogy and experiential learning to design, develop, and implement school experiences in science and technology (Sator, Data Source 1 Course Syllabus and Readings, 2017).

I take a stance in this authorizer on myths drawn from the popular culture about educational technologies and question with the class the blind positivity that surrounds educational technology. As evident in the course goals, I state that I ask teacher candidates to contemplate:

the ways in which science and technology issues that are currently unfolding in popular culture might productively be “brought in” to the K-12 science and technology classroom (Sator, Data Source 1 Course Syllabus and Readings, 2017).

This component of my practice is rooted in the belief that the scholarship of the field, the literature, educational research, and the history of educational technology are critical considerations for educators and educational technologists.

In my teacher education journal, my practice shows evidence of linking the definition of technology with historical movements and philosophical issues. This espoused theory aligns with the Q-sort of my theory of knowledge, wherein I agreed strongly with the statements that “knowing about historical and philosophical developments in technology enhances my knowledge about technology.” I state in my teacher educator journal that the purpose of technology is for the facilitation of understanding, learning, and knowing and should not be distinct from science. The philosophy of technology is evident in my practice of technology teacher education and is a focal point of a lesson that discusses science and technology. In the lesson for Week 3, I draw on the work of Bullock and Sator (2015), who discussed maker pedagogy as a response to the science and technology divide and suggested that:

- Maker pedagogy may be a way forward for curriculum studies of science and technology to reconnect the symbiotic relationship between the two fields of science and technology (Bullock & Sator, 2015).
- Maker pedagogy as a potentially useful way forward in engaging teacher candidates in thinking about curriculum and working with students (Bullock & Sator, 2015).
- Maker pedagogy as an overall way of working with those interested in learning about science and technology (Bullock & Sator, 2015).

My practice draws on reform movements in science education and I present arguments about the promises of making for science education to teacher candidates (Brevan, 2017).

My practice in the framing position of technology authorizer is to draw on the other authorizers, specifically the learning theory authorizer. My practice shows evidence that I look to the philosophy of technology to think about how maker pedagogy may support science education given the reform efforts in the curriculum studies of science. This evidence also highlights the entwined nature of the authorizers in my pedagogy of technology teacher education.

In my beliefs about the nature of technology I reference Snape's (2016) work in my teacher notes. I write that the nature of technology is the "awareness of the bigger picture purposes and drivers of technological development" (Snape, 2016, p. 24), and that the philosophy of technology is a field of human endeavour (Snape, 2016). My beliefs are also evident in the exemplars below that show further how I think about educational technologies through the lenses of design, sharing, creativity, and interdisciplinarity.

Makers share an ethos that involves the distribution of experiences, sharing, and collaboration and are drawn to the creation process through ethically hacking, reusing materials, remixing technologies that involves building, tinkering, and iteratively working on their designs (Sator, Data Source 1 Lesson Week 2, 2017).

Making takes people away from consumerism towards creationism and it provides opportunities for agency and ownership, nurtures curiosity, and involves collaboration and engagement with knowledge and skills, taking risks and experiencing failure, and engaging in experimental play (Sator, Data Source 1 Lesson Week 1, 2017).

Making is typically connected to STEM disciplines as making originated in rapid prototyping and computational types of thinking. Yet, the connections to arts, crafts, music, fabrics, wearable is mainstay for makers and there are rich opportunities at all level of technology that can be inter-disciplinary (Sator, Data Source 1 Lesson Week 1, 2017).

The self-study data in this authorizer indicates that my beliefs about the philosophy of technology are orientated toward social construction of technology and that I have an aversion towards technical rationalism. This aspect of my practice aligns with my theory of knowledge as indicated in the Q-sort activity wherein I strongly agreed with the statement that “I can shape the purposes of the technology I use irrespective of how it was designed.”

### **5.3.4. Learning Design**

This authorizer pulls together aspects of my practice around learning design in my pedagogy of technology teacher education. The elements of my practice include: 1) the learning environment, 2) abilities for a technological world and technological competence, 3) design thinking and evaluation of educational technology, and 4) relationship with technology.

#### ***Learning Environment***

In the learning environment, I find evidence of my technology teacher educator identity as extending beyond a curriculum assembler. In a lesson with the class, I share what Jonassen (2000) suggested that:

design is the most complex and ill-structured kind of problem that teachers must solve (Sator, Data Source 1 Lesson Week 6, 2017)

As well, I suggest that in the design of the learning environment, there is not a set of steps to follow to develop the curriculum. There is no template or simple recipe, but there are useful methods and educationally supported pedagogies (Sator, Data Source 1 Teacher Notes Week 6, 2017) that you can draw on as learning designer.

Class reflections and the integration of the teacher candidates’ voices in the learning environment are an integral part of the learning design and a feature of my practice as a technology teacher educator. The data show my practice as creating a learning environment, as discussed in the course philosophy (Sator, Data Source 1

Teacher Notes Week 1, 2017), that intentionally establishes a safe space for teacher candidates to ask questions and make inquiries. To integrate the teacher candidate voice, I ask direct questions, design for class reflections, and prompt inquiries about aspects of my teaching to make my practice explicit to teacher candidates. The exemplar below shows an in-class activity that focuses on dialogue and the teacher candidate voice.

You will be reflecting on the readings from this week. Each small group will focus in on a particular question. In your small groups, you will discuss your thoughts to the question. As a small group, you will then share your ideas with the entire class. Each group will form a question and/or comment on the reflection. Pose questions/ comments to your peers for us all to consider (Sator, Data Source 1 Lesson Week 3, 2017).

Share some thoughts about your experience in learning to program in Scratch and making Squishy Circuits. Unpack it through the maker pedagogy lens and what it means to learn from your experiences (Sator, Data Source 1 Lesson Week 2, 2017).

The precursor for this, as I write in my teacher educator journal and make clear to teacher candidates, is that they need to “come to class with some questions, comments or ideas and thoughts, and be prepared to engage with these” (Sator, Data Source 1 Pre-Course Thinking 1, 2017). I find evidence in the self-study data that my belief about learning design requires student preparation and agency.

Evidence in my practice indicates that collaboration is a part of the learning environment and I integrate collaborative activities. In my teaching notes, I refer to the scholarly literature and consider it carefully in planning the design of this course and for understanding my role as teacher that facilitates collaboration. As evident in the self-study data and associated with the learning theory authorizer, I take seriously the value of collaboration and write heavily about collaboration in my notes for Week 3.

Social constructivism involves the social and collaborative dimensions of group knowledge and knowing. Collaboration is defined as a “coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem” (Roschelle & Teasley, 1995, p.70) and dimensions involve interaction, dialogue and negotiation (Bonk & Cunningham, 1998). The ontological position is that meaning is constructed in a group interaction and collective prior knowledge shapes the group’s interpreted reality (Stahl, 2004). This suggests that knowledge resides in the mind of the individual-in-social-action (Cobb, 1994). This is aligned with Vygotsky’s view of reality wherein knowing is a constructive

process that is embedded in sociocultural practices (Duffy & Cunningham, 1996) (Sator, Data Source 1 Teacher Notes Week 3, 2017).

Knowing is distributed through co-construction of information via social activity. Knowing is not “attributed to the mental processes of any one individual” (Stahl, 2004, p. 3) or contribution of individuals. The collaborative discourse process is critical in making the group knowledge explicit as it draws from the foundation of tacit knowing (Stahl, 2004). In this view, individual cognition is not separate from group cognition, and the learning cycle comes full circle back to the individual level of interpretation (Stahl, 2004) through the externalization and internalization processes. Internalization of information through collaborative activity allows the individual to learn something they may not have been able to prior to the collaboration (Lipponen, 2002) (Sator, Data Source 1 Teacher Notes Week 3, 2017).

Social Constructivist teachers value heritage, the process of enculturation in activity, and culturally organized practices (Cobb, 1994). The role of the teacher is to engage with learners through social interactions as the more ‘knowledgeable other’ and scaffold learners towards their zone of proximal development through activities that foster legitimate peripheral participation (Cobb, 1994). Instructional strategies include modeling, scaffolding, coaching (Duffy & Cunningham, 1996) and priming of prior knowledge to foster construction of knowledge (Wise & O’Neill, 2009). Nurturing collaboration is also a crucial process for social constructivist teaching and learning and the teacher’s role is to support the interaction process and participation of learners around collective discourse activities (Lipponen, 2002); this is often done through continual probing to seek compatibility for deep levels of convergence/ divergence (Duffy & Cunningham, 1996). The teacher’s roles can be further detailed to include the division of tasks, pooling of results, facilitation of brainstorming, support for negotiations, agreement and compromising, as well as critiquing (Stahl, 2002) (Sator, Data Source 1 Teacher Notes Week 3, 2017).

As an authorizer, learning design has close associations to the other authorizers.

The data shows evidence of my practice as having associations with the epistemic leaning in experience and reflective practice authorizers in the design of the learning environment. For example, my practice in the learning environment includes small and large group reflective dialogues and collaborations that consistently invite the teacher candidates to have a voice and share their thinking about the experiences they have had. I write in my teacher educator journal that “I value the individual and group reflections for what I learn about my teacher candidates and how my practice impacts their learning outcomes” (Sator, Data Source 1 Pre-course Thinking 2, 2017).

## ***Abilities for a Technological World and Technological Competence***

A crucial aspect of learning design for educational technology as evident in my practice is to provide in-class time to foster abilities for a technological world and to encourage technological competence. As discussed with teacher candidates in a lesson about technological abilities, the mindset of exploration is highlighted to attain this goal. I use references from scholarly literature to foster abilities such as experimental play and a growth mindset. In Lesson 2, I invite teacher candidates to “engage in experimental play and play with technology to learn about it –play is a source of innovation (Dougherty, 2013)” (Sator, Data Source 1 Lesson 2, 2017). I also ask teacher candidates to consider how “a growth mindset tolerates risk and failure, learning from mistakes, iteration, and tinkering (Dougherty, 2013)” (Sator, Data Source 1 Lesson 2, 2017).

My practice also shows evidence that I provide extended in-class time for exploration, play, and inquiry with different maker activities and projects, and site-visits to experiential learning sites. My assumption is that time for experimental play will provide teacher candidates with a place and space for developing abilities for a technological world as the projects, activities, and site-visits focus on different types of experiences. These included place-based learning, using iPads, making circuits, creating models, programming, and virtual and augmented reality, to name a few.

Evidence in the self-study data sources illustrate that a component of my practice of learning design as an authorizer includes technological competence. This means that teacher candidates get to know technology and systems, and are able to discuss different uses, traditions, and what is needed for educational technology. The course goals explicitly state that teacher candidates will engage with “making things, engaging in science and technology experiences and design, implement, and evaluate science and technology projects” (Sator, Data Source 1 Course Syllabus and Readings, 2017).

Two maker activities and one maker project (Sator & Bullock, 2016) comprise the major in-class maker technologies to support teacher candidates’ technological competency growth. The activities are:

1. Squishy circuits: that supported talking about: circuits; power source; current flow; LED polarity; closed, short, parallel and series circuits; and, conductors and insulators.

2. Using Scratch to appreciate what it takes to create a game or simulation; be able to adapt, hack, and remix code; gain exposure to programming; and, develop identity as a coder and/or with technology.
3. Slowmations to teach a science and/or technology concept through modelling, animating, and taking digital still images of animation to create a StopMotion film.

My practice in learning design traces to the learning theory authorizer and the exemplar below exemplifies how I reference Howland's (2012) meaningful integration of technology. In the lesson for Week 6, my practice with teacher candidates discusses the development of technological competencies through:

Engaging active, constructive, intentional, authentic, and cooperative learning. Some examples include: - Inquiring with technology; Experimenting with technology - Designing with technology; Communicating with technology - Community building and collaboration with technology - Writing with technology - Modeling with technology; Visualizing with technology - Assessing meaningful learning and technology with technologies (Sator, Data Source 1 Lesson Week 6, 2017).

### ***Design Thinking and Evaluation of Technology***

My teacher education journal and lessons provide evidence that my practice of learning design is mindful of design thinking and the evaluation of technology, and foundational to this is philosophical and historical lenses. I discuss design thinking, as a method of ideation and iteration, and media literacy competencies as two frameworks to frame ways of thinking about learning design in science and technology. Further, in the lesson for Week 6, I share with teacher candidates the reference to West-Puckett (2014) who suggested that learning designers must consider the epistemic affordances of technology as an intellectual partner in the meaningful integration of technology. My teacher educator journal demonstrates my practice through notes about my thinking related to design as being iterative and potentially chaotic. I note that the creative process is not always in the pursuit of a problem that needs to be solved and could be framed a positive failure (Sator, Data Source 1 Teacher Notes Week 3, 2017).

My teacher educator notes also discuss my thinking about design through the different types of maker activities. I say that:

maker activities are used to develop or formatively assess teacher candidates' conceptual understanding by engaging them in application and understanding through design and engineering; maker activities support one to figure out the purpose of making (e.g.: entrepreneur, work skills, or educative), know the history of the technology, and think about the type of making (e.g.: kits, creative construction, or tinkering- sliding scale, degree of making) (Sator, Data Source 1 Teacher Notes Week 3, 2017).

The above exemplar demonstrates that I value historical thinking about the uses of educational technology and the evaluation of technological projects in my practice.

### ***Relationship with Technology***

Evidence in the data sources show that another component of my practice in the learning design authorizer includes supporting teacher candidates in their relationship with technology and identity development as curriculum makers and technology teachers. As I uncover in my practice, part of my role as a pedagogue is about facilitating a learning environment that fosters teacher candidates' development of their own identities. I note in my teacher educator journal that I “put myself in a less comfortable place” (Sator, Data Source 2 Teacher Reflection During Class, 2017) for the benefit of student learning, and this means my practice puts teacher candidates emerging needs and questions at the forefront of the learning experience. In one example, my practice shows that I draw teacher candidates into the conversation to consider their identities as they are asked to think about:

How Is Identity Understood? When thinking about your identity, consider it from a sociocultural theory lens—a loose cluster of complementary, sometimes competing, contributions from social psychology, social anthropology, sociolinguistics, and philosophy that focus on the self in practice; on the various interdependencies among person, context, history, and others; and on the situated, continuous nature of self-development (Sator, Data Source 1 Lesson Week 4).

Further, an in-class activity demonstrates that my practice is to bring awareness to teacher candidates about their identities and relationships with technology through thinking about:

the apprenticeship of observation (the way teacher candidates have witnessed how teaching creates prior assumptions and expectations), the problem of enactment (enacting visions of teaching may be challenging due to assumptions and prior experiences), and the problem of complexity (unaware of the complex work of teachers due to the limited exposure in practica) (Sator, Data Source 1 Lesson Week 2, 2017).

This aligns with the course goals that explicitly state that teacher candidates will:

enact pedagogical approaches to develop confidence and teacher identity by making things, engaging in science and technology experiences, and reflecting on what you learn (Sator, Data Source 1 Course Syllabus and Readings, 2017).

There is evidence in my practice that I foster teacher candidates' abilities for a technological world and have them consider their relationship to technology. Maker activities are discussed in the lesson for Week 2 as drawing "the whole body of the maker into the creation of the project and the resulting artefact(s) represent the creative process of design, social interaction, and ethos of sharing inherent in the personal and collective learning process" (Bullock & Sator, 2015, p. 70). In my practice I encourage teacher candidates to build a relationship with technology through playing, tinkering, exploring, and making to foster exploration, inquiry, and different levels of kinds of knowing (Sator, Data Source 1 Teacher Notes Week 3, 2017).

### **5.3.5. Learning Theory**

Learning theory is traced throughout all the authorizers, and my practice is to draw on relevant academic literature and learning theory to support my pedagogy of technology teacher education. My practice supports teacher candidates in their development and thinking about educational technology in a scholarly way. For example, in Lesson 6, we talk about why learning theory is important for educators and watch a short video on the topic. We unpack the utility of learning theory as a class and the lesson suggests that learning theory

gives information about how people learn. One theory cannot explain everything, so we draw from eclectic sources; helpful for curriculum designers to identify practices that support learning from different theoretical frameworks in order to develop pedagogical practices that facilitate teacher candidates' learning (Sator, Data Source 1 Lesson Week 6, 2017).

During the course, my practice is to engage in discussions about learning theory from the perspective of the underpinnings and principles latent in the theory. The utility in thinking about learning theory is described to teacher candidates as useful for making educative decisions. In one class activity, I ask teacher candidates to

pull together and support the development of coherence in curriculum design between learning theories, curriculum methods, maker pedagogy, and meaningful integration of technology (Sator, Data Source 1 Lesson Week 6, 2017).

Finally, evidence of my practice shows that teacher candidates are reminded throughout the course to reference their work to the readings, resources, and the learning theory and literature to demonstrate how they made pedagogical decisions that support their positions. For example, when creating their lessons, teacher candidates are asked to “use active learning activities that are informed by theory and frameworks about how people learn through making / experiences” (Sator, Data Source 1 Assignment Individual Paper, 2017).

### **5.3.6. Summary**

Five authorizers are evident in my espoused practice of technology teacher education. These are: 1) epistemic leaning in experience, 2) reflective practice, 3) framing position of technology, 4) learning design, and 5) learning theory. My authorizers are summarized below.

1. **Epistemic Leaning in Experience:** This authorizer describes the use of the educational technologies of maker pedagogy and experiential learning that support learning from experience as an epistemic source of knowledge. Methods of dialogue, reflection-in, and reflection-on experience are the supports for making meaning of experience. My practice is that epistemology and pedagogy are closely linked and that one’s epistemology influences their teaching actions.
2. **Reflective Practice:** This authorizer describes the use of reflecting-in-and-on experiences and learning from experience. My espoused practice is to draw on methods of dialogue, writing, open-ended questions, and online and face-to-face dialogue to support access to an authority of experience. My practices values knowing-in-action.

3. Framing Position of Technology: This authorizer is embedded in a definition of technology, definition of learning with and about educational technologies, philosophy of technology, the nature of technology, and technology and society. My espoused practice is based in the historical definitions of technology and current philosophy of educational technology such as the social shaping of technology. The historical movements in educational technology are foundational to my practice and support my educative decisions that challenge popular culture and the myths of educational technology.
4. Learning Design: This authorizer describes the design of pedagogy for the teaching-with and learning-about educational technology. The facilitation of learning is a part of the learning design authorizer as are considerations about evaluation, the learning environment, abilities for a technological world and technological competencies, relationship with technology, and collaboration. My espoused practice in learning design is to build collaborative and reflective learning environments that foster dialogue for meaning making. My espoused practice aims to provide ample time for teacher candidates to develop their abilities for a technological world alongside the competencies to support meaningful technology integrations in their in-service practices. A component that I believe is critical in the support of educational technology integration is to develop an identity and relationship with technology.
- 5 Learning Theory: This authorizer describes my espoused practice as drawing on scholarly literature and learning theory to support my pedagogical decisions.

The justification for selecting these authorizers is their intimate attachment and co-occurrence across all the data sources. Collectively, these authorizers represent my beliefs, values, activities, and assumptions in my practices and actions as a technology teacher educator. S-STTEP methodology supports the process of understanding my authorizers through dialogue with the self and dialogue with the literature. In the next part of the analytical framework, I come to understand my self-in-practice with others through critical self-reflexivity of my self-in-practice. The forthcoming analysis supports me to re-visit my authority of practice by unpacking my authorizers through a self-study of the space between my practices and actions.

## **Chapter 6.**

### **Professional Knowledge in an Epistemology of Practice**

The first part of this chapter presents the findings from Part 3 and Part 4 of the analytical framework. To remind the reader, in Part 3 of the analytical framework I unpack my authorizers via S-STTEP methodology to understand the space between my practices and actions, and capture accounts of ways that my actions transform my practice (Pinnegar & Hamilton, 2009). In Part 4 of the analytical framework, I coalesce my professional knowledge and articulate my assertions as a basis for knowing from my epistemology of practice in technology teacher education using maker pedagogy and experiential learning as educational technologies. The second part of this chapter presents the findings to the third research question:

How might my personal pedagogy of technology teacher education be influenced by my perceptions of students' changing theories of knowledge for the design of educational technology within a post-secondary environment?

#### **Part 1**

As I work through the parts of the analytical framework, I move from an ontological understanding of my practice towards the articulation of my professional knowledge in an epistemology of practice as a technology teacher educator. This part of Chapter 6 presents the analysis of my authorizers (Argyris & Schön, 1974) alongside my actions (Argyris & Schön, 1974) through a self-study to understand areas where my theories-in-use are misaligned to my espoused theories (Argyris & Schön, 1974). I study my authorizers via S-STTEP methodology and examine the space between my practices and actions to understand the epistemic development of my professional knowledge and reframe my practice in order to improve it. The epistemic warrant that allowed me to attend to the self-study data and reveal my tacit knowledge to help me draw assertions about my professional knowledge is the theories of action, as understood through the work of Argyris and Schön (1974). Self-study research provides a systematic methodology that allows me to critically examine the space between my practice,

wherein the focus is attending from what I know, and my action, wherein I attend to how I respond. My theories of action can be understood through my actions and through the study of my practices to help me construct my theories-in-use, which are tools to action. In this way, I attend to my self in the spaces and this self-study ‘turns back on itself’ because I show how I

reveal and support with empirical evidence the new understandings of and assertions for practice that emerged as [I] questioned again the practices being used and what they revealed about what [I] now knew (Pinnegar, Hamilton, & Fitzgerald, 2010, p. 205).

Argyris (1987) proclaimed that action has theoretical elements because action is not haphazard and has design aspects for which professionals are accountable. “Action science suggests that a lack of correspondence, that is, a gap between espoused theory and theory-in-use, is the norm for human behavior and that the use of tacit or untested assumptions to diagnose or explain inconsistencies is common” (Menges & Rando, 1989, p. 57). “Like most assumptions that support theories-in-use, these are untested and possibly inaccurate. If not made explicit and tested against real events, they may leave teachers with invalid theories of action and ineffective behaviour” (Menges & Rando, 1989, p. 54). The two theories of action are lenses for the study of my professional knowledge and allow me to improve my practices, particularly where there is incongruence “with the understandings and know-how implicit in patterns of action” (Schön, 2001, p. 201).

The examination of my practices and actions in this research draws on the pillars of S-STTEP and methods of reflective practices, interactivity, and dialogue. Reflective practices include my reflection-in-action (Schön, 1983); evidence of reframing through turning points (Bullock & Ritter, 2011); and, being reflexive and engaging in constant scrutiny and self-critique of my practices and actions. Other methods I use to examine my practices and actions include interactivity with “the understanding that engaging with others will help [me] more accurately develop and uncover [my] practice (Pinnegar & Hamilton, 2009, p. 154). The interactions occur with teacher candidates and the literature and scholarship in the field and involve extensive dialogue in my “process of coming-to-know” (Pinnegar & Hamilton, 2009, p. 154) my pedagogy of technology teacher education.

Throughout the analytical process, I access my authority of practice and understand changes to my ontological position as I reframe who I am in the action-present (Schön, 1983). This process supports me to attend in an authentic way to my practices and actions of technology teacher education and capture accounts of ways that my actions transform my practice (Pinnegar & Hamilton, 2009) and support the improvement of my practice. In summary, the examination of my knowing-in-action supports the understanding of my teacher educator professional knowledge and its epistemic development. As my authorizers always change, herein lies the ontological commitment and acknowledgement of “what is” as a result of my authority of practice in the development of my professional knowledge.

The forthcoming sections of this chapter present exemplars of how I came to know my practice differently as a result of this self-study. It is through the exemplars that I detail the complexities inherent in my pedagogy of technology teacher education and go beyond my story to connect with the broader field. In this way, I attend to trustworthiness and quality and strive for outcomes that “genuinely affect understandings of practice beyond the individual self” (Loughran, 2007, p.12) and move the research conversations forward in the field. The use of exemplars also facilitates the accurate examination of my teaching moments as they record with accuracy the present moment of my action and show evidence of how I came to think differently and where I reframed. In the exemplars I find evidence of how my theories-in-use may or may not align with my espoused theories and where there is tension (Loughran, 200) in my practice. As I state in my teacher educator journal:

decisions made in my classroom obviously come from the planning I have undertaken, which is rooted in my practice, and the actions I carry out are seemingly aligned but it will be through constant examination of my personal pedagogy and how things unfold in the classroom that I will be able to continually improve my practice (Sator, Data Source 2 Teacher Reflection-In Week 1, 2017).

## **6.1. Epistemic Learning in Experience**

My espoused theory in my pedagogy of technology teacher education is to provide epistemic ways for teacher candidates to learn from experience. “My goal was to develop a course that really supported teacher candidates in the development of their epistemology of experience” (Sator, Data Source 1 Pre-Course Thinking 2, 2017). There

is evidence in my actions throughout the course that demonstrate my support of teacher candidates' opportunities to understand their professional knowledge through making meaning of their experiences, both in-class and outside of class. For example, the course was structured in a manner that gave intentional focus to the knowledge teacher candidates gained from practical experiences through the activities, discussions, and assignments. However, S-STTEP methodology provided a lens for self-critique that broke through the surface of my actions. A turning point in the action-present (Bullock & Ritter, 2011) wherein I had the opportunity to take action on a situation revealed to me that my espoused theory was not aligned to my theory-in-use. I reflected-in-action during Week 2 of the course when I noticed that my action invited teacher candidates to discuss only the knowledge that they gained from the course readings. I wrote in my journal that:

I have to review an aspect of my learning design. My assumption is that theory and practice divides are not supportive of how people learn, and my assumption is that conceptual/ abstract and/or concrete experiences (making/ experiential) must be intentionally designed for such that the Understand-Know-Do cannot and should not be pulled apart, as these aspects of learning are one unit. Yet, when I reviewed a piece of the course activity (Do), in Week 2, the focal point in two of the 4 reflective class discussions is only on Know, specifically what teacher candidates took away from the readings (Sator, Data Source 2 Reflection-In Week 2, 2017).

I understand my actions in the above exemplar as posing a barrier for teacher candidates to access their authority of experience (Munby & Russell, 1994) as I place the authority of proposition ahead of experience and overlook the opportunity to have teacher candidates dialogue about their experiences. I examine my actions in this intermediate zone of practice and I note a tension in my teaching actions because I feel uncertain (Schön, 2001) about my actions with teacher candidates. To reframe my actions, I draw on the scholarship in the field (Munby & Russell, 1994; Brandenburg, 2008) to support the rethinking of my practice and embrace the experience as positive failure. I understand that my actions in this situation did not foster an epistemology of experience because it only focused on the 'know that' proposition, and this was the very concern that Munby and Russell (1994) stated about teacher education programs; namely:

learning from experience is never mastered, during preservice programs, in a way that gives direct access to the nature of the authority of experience. If Schön is correct that there is a knowledge-in-action that cannot be fully expressed in propositions and that learning from experience has its own epistemology, then our concern is that learning from experience is never clearly contrasted with learning that can be expressed and conveyed in propositions (Munby & Russell, 1993, p. 9).

Another situation I found puzzling in my pedagogy arose from the exemplar below. I said that:

I ask a lot of questions that are formally built into the lesson. These are not just questions for the sake of asking questions, they are very intentional and connected to experiences that I want teacher candidates to draw from. I always link the purpose of questions on bridging the learner into the context or evoking prior knowledge but that is not my only purpose. It is to make the learning personally meaningful and based in their experiences (Sator, Data Source 2 Reflection-in Week 1, 2017).

On the surface, my actions of asking questions to evoke the prior knowledge of teacher candidates appears to be consistent with my practice. However, I felt that my professional effectiveness in my epistemic leaning in experience authorizer could be enhanced because I felt uneasy about how I used the term 'questions' instead of 'reflections'. By seeking the other through the literature, I aimed to better align my two theories of action. I reviewed McGill and Warner Weil's (1989) definition of experiential learning, which says that learning from reflection is a

process whereby people individually and in association with others, engage in direct encounter, then purposefully reflect upon, validate, transform, give personal meaning to and seek to integrate their different ways of knowing. Experiential learning therefore enables the discovery of possibilities that may not be evident from direct experience alone (p.248).

When I interacted with the scholarship and engaged in reflexive approaches for coming to know my practice, I could identify why my theory-in-use was misaligned to my espoused theory and this triggered a shift in my governing variable. Although my espoused theory was that experiential learning is a unique educational technology that facilitates access to learning from experience, I seemed to confound and overestimate the role that questions played in supporting teacher candidates. I concluded that asking questions and prompting reflection involve very different processes. From this, I better understood that there is a need in my practice to be more intentional in engaging teacher candidates with the reflective methods and processes they require to make meaning of

their experiences and embrace their knowledge-in-action. I need to bring the reflective practice authorizer closer to the epistemic leaning in experience authorizer and self-study methodology helped me identify what was tacit and implicit in my action. This was valuable in my pursuit of understanding my profession knowledge and goes beyond just having a “feel for the stuff with which we are dealing” (Schön, 2001, p. 194).

I am grateful for these learning moments and for being able to identify a misalignment between my practices and actions and to reframe my practice. I was able to identify that my professional knowledge needs to be better grounded in an epistemology of experience that engages reflective practices. I need to encourage teacher candidates to access the authority of experience (Munby & Russell, 1994) as it connects to achievement of the course goals, and importantly, I need to embed methods that support them to do this work. The reframing of my practice improved it to focus more closely on the notion that what we know lies in actions (Munby & Russell’s, 1992). By adding knowing to knowledge, special attention is given to the concepts of knowledge-in-action, reflection-in-action, and the authority of experience so that one can account for the relationships between what we know and what we do in order to generate new knowledge and ways of knowing from experience.

The self-study of this authorizer sheds new light on my reflection later in the course where I said that I:

ask teacher candidates to draw on their experiences as it is part of my practice/ belief. I understand my belief in epistemology is founded in making meaningful learning opportunities for teacher candidates by drawing on their experiences and connecting the conceptual and experiential. I have some confidence in articulating this as my teaching goals are structured this way, but more than that, my actions reveal it, and I am doing it even on occasions where I have perhaps not specifically built it into the lesson, but wherein the present moment provides this opportunity (Sator, Data Source 3 Reflection-on Week 3, 2017).

Another aspect under scrutiny in my epistemic leaning in experience authorizer is how my actions support the connection of teacher candidates’ beliefs with their teaching actions and their teacher identity. A full week of the course was dedicated to epistemology as a topic for the purpose of understanding the utility of epistemic studies. The aim was to inform teacher candidates about the value of studying their beliefs about the nature of knowledge as these beliefs will influence their approaches to teaching

(Perusek, 2008) and technology integration (Cohen, 2017). During this part of the course, my reflection-in-action stated that teacher candidates were active in creating a visualization and verbalization of their teacher identity that drew on their personal epistemologies. Teacher candidates said that they found it “relevant to teaching because it interfaces with the way we think about the nature of knowledge and this is brought into our teaching and learning” (Sator, Data Source 2 Reflection-In Week 3, 2017).

Through my interactions with the teacher candidates, I was able to uncover an aspect of my tacit knowledge, namely: I have a propensity for drawing connections between beliefs and actions in teaching as I engage teacher candidates with activities that tap into the authority of experience to help them to understand the epistemic ways that teacher identity develops. This understanding has uncovered an aspect of my professional knowledge of epistemic leaning in experience that I was not able to state in the authorizer and is credited to the process of engaging with others to uncover tacit aspects of my practice (Pinnegar & Hamilton, 2009). S-STTEP helped me to understand further that the nature of my professional knowledge is made explicit through interactivity with teacher candidates (Anderson, Imdieke, Standerford, 2011) and this also supports my educative decision-making processes (Schraw & Olafson, 2002). Furthermore, I can now say in a more concise way that the design of the Q-sort activity, wherein I invite teacher candidates to share their perspectives about their theories of knowledge, has epistemic implications for teacher candidates. My assertions for action are for me to make more explicit in my future practices the relationship between the Q-sort, teacher’s belief and what this means for their teaching identity, teaching philosophy, and the connection between teaching beliefs and actions.

In summary, I engaged with S-STTEP methodology to access my authority of practice and to unpack my authorizer and frame my professional knowledge of epistemic leaning in experience. The assertions for action that I feel will improve my practice and better support teacher candidate learning is to provide teacher candidates with epistemic ways to understand their experiences as arising from their authority of experience and to support this through reflective practices. Further, I have made explicit that my professional knowledge is related to the connection of epistemic beliefs, teaching goals and actions, and teacher identity. The self study of my practices and actions in the epistemic leaning in experience authorizer is an example of how I made a reflexive turn (Bullock, 2014).

## 6.2. Reflective Practice

In Chapter 5 I discuss my reflective practice authorizer and note that my personal pedagogy encourages deep and extended dialogue with and between the teacher candidates to weave their experiences and support them to gain authority over their experiences. Further, I note that class dialogue and my use of questions with teacher candidates are underpinned by methods of reflection, and that I frequently use semi-guided reflections as the open-ended reflective approach did not appear to support teacher candidates' ability to write reflectively, as I witnessed in their online postings. I note in my teacher educator journal, that

I am now wanting to carry this (semi-guided reflection) through into the online discussions, which are public (and the writing reflections are private and not-submitted) (Sator, Data Source 3 Teacher Reflection-on Week 1, 2017).

I go further to say that:

The online discussions [prompts] are not pre-fabricated as I intend to use things that have come up in the class or in previous online discussions to pose new discussions to teacher candidates (Sator, Data Source 3 Teacher Reflection-on Week 1, 2017).

Through an inquiry into my action, I am presented with a problem in the action-present (Schön, 1983) that I have to reconcile. My actions reveal to me that I provide semi-structured reflection prompts in-class and that I use open-ended reflection prompts in the online environment (which I suggest do not support teacher candidate reflective writing as well as semi-guided prompts). I find myself facing a situation of professional complexity and as Schön (2001) eluded, the tension I felt did not quietly go into its demise and my "reflection-in-action took on a quality of struggle" (Schön, 2001, p. 202). In this process, I engaged the "dialectal in the sense of a coming to understand through a process of questions and answers" (Laidlaw & Whitehead, 1995, p. 3). To frame my problem of practice, I set the problem and made decisions about the issues that required attention, such as the course goals. Then I set the actions to be taken in order to translate the problem into a resolution (Schön, 2001). Through this self-study, I reframed my practice to understand that reflective writing does not need to be designed in the same way in all aspects of a course. There are contextual, situational, and content-

specific reasons that help determine the rationale for the type of reflective practice that is embedded into an activity, assignment, or discussion.

In my practices and actions, I invite the teacher candidates' voices to help shape the learning experience. The exemplars below demonstrate my practice-with-others through the way I weave reflective dialogue with teacher candidates:

I put questions out to the class because I am truly interested in their perspectives and prior experiences, what they want and need to know, and to have their input into their learning experience so that we can distribute the learning and shape the experience for the diverse needs of everyone. That is hard work [but] I remembered what people said and brought it back into the dialogue at different points in the class. And I could see reactions, teacher candidates were impressed, and I almost feel like it renewed their attention because I was paying attention (Sator, Data Source 1 Reflection-on Week 1, 2017).

I use the online discussions from the week in their class reflections to integrate what teacher candidates know. I ask them to consider their ideas related to the scholarship and I ask for them to share experiences. Then I try to integrate their reflections and experiences into the discussions (Sator, Data Source 1 Reflection-on Week 2, 2017).

Also, for example, during class activities, teacher candidates reflected on their knowing-in-action and I dedicated class time for dialogue in small groups. Below is an exemplar of a group discussion activity that shows how I enacted knowing-in-action for teacher candidates:

Share some thoughts about your experience in learning to program in Scratch and making Squishy Circuits. Unpack it through the maker pedagogy lens and what it means to learn from your experiences (Sator, Data Source 1, Teacher Notes Week 2, 2017).

Reflecting-on my action, after this situation has occurred, I am able to think about my action and coalesce the entire phenomenon of the experiences to question my theories-in-use and develop my repertoire of reflective practice (Schön, 1983). S-STTEP methodology help me to understand that open-ended questions that connect explicitly to specific experiences of teacher candidates had value for prompting the reflective semi-structured class discussions.

The above exemplars show that my teaching actions involve summaries of teacher candidates' online discussions and the use of embedded questions, and that I make connections between the reflections-on their experiences and then bring these

ideas to the in-class discussions. Further, the reflection prompts I provide to the teacher candidates in the online discussions are shaped by their emerging discussions, and in this way are open-ended but are not an opportunity for them to free write without guidance. By unpacking my actions related to the reflective practice authorizer through S-STTEP methodology, I took a reflexive approach to reveal my tacit knowledge, which is a tool to action, but not a part of the action itself (Cook & Brown, 1999). I now understand a component of my professional knowledge in a different way in that a critical strategy in my professional knowledge of reflective practice is to interact with teacher candidates, listen, and replay their voices. The timing, goals, topics, and needs of the teacher candidates will support how I determine the design of the reflective practice experiences, namely: whether reflective practice will be semi-structured or open-ended and that the approach is not consigned to the medium (in-class or online).

In examining my actions of the reflective practice authorizer, I find evidence of how I enact reflective practices with teacher candidates in the large group dialogue wherein teacher candidates were asked to unpack their making and/or experiential site visits with their peers using a reflective framework. An aspect of my tacit knowledge, that is a tool to my action, is to refer to specific reflective frameworks such as reflection-in the moment (Schön, 1983), and strategies from Kolb and Kolb's (2005) model of reflective learning to support teacher candidates to learn from their experiences and make meaning for future teaching situations. Further, my actions prompt teacher candidates to "learn from the various experiences of their peers" (Sator, Data Source 2, Reflection-in Week 6, 2017). Through my actions, I understand my professional knowledge also include the ample use of time to allow for teacher candidate reflections. For example, during the dialogues about the site visits, I did not rush teacher candidates or guide their reflections. Also, in my teacher journal during the lesson, I wrote down the word 'listen' multiple times. Through S-STTEP methodology, I am able to understand my practice of becoming a teacher educator and gain confidence in reflective practice as an authorizer of professional knowledge. S-STTEP revealed to me that a part of my tacit knowledge is that dialogue in reflective practice is the foundation of the "process of coming-to-know" (Pinnegar & Hamilton, 2009, p. 154) and making sense of the learning experience. I am also able to understand that a part of my professional knowledge related to reflective practice is that it is time sensitive both in terms of how much time and provide for reflections and how soon after the event that the reflection occurs.

S-STTEP methodology further made it clear to me that my self-in-practice-with-other involves elements of collaboration, dialogue, and a community of practice that supports reciprocal engagement between me and the teacher candidates, and amongst the teacher candidates. Reflexive approaches push me to consider myself in relation to others and in uncovering my tacit knowledge. I can assert that I do not feel that one person is the sole expert in a teaching environment. S-STTEP methodology has supported me in coming to understand that the teacher candidates' experiences drove the discussions and it was their authority of experience and learning from experiences that were at the forefront, and not my experiences (Brandenburg, 2008).

Another way I came to understand my professional knowledge of reflective practice differently was through reflection-in the moment of providing "dedicated time to writing to get a handle on knowledge" (Sator, Data Source 2 Reflection-in Week 3, 2017). The reflective approaches I used to guide teacher candidates are experiential-intuitive (Schön, 1987) wherein teacher candidates wrote about 'the what' of their experience, 'so what' does it mean, and 'now what' could their learning experiences be used for. Resources were provided to the teacher candidates to show examples of reflective writing and how critical thinking supports reflective learning. The strategy used in my practice-with-others involved "guided questions for reflective learning in class (Sator, Data Source 2 Reflection-in Week 3, 2017)" and "a lot of time devoted to reflection to unpack the learning value of an activity and make meaning of the experience" (Sator, Data Source 2 Reflection-in Week 3, 2017). I understand that a tacit component of my knowledge is attributed to "having consistent time to sit down and reflect on your writing" (Sator, Data Source 2 Reflection-in Week 3, 2017).

I engaged the teacher candidates in different methods to evoke reflection. For example, teacher candidates shared narratives (Clandinin & Connelly, 1992), labelled their knowing-in-action (Munby & Russell, 1994), participated in dialogues (Brandenburg, 2008) to turn experiences into knowledge, and wrote one-minute reflections about knowing-in-action, as thinking tools to bring their experiences into conscious awareness. My tacit knowledge in these actions is made explicit through S-STTEP methodology and I understand my professional knowledge of reflective practice to contain epistemic ways of engaging with reflection-in the present moment in an aim to develop teacher candidates' confidence, their teaching identity, and to make meaning of their diverse experiences. By coming to know through S-STTEP, my theories-in-use are more aligned

with my espoused theories and I improved my practice to bring new awareness to reflective practice as epistemic and “spontaneous, intuitive, and grounded in experience” (Russell & Martin, 2017, p. 30).

My professional knowledge of reflective practice and epistemic leaning are very closely connected as revealed in the self-study evidence about my actions with teacher candidates. As an example, one course activity draws on the method of writing for the purpose of reflecting on one’s changing teacher identities. The value of learning from experiences through writing was described in a lesson to teacher candidates as valuable for understanding that “by writing about your experiences and analyzing them, this supports the concurrent process of constructing and reconstructing your identity” (Sator, Data Source 1 Teacher Notes Week 3, 2017). This has value in learning about “how you can work on and further develop your teacher identity” (Sator, Data Source 1 Teacher Notes Week 3, 2017). As the activities below show, my practice with others connects my professional knowledge of reflective practice and epistemic leaning, as I ask teacher candidates to:

reflect on your (changing) identity as a science (and technology) educator. You will be referring to and modifying your teacher identity throughout this course (and during your career) by thinking about your epistemology, your teaching goals, and through understanding your teaching actions. How can you work on and further develop your teacher identity? By writing about your experiences and analyzing them; this supports the concurrent process of constructing and reconstructing your identity (Sator, Data Source 1 Teacher Notes Week 3, 2017).

My practice is specifically relevant to teacher education and Schön’s (1983) recommendation that professional educators build their artistry of coaching and develop methods to support upcoming professionals in their reflection-in-action abilities.

By listening to the teacher candidates’ voice and interacting with them throughout the course, I have confidence in my professional knowledge in this component of my pedagogy of technology teacher education. Teacher candidates said in the mid-course feedback (2017) that they generally enjoyed the challenge of reflections on their thinking and views and felt that the sharing of ideas/experience with their peers helped them to shape their own perspectives, especially in areas where their exposure is limited. The teacher candidates’ voices capture accounts of my actions and serve to authenticate my actions of reflective practice in my pedagogy of technology teacher education.

In my coming to know process as described in this section, I have a new appreciation for the “practice turn in social theory that acknowledged the decentralization of knowledge production and showed that concurrent reflection on experience could not only expand knowledge but could also improve practice” (Raelin, 2007, p. 497). The use of reflective practice supports learning experiences for technology teacher education through an approach that facilitates reflection on authentic and hands-on experiences (Ottenbreit-Leftwich, Glazewski, & Newby, 2010). Further, reflective practices connect the teacher candidates to the course goals as they think about their identity, the integration of technology, and future practice in the field through reflecting and contemplating their abilities and how to address gaps (Ottenbreit-Leftwich, Glazewski, & Newby, 2010). I have a deeper understanding of my practices that support the findings of Niederhauser, Salem, and Fields (1999) who stated that “the technology course can provide an authentic context for future educators to examine instructional practice and reflect on their learning as they learn new skills and content” (p. 153).

### **6.3. Framing Position of Technology**

The framing position of technology is a complex authorizer. Some aspects of my espoused theories as they relate to the framing position of technology authorizer are observed in my actions while other aspects of my espoused theories appear to be misaligned with my theories-in-use. My actions in this authorizer, when placed under serious self-critical scrutiny, provide me with an opportunity to learn about my professional knowledge as a technology teacher educator. S-STTEP provides a methodology to investigate and articulate my practice and notice the gaps between my self, my practice, and my practice with others. The methodology allows me to recommit in an ontological way to the improvement of my practice as a technology teacher educator.

The exemplar below shows evidence of my actions as a technology teacher educator in the nature of the way I bring forward a definition of technology to teacher candidates. As the exemplar demonstrates, I embed the definition of technology in the lens of maker pedagogy as an educative technological approach and suggest that:

making is educational design and can be brought into the classroom to focus on teacher candidate interests and understand learning as integrated in the embodiment of making projects rather than as isolated sets of skills (West-Puckett, 2014). While tools are exciting and 3D printer or laser cutters may be the newest technologies, the focus is on design for learning and not the tools, it is process over product. Designers need to be mindful of the meaningful integration of the affordances of technology as a tool to learn with as an intellectual partner (Sator, Data Source 1 Teacher Notes Week 1, 2017).

In scrutinizing my actions as a technology teacher educator, surprisingly, I find no evidence in my actions that expand the definition of technology and I missed an opportunity for dialogue with teacher candidates about their views-about and definitions-of technology. It is evident that there is a misalignment in my self-in-practice and my practice-with-others. Self-critique guides me to reframe my practice as the above exemplar shows that I do not actually define technology or invite and engage the teacher candidates to collaboratively define technology or educational technology. This action is entirely mis-aligned to my espoused theory that values the historical legacy of the definition of technology (Marx, 2010) and the consequent ideological and substantive developments that framed the changing definition of the term. I understand that to improve my practice, I need to engage teacher candidates in a collective definition of technology is critical in the context of this course to establish the meanings conveyed by the concept of technology to illustrate the harm of technologically deterministic thinking.

I sought corrective measures to my theories-in-use through a process of self-assessment and questioning in the search for effectiveness through *double-loop learning* (Argyris & Schön, 1974). Double-loop learning as an action has the potential to alter my governing variables and can result in a perspective shift, but it may be challenging to unearth if it remains an individual pursuit, wherein the knowledge remains tacit, and so I sought the literature to help me uncover the problem in my practice. To embrace this tension as positive failure, my assertions for action is to highlight the assumptions that define technology as an entity and agent of change (Marx, 2010), and in this way teacher candidates would have understood the assumptions made by the mechanic arts suggesting that innovation was the driving force of human history (Marx, 2010). This perspective would draw attention to the effects of science and mechanic arts that continue to triumph around the notion that innovation improves the human condition. Further, an improved practice would draw attention to the historical roots of technocracy

and the science and technology divide and set the scene for understanding a philosophy of technology in a different way.

Another assertion for action would be to draw attention to the outmoded lexicon (Marx, 2010) of technology and offer a definition of technology for everyone to think about, such as that offered by Howard (1994). Howard's (1994) definition would have offered a starting point in a dialogue that moves away from the reified view of technology to the study of technology that embraces the skills, knowledge, and machinery of society and serves the national identity (Howard, 1994). A further assertion is to invite an open discussion about technology and probe the teacher candidates to collectively articulate what technology means to them and how we may define it for the purposes of the course. Through such an activity, the exploration of educational technology and the historical and intellectual historicity of how technology is defined would have reflected my self-in-practice and provided a better foundation for my practice-with-others. Furthermore, the subsequent course topics, namely: 1) lessons from the field of educational technology and the lack of educational reform (Clark, 1994; Kozma, 1994; Reiser, 2001), and 2) myths related to educational technology resulting from popular culture, would have stronger underpinnings. I missed the opportunity to discuss from the teacher candidates' view how the historical definitions of technology have sociological implications (e.g., Agalianos, Whitty, & Noss, 2006; Cuban, 2001) and this could have shed light of the reason why myths exist in the field of education and technology. S-STTEP methodology is credited for revealing the space between my self-in-practice and my actions as a technology teacher educator to understand my professional knowledge. A deeply reflexive approach allowed me to question my practice, scrutinize the gaps in my actions, and propel me towards reframing my self-in-practice with others for the improvement of practice.

Evidence of my actions as a technology teacher educator show that my espoused theories related to the philosophy of technology and the nature of technology within the framing of technology authorizer are aligned to my theories-in-use. In my actions, I engage teacher candidates with thinking about the symbiotic relationships between science and technology, to consider technology not just as a tool to support science, and how maker pedagogy may reinstate the interdependent relationships (Bullock & Sator, 2015) between the disciplines (Sator, Data Source 1, Teacher Notes Week 1, 2017). Evidence in my actions also demonstrates that I raise attention to the

nature of technology (Bullock, 2016) through learning-about technology (Sator, Data Source 1, Teacher Notes Week 2, 2017) via maker activities (such as Scratch). Through interactivity with the scholarship in the field, S-STTEP methodology evokes a deeper understanding of my practice in the philosophy of technology. My theories in action draw on the philosophy of technology to help support teacher candidates' understanding about the nature of technology. For example, my actions reveal that I engage teacher candidates in reflection-in-action about how knowledge of how people learn-about technology in technological environments is linked to how teachers design learning environments. I improved my practice by understanding in depth that the nature of technology has abstract, practical, and tacit elements that are closely bound to the activity (Morrison-Love, 2016).

In the course, teacher candidates had hands-on and practical experiences with educational technology. For example, each maker experience was unpacked with teacher candidates through reflective dialogue to discuss the learning value, how learning through making happens, and the possible integration of the maker experience into future teaching opportunities to extend the social and epistemic competencies of technology (Desjardins, Lacasse, & Belair, 2001) in the teacher candidates. My practice aimed to avoid the pitfalls of other approaches wherein teacher candidates did not have support for the integration of technology in their practice beyond learning to use specific technological skills such as programs or software (Lawless & Pellegrino, 2007). I now also understand that my practice acknowledges what Bullock (2016) stated, in that typically there is "little attention paid to how future teachers might develop a sense of technology beyond a specific device" (p.3); which this is consistent with the findings that most technology courses and research focused on the attainment of skills for using technology (Niederhauser, Salem, & Fields, 1999).

I consistently bring maker pedagogy and experiential learning as educational technologies to the forefront in activities, discussions, and assignments as a way to frame thinking about educational technologies. S-STTEP methodology through the pillar of interactivity supported me to reveal a tacit component of my knowledge, namely: a main theme in the philosophy of technology is the nature of technology (de Vries, 2018). I understand my professional knowledge of a philosophy of technology to belong "to the realm of epistemological inquiry" (Skolimowski, 1996, p. 371) that involves reflective practice and "aims at the investigation of the nature and structure of technology,

conceived as a brand of human learning and analyzed for its cognitive content” (Skolimowski, 1996, p. 372). I understand my professional knowledge related to the framing position of technology in a different way as a result of interacting with the scholarship in the field.

Moving on to the other aspects within the framing position of technology authorizer, I found that my actions as a technology teacher educator showed little evidence for opening a conversation about technology and society, this similar to my actions related to the definition of technology. My espoused theories are fundamentally shaped by the social construction of technology (SCOT) theory (Pinch & Bijker, 1984) that provides a research program for viewing the technology and society relationship, yet, I found that my self-in-practice is not enacted in my practice-with-others. Self-critique in self-study methodology pushes me to improve my self in practice with others and to understand the importance of problem-finding in my practice (Schön, 2001). It is the problem-finding activity of professional practice that engaged me to access the artistry of teaching and cope with the uncertainty and complexity of the intermediate zone of practice (Schön, 1983).

An assertion for action is to integrate SCOT theory and social shaping of technology as lenses to support teacher candidates’ understanding about how innovation unfolds as a process of technology and society relationships wherein the meaning of technological artifacts is co-constructed (Bijker, Hughes, & Pinch, 2012). This would support teacher candidates in the integration of educational technology and coupled with more lessons from the field of educational technology, teacher candidates would be better able to dispel the myths of popular culture related to educational technology and to critically analyze the inherent positivity in the use of technology (Skolimowski, 1996). While I do address popular culture and historical frameworks as the exemplar below shows, I recognize that more attention to society and technology aspects within a framing position of technology would greatly enhance my professional knowledge and improve my practice for the benefit of teacher candidates learning.

Good question: "What is it that makes maker movement, the "maker movement?" Unfortunately, the answer is answer is complex, and it means a lot of different things to different people. For some, it is counter-culture inspired, for others it's economics and inventions, to others marketing, and for some it is anti-consumerism. So, I guess it depends who you ask. And even within particular affinity groups, you might find different positions. If

we look to Brevan's article for guidance, even educative making has different aims as it can come in the form of kits, creative construction, or tinkering, which ostensibly have different goals. I think it is context dependent and teachers will have to build an identity in the maker movement, and take a position. In this way we can contribute to a part of the movement that we firmly believe in, and that may differ for all of us. So, I don't know if we can direct the movement, or if we even want to, as part of the beauty is negotiating all the creative contributions from so many. What we can do is weigh the information, read the scholarship, and assess the evidence for practices we believe in (Sator, Data Source 3, Online Discussion Week 2, 2017),

S-STTEP supported my inquiry and allowed me to reveal the complexity inherent my professional knowledge of a framing position of technology. With this self-scrutiny and questioning I “turn thought back on itself” (Schön, 1984) to see the space between my practices and actions and understand the process of becoming a technology teacher educator, which includes all the nuanced and integral aspects of professional knowledge and its development.

## **6.4. Learning Design**

This section will unpack the learning design authorizer to uncover my professional knowledge of learning design and the four elements, namely: 1) the learning environment, 2) abilities for a technological world and technological competence, 3) design thinking and evaluation of technology, and 4) relationship with technology.

### **Learning Environment**

In my teaching, I frequently questioned my actions in the moment as the exemplar below demonstrates.

I am curious about something, my practice tends to make the assumption that teacher candidates know a concept, likely because I have assigned readings to them, and perhaps they have explored it in other courses. My practice tends to err on the side of wanting to entice and provide new ideas and extend the teacher candidates' thinking as perhaps I fear (and this may not be the right word) that teacher candidates have already heard or learned what I am talking about and I know that I want to avoid repetition for them- this is now signaling to me that I do need to get a better understanding of their personal history. So back to the point of wanting to provide new understandings for teacher candidates, my practice/ belief is

that they are prepared for elaborations of the materials in class, yet my actions reveal that I still check-in to see if teacher candidates have the underpinnings (Sator, Data Source 3, Reflection-on Week 3, 2017).

With the above concern identified, in the same week, I also note in my teacher educator journal an important discussion with a teacher candidate. This student came up to me after class and thanked me for the detailed feedback on her assignment and went further to say:

“we all really love your teaching and this class”. She told me what she meant by that was that the people she had spoken with agreed that they all appreciate how much input I seek from them to design their learning experience and that many teachers in her past did not care if the class did not seem to understand something, they just moved on. Also, she said that she knows how much work I put into drawing together their thoughts, comments and discussions and weaving them back into the class experiences. She apologized for not completing one discussion, which is not even for marks (Sator, Data Source 3, Reflection-on Week 10, 2017).

The exemplars above provide a great insight into a tension (Loughran, 2007) in my teaching about repetition and elaboration in the learning environment. It is through S-STTEP methodology that I am able to reflexively consider my relationship to my self and others in my practice and reframe my practice. S-STTEP methodology allowed me to use this interaction with the teacher candidate to understand how my actions with others are perceived and to understand how my intentions are aligned to my enactments. I understand that my theories-in-use are inclusive of teacher candidates' voice and evoke reciprocal discussions. This understanding reconciles my practice for the design of the learning environment to be inclusive of checking-in with teacher candidates as based on the content-specific needs and teacher candidates' voices and that elaborating and advancing the learning of teacher candidates' is my primary target.

I understand my practices and actions of technology teacher education to include the teacher candidate voice in the learning environment. I wrote in my teacher education journal that:

Teacher candidates need a voice and by sharing their voice, their learning is more meaningful. I encourage high-level thinking by inviting teacher candidate experiences, voices, opinion, negotiation, and co-construction of problem solving to my classroom. Then my role is connecting their experience to scholarship and literature and providing them with the foundations for decision-making and enhancing confidence in their practice (Sator, Data Source 3, Reflection-on Week 10, 2017).

I ask these questions as part of every class. The online discussions are built around what teacher candidates know, have done, and what questions they have, and these are brought into the follow week's lesson. This practice reveals to me that I believe in working in the present moment of what is real to teacher candidates, it's my ontological commitment as a teacher. I am not using examples that I have heard of or read, rather, I ask for examples from their own lives. This makes my teaching experience more challenging as I have to think carefully in the moment about how to navigate, integrate, and connect the shared experiences to the goals of the lesson. However, I really enjoy these moments and have unpacked this teaching strategy with my class, as it allows for the emergent outcomes of particular learners to surface as they all have unique angles or issues that they would like to pursue (Sator, Data Source 3, Reflection-on Week 9, 2017).

However, I aimed to uncover how I seek the teacher candidates' voice in the present moment. In my teacher educator journal, I said:

while we were co-constructing the group project rubrics, part of which has a peer and self-assessment of contribution to the project, what I perhaps did find unexpected, yet completely logical, was that the teacher candidates did not think that peer and self-assessment of contributions to the group project were relevant at this stage of their academics as they felt that they were all making a consistent contribution to the group project. Therefore, after a class discussion, and me asking more specifically what type of feedback they would find useful, they suggested that open-ended qualitative feedback, by way of 2 stars (what was good) and 1 wish (what needs improvement) was something they would like to implement. I will create a Canvas Collaboration for peer feedback on each group project and allowed for anonymous and immediate opportunities for teacher candidates to do to (Sator, Data Source 2, Reflection-in Week 10, 2017).

I use the online discussions for the week in their class reflections to integrate what teacher candidates know. I ask them to consider how their ideas relate to the scholarship and I ask them to share experiences. Then I try to integrate their reflections and experiences into the discussions (Sator, Data Source 3, Reflection-on Week 2, 2017).

Self-study methodology allowed me to understand my practice in a different way and to notice that collaboration is inherent in my practices-with-others in the design of the learning environment and this is consistent with strategies for technology teacher education (Kay, 2006). I refer to the literature to improve my practice of using collaborative discourse processes for making group knowledge explicit as it draws from the foundation of tacit knowing (Stahl, 2004). I uncover in my practice that collaboration has an ontological position in that meaning is constructed in group interactions and that collective prior knowledge shapes the group's interpreted reality (Stahl, 2004).

I understand now that the course activities are designed with collaboration in mind and the use of dialogue and reflection (Ottenbreit-Leftwich, Glazewski, & Newby, 2010) on in-and-out of class experiences and on the readings are commonplace. This practice is similar to what Anderson, Imdieke, and Standerford (2011) concluded in their self-study, that feedback from teacher candidates is “vital to validating our competence to helping us modify our teaching” (p. 12). Through reflexive methods in S-STTEP, I consider my self in practice with the other and understand that my tacit knowledge is connected to facilitation as an epistemic position (Hunt & Melrose, 2005) of the technology teacher educator. The course activities invite the teacher candidates to have a voice wherein the learning space is open for query, comments, and as a class we unpack my teaching actions as I model the use of technology integrations (Moursund & Bieleedt, 1999; Kay, 2006; Ottenbreit-Leftwich, Glazewski, & Newby, 2010). In this way, I feel that “by demonstrating and articulating what comprises our expertise, we are able to make explicit the complexity inherent in teaching” (Boche & Shoffner, 2017, p. 62).

Using S-STTEP methodology and the method of interactivity with teacher candidates, I have come to understand differently that my professional knowledge of learning design involves the constant reflection on my practice-with-others in how I mediate the learning environment. Through S-STTEP I am able to reflexively uncover my tacit knowledge of facilitation as a way to learn collaboratively with-and-from each other. This embodies maker pedagogy in the design of technology teacher education in that I re-use and re-mix their feedback and adapt my practices in the moment to model the identity of the teacher as a curriculum maker (Clandinin & Connelly, 1992). Through an examination of my practice with teacher candidates, I uncovered that my actions are not about making a lesson and following it through, it is about being in the moment and making an experience for your learners. In the course we learned about creating maker dispositions, a maker ethos, and maker mindsets for those we teach, but as maker educators, we must live that in the classroom. The lesson plans I designed are the products I develop in advance of my teaching and present my ideas and imagination, but being in the classroom with the teacher candidates is about iteration, getting live feedback from your audience, about seeing if things work in the way you had intended (likened to the prototype/ lesson), and embracing positive failure as learning moments for yourself and the teacher candidates. I can now say with confidence that maker pedagogy was the catalyst for the design of a learning environment that simultaneously

provided a lens to examine my teaching practices and actions from a theoretical stance. This creating is rather unique in my pedagogy as the literature in technology teacher education does not appear, to my knowledge, to discuss the importance for creating a learning environment with teacher candidates.

## **Abilities for a Technological World and Technological Competence**

To foster technological abilities and technological competencies, my practice with others as a technology teacher educator involves extending the learning environment beyond the confines of the university and classroom setting. My actions reveal to me that I invite the knowledge created, processes of learning, and lenses of a variety of contexts in how these shape teacher identities. The contexts outside of the classroom have the same rigour as the in-class experiences and I engage teacher candidates with the self-assessment of skills and knowledge required to complete the project at hand (Bullock & Sator, 2015). Although this finding is personally valuable, it also connects to the scholarship in the field. My practice is consistent with Cohen's (2017) recommendation that research on technology integrations showed that technology use is more likely if there is 1) relevant technological knowledge (Mueller, Wood, Willoughby, Ross, & Specht, 2008), (2) self-efficacy relative to teaching with technology (Wozny, Venkatesh, & Abrami, 2006), and (3) a belief system which values technology as a necessary ingredient to successful education (Ertmer, 2005; Ertmer & Ottenbreit-Leftwich, 2010; Kim, Kim, Lee, Spector, & DeMeester, 2013).

In the examination of the self-study data and my actions as a technology teacher educator using maker pedagogy as an educational technology, I uncover aspects of my tacit knowledge. Using S-STTEP methodology and interacting with the literature, I uncover aspects of my professional knowledge to understand my practice at a deeper level. By having teacher candidates engage in hands-on learning (Ottenbreit-Leftwich, Glazewski, & Newby, 2010) with educational technologies outside of the institution, I designed a learning environment that allowed teacher candidates to get a sense of science and technology education at authentic (Ottenbreit-Leftwich, Glazewski, & Newby, 2010) experiential learning sites. Following the diverse site visits, teacher candidates used reflective methods to contemplate their abilities and discussed how to address gaps (Ottenbreit-Leftwich, Glazewski, & Newby, 2010) in their knowledge. My practice is consistent with Foulger, Graziano, Schmidt-Crawford and Slykhuis (2017),

who developed twelve competencies that they believed teachers needed to support the integration and use of educational technology. The site-visits and sharing of reflection improved teacher candidates' access (Kay, 2006) to diverse educational technologies and was formative in their transfer of knowledge to other contexts. My actions included having teacher candidates talk about various applications of educational technology in different educational settings and the possibilities for integration into their teaching practices.

S-STTEP methodology allowed me to understand my practice in a different way and I shifted the way I understood how to design for expanding teacher candidate's technological competencies and the processes of getting to know diverse technologies and systems. My tacit knowledge in the activities place at the forefront how I foster teacher candidates' mindsets for being curious, being inquisitive, and to explore and play while learning about different educational technologies. Through S-STTEP methodology and interacting with the scholarship in the field of educational technology, I uncovered that my enactment of technology is influenced by factors such as providing time for experimentation and discussing the beliefs and attitudes (Goos, 2005) that enhance technology integration. This is consistent with Wise and O'Neill (2009) recommendations for educational technologists to be mindful of timing and context as part of the design toolkit.

In the course, the teacher candidates completed maker activities (e.g.: squishy circuits, Scratch, augmented reality) and a maker project (e.g. Slowmations) to develop technological competencies. The activities provided intentional time for teacher candidates to gain practical abilities with the technological world and connect with their authentic interests and personal inquiries. Evidence of my actions with others demonstrated that I dedicated class time to allow teacher candidates to develop abilities for a technological world and that I integrated reflection-in the moment of the activity to make explicit teacher candidates' knowing-in-action (Sator, Data Source 1, Teacher Notes Week 2, 2017). After a class where teacher candidate's explored Scratch, I wrote in my teacher educator journal that:

this week we started in a computer lab, where I gave a quick demonstration (5min) about Scratch, and it was intentionally low level. I did not give an expectation to the class that they had to create anything specific, I just let them play with the technology. I did not expect that they would be as enthusiastic as they were. They all wanted to play, would get up and ask me or each other questions, and show one another what they had discovered. It was unexpected that the time would pass so quickly; I thought perhaps I had booked too much time for this activity, but in fact, it was just right, perhaps could even have been extended. Their reactions were slightly unexpected in that they were so pleased to play with the programming and it affected teacher candidate learning, as I understood later in the unpacking of the activity using a maker pedagogy lens in the class reflections, that they appreciated having no final or decisive outcomes, but the task was to hack, adapt, reuse, and create something meaningful to them (Sator, Data Source 3, Reflection-on Week 2, 3017).

I am able to state that a part of my tacit professional knowledge of supporting teacher candidates to develop abilities for a technology world is deeply connected to Howland's (2012) meaningful integration of technology and Schön's (1983) knowing-in-action. Howland (2012) re-united the field of technology and the use of technology in schools by refocusing the connection between technology and thinking about learning and framed the integration of technology as meaningful learning activities rather than the affordances of technologies. The Scratch maker activity supported teacher candidates to inquire, experiment, and design with the technology in a way that engaged them in intentional, active, and collaborative learning (Howland, 2012). Further, the activity supported the development of teacher candidates' competencies in their use of technology. As the exemplar above demonstrates, teacher candidates had the opportunity to develop competencies with technical order (Desjardins, et al., 2001) in that they operated on the software, and they developed social order competencies (Desjardins, et al., 2001) in the use of technology to interact with their peers. This is also consistent with Hasse's (2017) recommendation to explicitly address "the analytic capabilities that teachers need in order to engage effectively with technological development" (p. 365). Finally, the maker activities supported teacher candidates' development of epistemological order (Desjardins, et al., 2001) competencies by way of learning with technologies to engage in authentic situations, test their ideas, and modify and create diverse technological artifacts.

While my teaching actions with others do align to my self-in-practice, reflexive approaches push me to question my actions in this professional knowledge authorizer more deeply. Reflexivity and self-scrutiny suggest to me that the topics and suggestions

for the maker activities, maker projects, and educational technologies may better support teacher inquiry if they are teacher-candidate-directed. I could improve my practice by inviting the teacher candidate's voice in determining the educational technologies that we investigate as a learning community. S-STTEP methodology supported me to understand that the authority resides in feeling confident about providing material experiences for teacher candidates to make meaning of learning for themselves. This ties in closely with espoused theory, as identified in my Q-sort, in that my assumptions, practice, and actions are based in the belief that experiences are an epistemic source of knowledge. I feel the provision of tangible experiences will allow teacher candidates to get a feel-for-it and that this is imperative for the development of teacher identity, attitudes that support development of technological competencies (Foulger, et al., 2017), and abilities for a technological world.

## **Design Thinking and Evaluation of Technology**

Design thinking and the evaluation of technology in my practice with others is an aspect of my pedagogy as a technology teacher educator. My espoused theories are enacted by design thinking and media literacy frameworks (Sator, Data Source 1, Teacher Notes Week 6, 2017) to engage teacher candidates in their roles as curriculum makers (Clandinin & Connelly, 1992). Evidence of my actions demonstrate that my practices integrate evaluation of educational technologies as tools to learn-with (Howland, 2012) in order to support teacher candidates to think about the appraisal of educational technologies and the design of learning. To support teacher candidates in their design thinking, evaluation abilities, and assessment with technologies, one of the course assignments asked teacher candidates to:

use diverse technological media (e.g. podcasts, screen casts, mind maps, animation, infographics, and/or digital portfolio) to demonstrate pedagogical insights afforded by doing things, having experiences, and/or making things in a technological environment (Assignment #2, Education 496, 2017).

S-STTEP methodology allowed me to uncover a tacit component of my professional knowledge for design thinking and evaluation with-and-of technology, namely: different technologies do different epistemic work and that this is a core part of the design of learning. I am able to articulate, through interaction with the scholarship in the field, that the design of the learning environment impacts the function of the technologies (e.g.:

Howland, 2012; O'Neill, 2016) and that selection, evaluation, and design for thinking are integral components of my professional knowledge.

## **Relationship with Technology**

My espoused theory as a technology teacher educator is to engage teacher candidates with thinking about their relationship with technology through dialogue to support their “process of coming-to-know” (Pinnegar & Hamilton, 2009) themselves as teachers. One teacher candidate commented on the fear that her own students may have more technology knowledge than she does, but that this did not shape how she felt about working with new technologies (Sator, Data Source 2, Reflection-in Week 6, 2017). Examining the teacher candidate’s voice more closely using S-STTEP, I am able to make explicit my practice-with-others; the premise here rests on the spontaneity of my actions wherein I often “cannot say what [they] know” (Schön, 2001, p. 194) and this involves knowledge which is inherent in my patterns of actions. I can now say that I support teacher candidates to state their beliefs and that this allow for their self-discovery of how technology may be integrated (or the barriers) into their in-service teaching. My knowing-in-action signals that my tacit knowledge is to guide, facilitate, and mentors teacher candidates by providing a space for them to gain confidence from their authority of experience (Brandenburg, 2008).

With this understanding about my professional knowledge, I am able to self-critique via self-study methodology this practice and improve it, specially in the way that I integrate the teacher candidates’ perspectives about knowledge in technological environment from the Q-sort activity. Further to the activity in class, wherein teacher candidates reviewed and commented on my interpretations of their world views and discussed implications for teaching as drawn from the world views (Sator, Data Source 1, Teacher Notes Week 3, 2017), we could have unpacked their beliefs and related these to implications for technology integration. My assertion for action is to integrate into my future practice an explicit discussion with teacher candidates that focuses on how their beliefs will influence their practice and motivations to integrate technology (Derban & O'Neill, 2018).

My espoused theory is that the relationship to technology is related to identity as a technology teacher educator. My theory-in-use is aligned to this and my actions

demonstrate that I support teacher candidates to draw these connections throughout the course and activities (Sator, Data Source 1, Teacher Notes Week 4, 2017). An exemplar of my practice-with-others is in a lesson (Sator, Data Source 1, Teacher Notes Week 4, 2017) that invites teacher candidates to grapple with their identity as teachers. The lesson underscores for the teacher candidates the purpose of understanding their identities as related to their beliefs and assumptions about the theory of knowledge and the influence this bears on learning design. Socio-cultural lenses supported the teacher candidates in understanding their identity and teacher candidates are asked to consider the role of emotions and feelings that affect the way we learn, reflect, and teach (Sator, Data Source 1, Teacher Notes Week 4, 2017). To unpack their teacher identities, the teacher candidates first created a found poem or an identity sketch and then engaged in dialogue with a peer to unpack the meaning ascribed to the artifact (Sator, Data Source 1, Teacher Notes Week 4, 2017). Self-scrutiny and reflection-on this practice through self-study methodology invites me to look more closely at my actions related to fostering a teacher identity. I understand my professional knowledge in a different way through S-STTEP and realize that I did not draw connections between the teacher candidates' beliefs about the theories of knowledge from the Q-sort and their identities as technology teachers. I expose this tension in my practice as a way to improve it for the benefit of teacher candidate learning. Further, I did not engage teacher candidates with an activity to illuminate their beliefs about educational technology and how there is a relationship between pedagogy and technology. My assertions for action are to improve my practice to include implications for technology integration from Deng, Chaai, Tsai, and Lee's (2014) findings about teachers' beliefs in educational technology; these are of two types: 1) teacher-centered beliefs that are linked with behaviorist approaches to learning and the role of the teacher, and 2) student-centered beliefs that are linked to constructivist approaches to learning and the role of the teacher. S-STTEP methodology revealed to me the ways in which I can better support teacher candidates development of a teacher identity and relationship with technology.

## 6.5. Learning Theory

Using learning theory in my pedagogy draws heavily of the scholarship of the field of how people learn, the history of technology and philosophy, the movements in educational technology, technology teacher education, and epistemology. As an example, the approach taken by Niederhauser, Salem, and Fields (1999) in their research with technology teacher education was formative in my practice as I also aimed to guide teacher candidates towards the development of a theoretical orientation towards pedagogy. Niederhauser, Salem, and Fields (1999) felt that by having a handle on theory, teachers could attend to the decision-making processes required for the effective integration of technology in their teaching. Niederhauser, Salem, and Fields (1999) focused on learning theory to provide a framework for:

- a) examining how different types of computer programs can support different learning goals, (b) how software can be selected to meet instructional goals based on learners' needs, and (c) how to evaluate new educational technologies in the context of student learning (p.169).

My actions with teacher candidates provide evidence that I my espoused theories and theories-in-use are consistent in my professional knowledge of learning theory. I always provided teacher candidates with the opportunity to intentionally integrate learning theory with theoretical frameworks in their educative decision-making processes. For example, I engaged teacher candidates to use personal experiences and theoretical frameworks as thinking tools, as the assignment below shows.

The goal of this assignment is to provide you with an opportunity to explore a science and/or technology curricular learning experiences (i.e., that you had in the classroom) and to challenge to you think about this pedagogical experience and how you might teach that curriculum and/or concept differently. Consider the theoretical framework and principles of maker pedagogy and/or experiential pedagogy and the implications for design, development, and implementation of science and technology education using this approach (Education 496, Assignment #3, 2017).

I was however surprised with the teacher candidates' candid comments about their thoughts and knowledge about learning theory. My teacher educator journal notes that:

During the class discussions, my expectations was that there may be more explicit reference to the articles. There was some, but not quite as grounded in the readings as I thought, yet they connected the questions I posed for them to things that were realistic and practical in their experiences. This gave me the opportunity to draw that together with the readings, and so the lesson I prepared was supportive for reinforcing the language and reasoning for their experiences (Sator, Data Source 2 Reflection-in Week 2, 2017). Teacher candidates were surprisingly unaware of concepts like sociocultural theory and how this lens has affordances for understanding one's identity. They asked some questions. This signaled to me that I needed to further explain this theory to them (Sator, Data Source 2, Reflection-in Week 3, 2017).

Using S-STTEP methodology, I understood my professional knowledge more deeply as a result of my interaction with teacher candidates, which helped me uncover my practice (Pinnegar & Hamilton, 2009). Some teacher candidates remarked that learning theory was not a big feature of their academic programs. The voice of the teacher candidates drew my attention to the extraordinary place that the literature and learning theory has for some teacher candidates and that they often do not see the utility of drawing on these foundations in making educative decisions. Further, as I wrote in my teacher educator journal, the challenge as indicated to me by teacher candidates is that the literature is complex and vast, and they had difficulty in determining the right sources for their teaching practices. I concurred with their sentiments and said in my journal that:

There are a few things that made this lesson planning challenging, largely, that there is no single resource or foundation of learning theory in maker pedagogy that underpins the learning outcomes and thus governs the pedagogical practices that a learning designer may adhere to. Further, there is little research evidence on educational outcomes, what teacher candidates are really learning, through making. There are many valuable sources of information and I drew on learning theories of constructivism and constructionism, and pedagogical principles of design thinking, media literacies, and meaningful integration of technology to support thinking about curriculum design. This is work that I have been engaged with for quite some time, and it took a lot of time to process, synthesize and analyze all of what I see as inputs (learning theories and theoretical frameworks) into the process of planning curriculum using maker pedagogy. This work is not something my learners have engaged with and much to my surprise during the lesson, many teacher candidates (perhaps even all) did not know what a learning theory was or why it had utility for teachers (Sator, Data Source 2, Reflection-in Week 6, 2017).

Further, I wondered if teacher candidates saw the value of theory in their own practices. After a lesson, I wrote in my teacher educator journal that:

I felt that I used some very practical examples of why to consider theory and knowing about how people learn is relevant to their thinking, as it provides the theoretical foundation and frameworks from which they may draw from to demonstrate the educational significance in the decisions they make in their teaching. We dove deeply into Kolb and Kolb's (2005) Cycle of learning, Schön's reflective practice, and Lave and Wenger's situated learning, and I introduced Meizrow's transformative learning, which they had not heard about before. I think with theory and this makes me comfortable in my pedagogy of technology education and I feel that I gravitate towards orientations to curriculum that support experiential and constructionist views on why learning works in a technological environment. I tried to make this perspective clear to the teacher candidates and I could sense some shift in how they felt about the value of learning theory. I do however wonder how they carry out their planning and curriculum design. I sincerely wonder if they are still thinking about 'an activity' they like teaching with and then designing curriculum around that because as I listened to one group talk, this is the sense that I got (Sator, Data Source 3, Reflection-on Week 7, 2017).

S-STTEP methodology and interactivity with others supported my deep understanding and improvement of my professional knowledge of reflective practice. I stated that I understood that theory must be discussed in application to teaching and through teacher candidate-led dialogues about the implications, value, and utility of theory in their pedagogy. I circled back to Okojie, Olinzock, and Okojie-Boulder's (2016) work that appeared to take up the ideas of Niederhauser, Salem, and Fields (1999) and detailed the importance of thinking about pedagogy in the success of technology integration through the exploration of the relationship between pedagogy and technology. I came to understand more deeply now that learning theories describe how people learn and have utility for the field of educational technology in supporting how people develop and use learning resources, as well as for the articulation of problems from which research stems.

This brings to clearer focus the point where Reigeluth (1983) reminds me of the descriptive-prescriptive distinction in the construction of instructional theory from learning theory and suggests that it is challenging to derive implications for practice from abstract theory. I am able to reframe my practice-with-others in a way that in the future will provide more discussions about the utility of theory, frameworks, and the scholarship of the field by drawing on teacher candidates' perspectives and modeling my practices. This moves my professional knowledge forward in a way that acknowledges the relationship between epistemology, pedagogy, and technology (Okojie, Olinzock, and Okojie-Boulder, 2016). I am now able to state that part of my professional knowledge as

a teacher educator is to draw intentional linkages for teacher candidates, to make inquiries of teacher candidates, and facilitate meaning making between their authority of experience and the scholarship, which sometimes teacher candidates do not do on their own.

## **Part 2**

### **6.6. Research Question 3: My Pedagogy of Technology Teacher Education**

This section will address the third research question: How might my personal pedagogy of technology teacher education be influenced by my perceptions of students' changing theories of knowledge for the design of educational technology within a post-secondary environment?

My perceptions of teacher candidates' changing theories of knowledge provided me with insight about my personal pedagogy of technology teacher education and for the design of educational technology within a post-secondary environment. In this section, I analyze my perceptions of teacher candidate's changing theories of knowledge and use self-study methodology to reflexively examine my professional knowledge to understand the influences of teacher candidates' changing theories of knowledge on my pedagogy of technology teacher education. Exemplars of the teacher candidates' voice are used throughout this section as they are the signals that allowed me to re-frame my pedagogy of technology teacher education.

#### **6.6.1. Reflective Practice**

The quote below, as written in my teacher reflection journal, captures my thoughts about teacher candidates' changing theories of knowledge and the role of reflective practice:

We had a good and detailed discussion about the value of reflection and how the process really fosters the analysis and synthesis of teacher candidates' knowledge. Teacher candidates admittedly dismissed the power of reflection in the early stages of the course. However, using Schön's theoretical framework, they realize now that they are reflecting in action and this shapes their teaching in the moment (Sator, Data Source 3, Reflection-on Week 7, 2017).

As discussed in my interpretations of teacher candidates' world view in Chapter 4, some teacher candidates' theories of knowledge embraced reflective practice, particularly those sharing World View 2, and other teacher candidates felt less closely connected with reflective practice. The largest shifts in thinking that I observed occurred with teacher candidates sharing World View 3; these teacher candidates indicated in the Q-sort that they do not believe that reflective practice supported the construction of their knowledge in technological environments, and they tend to evaluate the knowledge gained from experience against their propositional knowledge. Yet, as the course progressed, in the course assignments of teacher candidates sharing World View 3, I found evidence of the teacher candidates' shifting perspectives towards reflective practice as a method that supports the construction of knowledge. One exemplar that demonstrates this shift in how a teacher candidate viewed reflection and stated that, "I will change I how implement learning experience through Kolb and Kolb's (2005) model, how to share findings, and reflect on knowledge" (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Another shifting perspective was in teacher candidates who share World View 1, as initially they did not indicate that reflective practice, or that reflection-in-action, was a significant component of their theory of knowledge. Over the course, as evident in their assignments, the teacher candidates in World View 1 did shift their perspectives, and one teacher candidate said they see "the value of reflection" (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Teacher candidates sharing World View 2 indicated that reflective practice is an important part of their theory of knowledge. And, as the course progressed, these teacher candidates demonstrated a deeper level of understanding about reflective practice. For example, teacher candidates in World View 2 said that they understand the:

Use theory as a lens to support teacher candidate learning, e.g. Kolb and Kolb's (2005) reflection cycle (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Assessment strategy with technology to learn through building on knowledge representations e.g. project with a reflection component to learn using the what, so what, now what (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Value of detailed reflective journal- why and how thinking/ models change (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Increase reflection, reflect on experience for deep understanding (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Curricular alignment with reflection to check back and internalize the learning process (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Value of reflection and Kolb and Kolb's (2005) reflective cycle, understand how to assess reflection, what reflective processes mean (Sator, Data Source 3 Teacher Candidate Voice, 2017).

The exemplars below present the teacher candidates' voices after Week 7, as drawn from their course assignments. The exemplars demonstrate the teacher candidates' changing theories of knowledge towards being more mindful of the value of reflective practice. The teacher candidates stated that:

You can also potentially supplement the project with a reflection piece, where students have journals regarding their own experience and process throughout the project. You can include guided questions such as what they tried to do, what didn't work, why it didn't work, and what they did as an individual or a team to solve the problem (Sator, Data Source 3 Teacher Candidate Voice, 2017).

I remember one of my colleague's comment about the maker faire and her experience in asking a child who was participating in a making activity and had no clue about what she was doing. There was something important missing and this important part of the puzzle was the reflection which gave meaning to the whole activity. If it is not intentional, it is not going to work at all. The lack of reflection and intention turns making into a meaningless activity (Sator, Data Source 3 Teacher Candidate Voice, 2017).

I have never been big on reflections, but I am becoming more considerate/aware of the value of this part of an experience for myself. I believe students will benefit from this as well, so I plan to use reflections more often in my assessment. Here is where I can see opportunities for transfer or progression of knowledge by students through the reflective part of the Kolb and Kolb's (2005) cycle (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Prior to this course, I did not understand the full value of learning and understanding that can result from experiential learning. I also had equated this term to learning from experience. After reading the chapters from the reflective and experiential learning handbook, I have started to navigate the subtleties between learning from experience and experiential learning. However, this reading also challenged my notion of learning from experience and actually states that “all learning is learning from experience”. At first, I strongly disagreed with this statement but as I continued to read, I started to see what was meant. Essentially, the author proposes the idea that in order for learning to occur, the learner brings their own prior experiences through making connections to what is being taught regardless of how it's being taught. Learning occurs as a result of this process. While I agree that one learns through experience and experiential learning are different things, I am hesitant to group all learning as learning from experience. Rather I would suggest that learning occurs through reflecting on your experiences (Sator, Data Source 3 Teacher Candidate Voice, 2017).

This has made me look back on my own experiences and question whether those experiences have really helped gain deeper understanding or knowledge. I can see how fieldtrips such as going to science world or the aquarium where the purpose is providing students with experience can be meaningless. Therefore, it is important for us as teachers to make sure that the experiences we provide students are being reflected upon. Therefore, I like the idea of the experiential learning cycle presented by Kolb and Kolb (2005) (Sator, Data Source 3 Teacher Candidate Voice, 2017).

I never made the connection between how much reflective learning we do in the PDP program and why we should be implementing reflective learning activities in my own classroom (Sator, Data Source 3 Teacher Candidate Voice, 2017).

My personal pedagogy of technology education and professional knowledge of reflective practices have shifted slightly after analyzing the teacher candidates' changing theories of knowledge as they relate to reflective practice. As a technology teacher educator, I lead teacher candidates through many experiential learning opportunities, maker projects and activities, through collaborative opportunities to reflect-in and reflect-on experiences, and to think about the applications of their knowledge from these experiences to future teaching contexts. However, using self-study and reflexive methods about my role in supporting the design for reflective practice, I now understand that my professional knowledge needs to include more scaffolding for the teacher candidates. An assertion for action would be to include modeling in my practice (Kay, 2006) or facilitating more dialogue about the utility and value of reflective practices. While the integration of reflective practice was integral in every course activity, discussion, and assignment, perhaps the intentionality and rationale are not articulated

with enough depth in advance to teacher candidates. I have reframed this practice to underscore the value in discussing the utility and purpose of reflective practice and being more transparent with teacher candidates about the why, when, how, and what reflective practice means and looks like. S-STTEP methodology has supported me to understand my practice with others and how to meet the teacher candidates in the spaces that are most relevant to them.

### **6.6.2. Experiential Learning**

The exemplars below are drawn from teacher candidates' assignments and signal their shifting perspectives towards theories of knowledge that embrace hands-on learning, learning-by doing, and experiential learning. The perspectives of teacher candidates presented below signal changes in how they view learning design and particularly notable is their commentary about teacher identity.

As someone who went through the system when the maker movement and experiential learning was not inherent, I am excited to be part of this shift in pedagogy. I also found it interesting how it talks about teachers as makers of curriculum rather than simply delivering curriculum (Sator, Data Source 3 Teacher Candidate Voice, 2017).

I also liked the idea of teachers as makers of curriculum, as opposed to simply deliverers of information (Sator, Data Source 3 Teacher Candidate Voice, 2017).

I've noticed that many students accept the "way things are" from the authority figures in their lives, and kind of slip into a non-creative non-emotional attachment to the outcomes of things kind of attitude. As if they know exactly what they are capable of and don't push themselves any further because it's safer where they are (Sator, Data Source 3 Teacher Candidate Voice, 2017).

The whole the making process opens up a whole can of worms when it comes to self-determination, emotional control when frustrated or confused, motivation, and creativity. I think its super important to stress that trials/mistakes/ failures/ and throw aways are expected, celebrated, and contribute to learning in ways that following, instructions couldn't provide (Sator, Data Source 3 Teacher Candidate Voice, 2017).

The first is that making in education does not just happen on a purely individual level, as it often is in areas outside of school, but students can collaborate while working on individual projects. I think this is a great way to get students actively involved in their learning by teaching and working with each other. When we worked with Scratch, there was a lot of dialogue between us, the teacher candidates, to understand what works and how (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Epistemic sources of knowledge for teacher candidates sharing World View 1 include experiences, practical, and procedural knowledge and they believe that knowledge is constructed out of experience. Despite their strong beliefs in learning from experience, teacher candidates in World View 1 still expanded their perspectives to include “design and experiments for investigating and understanding, reflection on planning, and incorporate feedback and iterations to re-design plan” (Sator, Data Source 3 Teacher Candidate Voice, 2017) into the design of learning in technological environments. While, teacher candidates sharing World View 2 believe in experiential knowledge, practical knowledge, and that knowledge is gained through the experience of doing or making something, they affirmed that their theories of knowledge indicate the belief that knowledge can be produced and created versus reproduced or reiterated. Similar to the teacher candidates in World View 1, teacher candidates in World View 2 extended their thinking to include the value of hands-on-learning and learning by-doing as the exemplars below demonstrate.

Process-based meaning making (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Towards student-directed, agency, tinker and brainstorm solutions to a problem they are interested in (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Allowing students to have experience for themselves beyond the teacher demonstration to take ownership of education; students need to do it, need experience for themselves to learn; teacher is not the expert (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Integrate into learning design – planning, collaboration, analysis, meaningful conversation, reflection and iteration (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Role of teacher as facilitator that probes questions; Meaningful peer and teacher feedback (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Offer diverse materials/ tools for different knowledge representations (e.g. digital representations) (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Design the lesson in such way that students are leading their own learning through their curiosity within a well-structured framework (Sator, Data Source 3 Teacher Candidate Voice, 2017).

The thinking presented above demonstrates that teacher candidates in World View 2 broadened their perspectives to include more student agency in the learning design and concurrently thought about their relationship with technology and their identity as teacher-as-facilitator. As well, the exemplars above demonstrate that teacher candidates applied design thinking frameworks and thought about how to integrate technology in a way that supports the development of technological competencies through authentic (Ottenbreit-Leftwich, Glazewski, & Newby, 2010) experiences.

Finally, teacher candidates in World View 3 had strong beliefs that before one makes things or has an experience, they must develop their knowledge by reading about it, and this knowledge comes from things that they read in books or articles and/or learn from lectures. Teacher candidates sharing World View 3 demonstrated the largest shifts in theories of knowledge and showed evidence of an epistemic shift that embraced experiences in hands-on-learning and learning-by-doing through educational technologies. For example, teacher candidates in World View 3 said in their assignments that:

Inquiry versus teacher-direction, incorporate dialogue (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Move to student-centered problem finding/ solving in authentic contexts that is important to students and has a community connection; make meaning in way that is relevant to students (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Teaching approach towards meaningful learning, less didactic, create their own representation of understanding through technology (Sator, Data Source 3 Teacher Candidate Voice, 2017).

The above exemplars from teacher candidates in all world views demonstrate their shift in thinking about learning design, their identities as makers of curriculum, and using educational technology such as maker pedagogy to think about learning environments and their places as teachers with in it. Self-scrutiny through self-study methodology urges me to think about my professional knowledge and how I can improve

it. In analyzing my practice-with-other, I am able to reframe my practice for the design of educational technology in post-secondary environments to provide more opportunity to discuss the value and role that positive failure plays in meaningful learning with technologies (Howland, 2012) as well as demonstrating challenges with technology integration for teacher candidates (Kay, 2006). For example, in my teacher educator journal, I note that:

I did experience some technical problems, namely, that I could not get the video to run nor the ppt to show on the projector, but I got the teacher candidates started on the activity and the technology did eventually work. I was not as nervous about this, and I think it provided good exposure to teacher candidates about dealing with challenges in the classroom (Sator, Data Source 2 Reflection-in Week 3).

S-STTEP methodology supported the examination of my self in relation to others and how I could in future teaching opportunities intentionally plan for failure. In this way, I could illuminate tense experiences to expose fears around using digital or physical technologies as they are naturally pre-disposed to imperfection. Fear is an undercurrent that I felt in the teacher candidates and I now understand that it can really limit how one identifies with technology and positions themselves in their relationship to technology.

### **6.6.3. Framing Position of Technology**

At the start of the course, teacher candidates sharing World View 1 believed that knowing about historical and philosophical developments in technology enhanced their knowledge about technology. They strongly disagreed that technology cannot be altered and should be used the way it is designed. The teacher candidates holding this world view did not shift their perspectives but did deepen their thinking about methods in their framing position of technology. The teacher candidates stated:

Seeing how maker pedagogy and technology integration support goals to change the way we access methods of education (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Maker pedagogy includes the questions, predicting, planning, conducting, process and analyzing data, evaluation, communication, application and innovation- all the things that were missing from personal education experiences that would be brought into practice as a teacher (Sator, Data Source 3 Teacher Candidate Voice, 2017)

Other exemplars by teacher candidates in World View 1 highlight their thinking about the meaningful integration of technology (Howland, 2012) and they indicate that methods of testing idea, iteration, and positive failure are part of their framing position of technology. Further, these teacher candidates focused on the importance of learning through experiences and the complex processes involved in making meaning of that learning.

At the start of the course, teacher candidates sharing World View 2 approached educational technology from a place of exploration and novelty, rather than seek historical information about technological integrations and outcomes. Throughout the course, my perception was that teacher candidates were shifting in their perspective around a framing position of technology, as indicated by the following exemplars:

Values of history in technology- should be exposed to the latest technologies as well as the old methods so they can see the advantages and gain a deeper understanding of the reason why advancement in the methods was necessary and where the technology is still lacking (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Experiencing technology increased understanding about useful technology integrations (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Low risk for learning in maker pedagogy as design thinking supports iteration, problem solving, construction of knowledge (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Educative understanding of maker pedagogy approach: experiences, reflection, construction of new ideas, modification of ideas, student-centered in collaborative not competitive (Sator, Data Source 3 Teacher Candidate Voice, 2017).

As demonstrated in the above exemplars, teacher candidates sharing World View 2 did shift their theory of knowledge towards embracing the historical and philosophical nature of technology. These teacher candidates appeared to understand at a deeper level their identity in facilitating the learning environment and showed an increased understanding for the value of the processes over products in their theory of knowledge. The teacher candidates' exemplars revealed that student-centric approaches and authentic engagement gave them agency and the freedom to explore and that this comprises their framing position on technology.

At the start of the course, the teacher candidates sharing World view 3 expressed a strong belief in having propositional knowledge before they approach

activities, and this suggests the construction of knowledge may occur in specific ways in technological environments. These teacher candidates are inclined towards structure, such as building-on the knowledge they gain in demonstrations, through watching and listening to the instructor, reading articles, learning through instructional videos, and/or seeking reference materials prior to engaging with technology in the learning environment. As the course progressed, the teacher candidates in this world view shifted their perspectives on knowledge and stated that:

Experience is subjective (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Technology to learn from to technology to learn with and meaningful to learner engages and facilitates thinking and not delivery (Sator, Data Source 3 Teacher Candidate Voice, 2017).

Learning experience with technology is a relationship involving conversation, collaboration, reflection (Sator, Data Source 3 Teacher Candidate Voice, 2017).

As demonstrated in the above exemplars, teacher candidates sharing World View 3 expressed some shift in their theory of knowledge that allowed them to embrace the subjectivity of knowledge. These teacher candidates also started to see the value of knowledge gained through technological experiences in their framing position of technology.

Using S-STTEP methodology and interacting with the teacher candidates shifting theories of knowledge, I came to understand my practice in a different way. S-STTEP methodology revealed to me that teacher candidates may not have understood educational technologies as an epistemic source of knowledge. S-STTEP methodology allows me to re-frame my practice-with-others to explicitly link learning-about-technology to epistemology for teacher candidates. Part of this assertion for action is to connect epistemic and technological mindsets in a framing position of technology and include concepts such as growth-orientation, resilience, and positive failure in order to improve my practice for the benefit of teacher candidate learning.

## 6.7. Summary of My Epistemology of Practice

The self-study of my authorizers helped me to understand the nature of my professional knowledge, its development, and how to improve my practice. The analytical framework of this study uses S-STTEP methodology to allow me to access my authority of practice as a source of knowledge and uncover the tacit knowledge inherent in my knowing-in-action. Through an understanding of my theories-in-use and my espoused theories in my epistemology of practice, I am able to make assertions for action and improve my professional knowledge. S-STTEP methodology helped me to see my professional knowledge differently, particularly as I engaged with the discovery of my professional knowledge through interactivity with teacher candidates (Anderson, Imdieke, Standerford, 2011) to support my educative decision-making processes (Schraw & Olafson, 2002). Through seeking the other in this study, I embraced a variety of perspectives to see my professional knowledge differently and reframe my practice and identity as a technology teacher educator (Cutri & Whiting, 2018). The processes involved dialogue with critical others to unpack, shift, and reassemble my tacit knowledge and reframe it for the purpose of improving my practice. Further, the pillars of self-study methodology support double-loop learning (Argyris & Schön, 1974) that altered my governing variables and resulted in perspective shifts because my knowledge did not remain tacit. The adoption of a critical reflexive position, or the reflexive turn to the self, is crucial in the analytical process as it is the turning back on one's understanding that propels the way. The reflective turn is facilitated by understanding the present moment through reflection-in practice (Bullock, 2014) to "turn on its head the problem of constructing an epistemology of practice" (Schön, 1991, p. 5). In this way, through the pillars of S-STTEP methodology, I was able to reveal the tacit components of my knowledge in my practice with others. I also used methods of reflexivity and self-critical scrutiny of my teaching actions to make assertions for actions. Through self-study methodology I recommitted in an ontological way to the improvement of my practice as a technology teacher educator. A summary of my professional knowledge is presented in the paragraphs below.

My professional knowledge of an epistemic leaning in experience underscores the teacher candidates' authority of experience (Munby & Russell, 1994), which are accessed using educational technologies of maker pedagogy and experiential learning

as these technologies have epistemic affordances. My professional knowledge invites teacher to make meaning of experiences and draw on the authority of their experience as a source of knowledge. My assertion for action is that my practice has to be more intentional in engaging teacher candidates with the reflective methods and processes they require to make meaning of their experiences and embrace their knowledge-in-action. I need to bring the reflective practice authorizer closer to the epistemic leaning in experience authorizer and self-study methodology helped me identify what was tacit and implicit in my action. My professional knowledge of an epistemic leaning in experience supports teacher candidates to understand the epistemic ways that teacher identity develops and to draw connections between beliefs, goals, and actions in teaching.

My professional knowledge of reflective practice draws on methods of dialogue, writing, open-ended questions, and online and face-to-face dialogue to support teacher candidates' access to the authority of experience to understand the value of reflecting on knowing-in-action in the process of coming-to-know (Pinnegar & Hamilton, 2009) themselves as teacher. My professional knowledge of reflective practice is to evoke teacher candidates' reflections in a time sensitive manner, and in this way, overcomes mere reflection-on action practices that are commonplace and often critiqued in teacher education (Russell & Martin, 2017) programs. I understand that my professional knowledge needs to include more scaffolding for the teacher candidates and to provide the rationale for reflection in advance of the reflective practices. An assertion for action is to include modeling in my practice (Kay, 2006) and facilitate more dialogue about the utility and value of reflective practices. My professional knowledge of reflective practice includes making space for the teacher candidates' voice and to listen closely, and in this way may not always involve pre-planned prompts for reflections. My professional knowledge of reflective practice involves elements of collaboration, dialogue, and a community of practice that supports reciprocal engagement between the teacher educator and the teacher candidates, and amongst the teacher candidates. Finally, my professional knowledge of reflective practices places the teacher candidates' experiences and learning from experiences at the forefront (Brandenburg, 2008). I understand my professional knowledge of reflective practice to contain epistemic ways of engaging with reflection-in the present moment in an aim to develop teacher candidates' confidence and their teacher identity as curriculum makers (Clandinin & Connelly, 1992).

My professional knowledge of a framing position of technology is improved through the reframing of my authorizer through S-STTEP methodology. I understand my professional knowledge needs to be better embedded with opportunities with teacher candidates to create a collective definition of technology as well as a definition of learning with-and-about educational technologies. My professional knowledge draws on the philosophy of technology and a crucial theme is the nature of technology (de Vries, 2018). I understand my professional knowledge of a philosophy of technology to belong “to the realm of epistemological inquiry” (Skolimowski, 1996, p. 371) that involves reflective practice and “aims at the investigation of the nature and structure of technology, conceived as a brand of human learning and analyzed for its cognitive content” (Skolimowski, 1996, p. 372). An assertion for action is to integrate SCOT theory and social shaping of technology as critical lenses to support teacher educators’ understandings about how innovation unfolds as a process of technology and society relationships wherein the meaning of technological artifacts are co-constructed practices (Bijker, Hughes, & Pinch, 2012). My professional knowledge of a framing position of technology also involves the historical definitions of technology to understand the current ideologies of the social shaping of technology. The historical foundations of technology and educational technology are foundations to my practice for making educative decisions that challenge popular culture and the myths about technology and education.

My professional knowledge of learning design involves the design of pedagogy for teaching-with and learning-about educational technology. I understand that my tacit knowledge is connected to facilitation as an epistemic position (Hunt & Melrose, 2005) of the technology teacher educator. The facilitation of learning is a part of my professional knowledge for learning design and collaboration is evident in my practices-with-others for the design of the learning environment; this is consistent with suggested strategies for technology teacher educators (Kay, 2006). I have come to understand that my professional knowledge is underscored by constant reflection on my practice-with-others in how I mediate the learning environment and that facilitation provides a method for teacher candidates to learn collaboratively with-and-from each other. In my professional knowledge I evoke considerations about evaluation of educational technologies and my professional knowledge of the learning environment involves providing ample time for teacher candidates to develop their abilities for a technological world alongside the competencies they required to support meaningful technology integrations into their in-

service practices. I understand that my professional knowledge is deeply connected to Howland's (2012) meaningful integration of technology and Schön's (1983) knowing-in-action. There is an authority that resides in feeling confident about technological experiences and drawing on the learning from those experiences that raises teacher candidates' confidence with technological environments. As such, my assertions for action are to illuminate tense experiences to expose fears around using digital or physical educational technologies as they are naturally pre-disposed to imperfection. As well as, my practice should demonstrate challenges with technology integrations for teacher candidates (Kay, 2006). Further, I understand that my practice should include opportunities within technology teacher education to discuss the value and roles that growth-orientation, resilience, and positive failure play in meaningful learning with technologies (Howland, 2012) so that they may embrace the learning that comes alongside positive failure. Another component of my professional knowledge is to support the development of teacher candidates' relationship and identity, which include understanding the mindset and iterative design process. I understand that teacher candidates may not have understood technology as an epistemic source of knowledge and that I need to make more transparent in my practice and bring to the forefront that different technologies do different epistemic work and that this thinking is a core part of the design of learning. S-STTEP methodology allowed me to re-frame my practice-with-others to explicitly link learning-about-technology to epistemology for teacher candidates. I am able to articulate through interacting with the scholarship in the field that the design of the learning environment impacts the function of the technologies (O'Neill, 2016) and that selection, evaluation, and design for thinking are integral components of my professional knowledge for supporting teacher candidates to develop technologies competencies (Foulger, Graziano, Schmidt-Crawford, & Slykhuis, 2017).

My professional knowledge of learning is that scholarly literature and learning theory must be discussed in application-to and through teacher candidate-led dialogues. Teacher candidates need to understand the implications, value, and the utility of theory and scholarly literature in their own experiences to support their pedagogical decisions. I understand more deeply now that learning theories describes how people learn and has utility for the field of educational technology in supporting how people develop and use learning resources.

## **Chapter 7.**

### **Conclusions**

This research investigates the teacher candidates' theories of knowledge in technological environments and my epistemology of practice as a post-secondary technology teacher educator. This dissertation attends to the pedagogical interdependence of technological environments and teacher candidates' epistemologies to narrow the epistemic gap between my theories of knowledge and those of teacher candidates through the design of educational technology within an undergraduate course. The research context is an undergraduate teacher education course that positions maker pedagogy and experiential learning as educational technologies that challenges technical rationalism (Schön, 1983) and have the potential to produce skilled and work-ready teachers who can transition to professional environments. Maker pedagogy and experiential learning are the approaches used in my teacher education classroom, in the same way that other teacher educators may use science or math. Through this self-study, I engage with many reflective turns to understand my pedagogy of technology teacher education. In this research, I analyze and articulate my professional knowledge and discuss actions for how I may improve my pedagogy. In this chapter, I detail the scholarly contributions of this study that move it beyond my research context and individual story to bear influence on educational research (Bullock & Madigan Peercy, 2018) in technology teacher education more broadly. This chapter details the contributions that this dissertation makes to the fields of an epistemology of practice; educational technologies and learning design; pedagogy and technology integration; and, self-study methodology.

#### **7.1. Epistemology of Practice**

My professional knowledge is understood through an analysis of my epistemology of practice, which includes the study of my practices and actions, my theories of action, and my perspectives of teacher candidates changing theories of knowledge, which are insightful for the design of educational technology. The epistemology of practice in this study reclaims the epistemological underpinnings of Schön's (1983) epistemology of practice and expands the lens to the study of teacher

educators' professional knowledge and its development. An epistemology of practice is the professional knowledge formed in action in the context of professional situations and evokes assertions that count as knowledge about practice and who you are in practice as drawn from a basis for knowing. The study of an epistemology of practice in this study is facilitated through an analytical framework, which has tools and warrants for the justified study of professional knowledge in order to make warranted assertions for understandings and actions. The methodology that supports this study of my epistemology of practice is S-STTEP educational research, which is a self-initiated (LaBoskey, 2004) examination that aims to understand the reality of the self-in-practice with others for the improvement of practice and does not claim to find one truth (Samaras & Freese, 2009). This study demonstrates what I learned from an examination of my practices and actions, that practice has its own epistemology, and how I connect this research to the broader scholarship of the field.

For the process of coming to know (Pinnegar & Hamilton, 2009) my pedagogy of technology teacher education, I designed a four-part analytical framework to understand and examine my espoused theories and theories-in-use (Argyris & Schön, 1974) in an epistemic way. See Figure 2 for an overview of the analytical framework. In Part 1 of the framework, I label my self-study data to pinpoint instances of my practices and actions in my personal pedagogy of technology teacher education and for the design of educational technologies. Also, in Part 1 of the framework, I label teacher candidates' voices and my perceptions of teacher candidates' changing theories of knowledge, based on the world views of teacher candidates' epistemologies of technological environments as understood through Q-methodology. In Part 2 of the framework, I analyze the labels (codes) from Part 1 using thematic analysis to identify my authorizers, namely: the things that shape my professional knowledge in order to capture precise accounts of my practice (Pinnegar & Hamilton, 2009). In Part 3 of the framework, I review and unpack my authorizers via S-STTEP methodology to understand the space between my practices (where I attended from what I know) and actions (where I attended to how I respond) to capture accounts of ways that my actions transform my practice (Pinnegar & Hamilton, 2009). In Part 4 of the framework, I coalesce my professional knowledge in an epistemology of practice and articulate assertions from a basis for knowing to improve my practice of technology teacher education using maker

pedagogy and experiential learning as educational technologies in my pedagogical approach.

The study of practice as an epistemic source of knowledge accesses my authority of practice, a concept that I contribute to the scholarship of the field, as an ontological lens to study what resides in teacher educators' knowing-in-action. An authority of practice is the warrant that leads to a teacher educators' professional identity and understanding of professional knowledge, how it develops, and how it is reframed. The epistemic study of practice in this research makes contributions to educational research about practice and to professional development inquiries in teacher education. The identification of authorizers in the authority of practice exist in the action-present (Schön, 2001) of practice and this recognizes that authorizers are moving targets. It is one thing to engage in reflection-in-action and another to reflect and describe it as professional knowing-in-action. This involves the professional having the ability to "make decisions and carry out action in the moment, without necessarily being able to articulate either their reason for taking such action or how they learnt to carry out such actions in the first place" (Bullock, 2011, p. 29). The analytical framework in this study provides a way to understand and analyze the action-present (Schön, 2001) in an epistemology of practice, and in this way, is committed to ontology as a pillar of self-study methodology.

The analytical framework supports my assertions for understanding and action and serves to provoke, challenge, and illuminate (Bullough & Pinnegar, 2001) my practice of technology teacher education and its improvement. The examination of my practices and actions draws on methods of reflective practice such as reflection-in-action; reframing through turning points (Bullock & Ritter, 2011); and, reflexivity, constant scrutiny, and self-critique. Another important method is interactivity "in the understanding that engaging with others will help us more accurately develop and uncover the practice in which we participate (Pinnegar & Hamilton, 2009, p. 154). Interactivity includes interactions with teacher candidates and engaging with the literature and scholarship of the field; and, dialogue in the "process of coming-to-know" (Pinnegar & Hamilton, 2009, p. 154).

A self-study of my authorizers helped me to understand the nature of my professional knowledge and its development differently as a result of engaging in this process. The insights gained in this research are influenced by: my views on what I

valued; interactivity with teacher candidates; and, how my values were reflected in my practice. In this way, I could confront and align my intentions and actions (Loughran, 2007) that concurrently are contextualized within the research conversations of the field. As I work through the analytical framework, I recommit in an ontological way to the study of “what is” in my practice and move from an ontological to epistemological understanding of my practice. For this reason, it is important to study knowledge despite the argument that postmodernism has gone beyond the question of epistemology, as it is the study of knowledge that reflects ontology and from it, I draw assertions for action.

An epistemology of practice speaks to me as a teacher educator personally through the self-study of my reflection-in-action. For this reason, there is no universal theory of an epistemology of practice. An epistemology of practice is personal, embodied, dynamic, and changes with time, which is why there is a need to recommit to it constantly through self-study methodology. An epistemology of practice is arrived at by going through the analytical process and understanding myself through the rigour of S-STTEP and the structured methods that support how I see my professional knowledge differently. I also closely attend to where my practice may be improved in the commitment to pedagogy that supports teacher candidates’ achievement of the course goals in technology education.

In summary, the analytical framework in this study provides a tool for educational researchers to use in the understanding and analysis of their professional development and for the identification of areas they could improve in their practices to better align their theories-in-use and espoused theories (Argyris & Schon, 1974). The analytical framework has utility as it provides an example for others to follow in arriving at an epistemology of practice. Further, the analytical framework contributes to the scholarship in the field of teacher educator professional development. This research creates a space for a cannon of work in educational technology and learning design and demonstrates that in an atheoretical field such as educational technology and learning design, an epistemology of practice can contribute to educational research, particularly via self-study methodology, as the self-studies of technology teacher education is just starting to grow.

## 7.2. Educational Technologies and Learning Design

Technology teacher education has many expectations from diverse stakeholders. For example, teacher candidates expect that their academic programs will have acquainted them “with ways to engage meaningfully with technology in their classrooms” (Garbett & Oven, 2017, p. 3). Also, employers expect that teacher education programs produce teachers that are classroom ready (Loughran, 2017) and have relevant experiences (Northfield, 1993) with educational technologies (Kosnick, White, Beck, Marshall, Goodwin, & Murray, 2016). This research positions maker pedagogy and experiential learning as educational technologies that have the potential to produce skilled and work-ready teachers who can transition to professional environments.

Maker pedagogy and experiential learning as educational technologies have unique epistemic affordances that position experience as an epistemic source of knowledge. This supports teacher candidates to reflect on their knowing-in-action and to develop their identity and relationship with technology to support the competencies they require for the integration of technology into their in-service teaching (e.g., Cohen, 2017; Foulger, Graziano, Schmidt-Crawford and Slykhuis, 2017). These educational technologies embrace educative approaches that enable the intentional processes of reflection-in-action. Some may

call such a process “trial and error.” But it is not a series of random trails continued until a desired result has been produced. The process has a form, and inner logic according to which reflection on the unexpected consequences of one action influences the design of the next one... In the course of such a process, the performer “reflects”, not only in the sense of thinking about the action he has undertaken and the result he has achieved, but in the more precise sense of turning his thought back on the knowing-in-action implicit in his action. He reflects “in action” in the sense that his thinking occurs within the boundaries of what I call an action-present—a stretch of time within which it is still possible to make a difference to the outcomes of action. (Schön, 2001, p. 197).

The educational technologies facilitate learning about the connections between reflective practices and experiences as an epistemic source of knowledge.

An epistemic shift towards understanding the expertise in action (Hunt & Melrose, 2005) is what supports the understanding of teacher candidates’ development and identification of an identify and relationship between pedagogy, epistemology, and

technology. It is the epistemic position of facilitation in maker pedagogy and experiential learning that supports learning about the use of technology as well as the “qualitative judgment and imaginative roles” (Hunt & Melrose, 2005, p. 70) of technologies in the design of the learning environment. Much like Garbett and Ovens (2017) allude to about digital technologies, educational technologies in this study are “more about what transformation they enable rather than the specific technologies themselves” (p.5).

Maker pedagogy and experiential learning were the catalysts for the design of a learning environment that simultaneously provide a lens to examine my teaching practices and actions from a theoretical stance and for interactively integrating the teacher candidates voice in the learning environment. I understand that facilitation provides a method for teacher candidates to learn collaboratively with-and-from each other and this is consistent with suggested strategies for technology teacher educators (Kay, 2006). Further, I understand my professional knowledge of reflective practice to contain epistemic ways of engaging with reflection-in the present moment in an aim to develop teacher candidates’ confidence and their teacher identity; a primary method that supports the development of teacher identities is having teacher candidates reflect on their roles as curriculum makers (Clandinin & Connelly, 1992). It is this interplay between the designer and the educational technologies that reclaims the “bringing-forth of the true” (Heidegger, 1977, p. 17) nature of craft in teaching.

Both experiential learning and making technological artifacts give insights into the development of professional knowledge, the nature of how professional knowledge is constructed, and can reveal much about high impact learning design and educational technologies. I respond in this study to the calls in the field, which voice the need to advance the field of educational technology and learning design in an integrated and scholarly way, through a systematic study of my practices. In this sense, this study carved out a different approach to understanding the pedagogy of technology teacher education in an aim to understand how technology education interfaces with pedagogy, epistemology, and educational technologies.

Maker pedagogy and experiential learning are also the educational technologies that provided a lens to examine my teaching practices and actions in the development of a learning environment. My professional knowledge of learning design involves the design of pedagogy for teaching-with and learning-about educational technology.

Further, by understanding the theories of knowledge that teacher candidates bring to the learning experiences, I am able to better design learning environments for educational technology that pay attention to the nature of technology (Bullock, 2016). This responds to the paradox posed by Garbett and Oven's (2017) that suggest "while educational technology is rapidly changing, the philosophical and theoretical development of research on, with, and for such technology are developing at a slower rate (p. 6).

This study adds to the research by Howland (2012) as I found that different technologies do different epistemic work and that this is a core part of the design of learning. Maker pedagogy and experiential learning support the epistemic work of learning about technologies to access the authority of experience through *reflection-in-action with educational technologies*. There is an authority that resides in feeling confident about technological experiences and drawing on the learning from those experiences that raises teacher candidates' confidence with technological environments that are afforded by maker pedagogy and experiential learning.

Another important contribution is that different mediums used in the educational technologies, independent of the content it mediates, has its own intrinsic effects that are its unique message (McLuhan, 1964). The teacher candidates responded differently to media in the educational technology, for example, Slowmations versus Scratch, due to the properties of the media. This contributes to the field of educational technology and learning design and it differs from traditional educational technology research and goes beyond "examining technology as a 'way of doing,' [which,] gives us insight into what technology does, but does little to improve our understanding of what technology means, giving us insight into the existential impact educational technology has on learners and teachers" (Howard, 1994, p. 365). This study looked beyond the effects that media such as computers or iPads have on teacher candidates' performance and examined how educational technology mediated the teacher candidates' lives, what meanings they attach to the educational experience as a result of technological mediation, and what implications those meanings have for pedagogy (Howard, 1994, p. 365). In this way, this study contributes to the understanding of learning design by looking at the affordances that are a property of the media and the way people interact with the affordances that lead to activity patterns that are pertinent for learning (McLuhan, 1964). Further, it is the facilitation of the educational technology around the media in learning design (Clark & Kozma, 1994) that is the greatest influencer of learning outcomes. The *design* element

of maker pedagogy and experiential learning as educational technologies engages the interplay between technology and science, and the craft of teaching, which is very exhilarating as this had historically been separated, and much can be learned from how each informs the other. This way of thinking in the field moves away from a systems or instructional design approach to the creation of educational processes for facilitating learning through student-centric environments. My practitioner-generated knowledge (Zeichner, 2007) from this self-study methodology offers new ways of understanding the rapidly shifting landscape of educational technology and learning design.

Making in the context of this study is a space for teacher educators and teacher candidates to develop the habits of mind and develop confidence in one's identity as a curriculum maker (Clandinin & Connelly, 1992). Maker pedagogy and experiential learning as educational technologies offer a unique contribution to the field of educational technology and learning design for technology teacher education as to my knowledge, there are not many studies that discuss the creation of a learning environment that facilitates action and focuses on the knowledge gained in experience. This study connects epistemic and technological mindsets in a framing position of technology and includes concepts such as growth-orientation, resilience, and positive failure (Kay, 2006) for the benefit of teacher candidate learning. This study also contributes to the conversations in the field about considerations for the design of the learning environment. This includes for example, how the learning environment impacts the function of the technologies (O'Neill, 2016) and that the selection, evaluation, and design for thinking are integral components for supporting teacher candidates to develop technologies competencies (Foulger, Graziano, Schmidt-Crawford, & Slykhuis, 2017).

Technology integration in this study involves thinking that is mindful of the history in the field of educational technology, the nature of technology, and the philosophy of technology as contexts for understanding the complex nature of technology and how signals cultural changes. This steps away from technological determinism that treats technology as "inanimate objects-machines-as causal agents [and] drive attention from the human relations" (Marx, 2010, p. 577). Both maker pedagogy and experiential learning are educational technologies that may be viewed as socially shaped technological environments that challenge technical rationalism (Schön, 1983) as they situate the learner in the robust and culturally embedded practices of the profession. Maker pedagogy creates a space to disrupt deep historical technocracy roots, the

science and technology divide, and the popular notions of technology as an applied science that still exist today and influence the philosophy of technology. Howard (1994) said that

if we see educational technology as only tools used and directed through the intentions of a teacher, we may be satisfied with understanding educational technology through the measurement of technology's effects on students. On the other hand, if we view technology as having its own intentionality, our understanding of educational technology may include an examination of technology's existential impact (p. 394).

Howard's (1994) position about educational technology embraces Skolimowski's (1966) statement about the philosophy of technology in that it "belongs to the realm of epistemological inquiry and attempts to situate technology within the scope of human knowledge" (p. 371). This philosophy, according to Skolimowski (1966) "aims at the investigation of the nature and structure of technology, conceived as a brand of human learning and analyzed for its cognitive content" (p. 372). Skolimowski (1966) considers technology to be a form of human knowledge and the philosophy of technology includes the epistemological analysis of technology. This study takes seriously the philosophy of technology and the philosophical examinations of educational technology in this research enables an understanding of the diverse theories of knowledge that teacher candidates bring to technological environments. Future research could aim to say more about these epistemic frameworks in the philosophy of technology, as this is not fully established (Morrison-Love, 2017) in the literature, as well as study how teacher candidates construct knowledge from their experiences in maker pedagogy and experiential learning.

### **7.3. Pedagogy and Technology Integration**

There is a diversity of technology integration approaches suggested in the literature. For example, Ottenbreit-Leftwich, Glazewski, and Newby (2010) proposed six approaches for the design of technology experiences. The six approaches and intended outcomes (in brackets) as offered by Ottenbreit-Leftwich, Glazewski, and Newby (2010) were: 1) information delivery (be familiar with specific technology integration content), 2) hands-on skill building activities (build technology skills), 3) practice in the field (apply technology integration knowledge), 4) observation and modeling (recognize quality technology integration) , 5) authentic experiences (discern consequences of instructional

technology integration decisions), and 6) reflection (contemplate abilities and how to address gaps). Ottenbreit-Leftwich, Glazewski, and Newby (2010) urged teacher educators to “consider which approach best meet the intended goals of the teacher education program” (p. 20). Other typical forms of professional development that support technology integration include modeling, reflection, and collaboration to develop the skills, knowledge, and problem-solving abilities (Derban & O’Neill, 2018). Yet these models of professional development are often offered as direct-instruction and are practice-oriented with the focal point being on one tool. As such, these approaches may present limitations for supporting a systemic goals of technology integration (Derban & O’Neill, 2018). Because of the diverse approaches to technology integration, it is difficult for teacher educators to design quality programs (Elwood & Savenye, 2015) as there is little agreement in the field about the recommended approach to technology integration in teacher education.

This study has implications for the pedagogical decisions that technology teacher educators make for technology integration and contributes to thinking about the epistemological consequences of learning design in educational technology, namely: design is not a one size fits all approach (Land, Hannafin, & Oliver, 2012). My professional knowledge adds to the scholarship of technology teacher education and the integration of educational technologies in a way that breaks-free from the single silos of technology to understand technology integration rather than implementation (Kosnick, Menna, & Bullock, 2012). My assertions connect to conversations in the field of technology teacher education and link to other self-studies and teacher education research to engage with the wider fields of educational research and cross boundaries (Bullock & Madigan Peercy, 2017).

As identified in this self-study, my espoused theory is that my relationship to technology is related to my identity as a technology teacher educator and subsequently to my pedagogy of technology teacher education. This study of my professional knowledge acknowledges the relationship between epistemology, pedagogy, and technology which moves the conversations forward in the field of technology integration in teacher education. I take seriously Okojie-Boulder’s (2016) recommendation as not only do I consider the relationship of teaching and learning about technology integration, but I use technology in an “an integral part of instruction and not as an object exclusive to itself” (p. 66). To that end, maker pedagogy and experiential learning are educational

technologies that have processes, inclusive of artifacts and tools, that support and facilitate learning. In particular, maker pedagogy and experiential learning are educational technologies that represent educative designs for teacher candidate to participate in to develop a theory of knowledge from experiences that is required of them to perform in their professional roles.

Perusek (2008) advocated for a scholarly focus on the diverse methods that teachers and students use in the acquisition and transfer of knowledge. “As teacher[s] learn more about student’s epistemological perspectives, it is imperative that teachers develop curriculum that will bridge any gaps in knowledge” (Perusek, 2008, p. 3). “In this sense, in order to design teacher preparation programs that can help preservice teachers to develop adequate understandings about teaching and their role in the classroom, teacher educators need to be aware of preservice teachers’ prior belief systems, which can jeopardize their learning experiences during the program and, hence, their future teaching practices (Yadav, Herron, & Samarapungavan, 2011, p. 26). In this research, maker pedagogy and experiential learning are used as educational technologies that engage teacher candidates to think about their experiences as epistemic, and how knowing-in-action in technological environments connects to their pedagogical beliefs and relationship to technology. Additionally, this self-study offers teacher educators a way to think about teacher candidates’ beliefs and how teacher candidates’ perspectives changing perspectives about theories of knowledge in technological environments offers insight into learning design that bridges the epistemic gap between teacher candidates’ and teacher educator’s theories of knowledge in technological environments. This approach provides new answers to why technology integrations are misaligned (Judson, 2006) with espoused beliefs, wherein “teaching practices is truly and markedly different from actual practice” (Judson, 2006, p. 585). In summary, the educational technology and learning design approaches in this study carve out a new domain that supports a novel teacher educators’ identity development (Cutri & Whiting, 2018) and ways of facilitating teacher candidates in technology integration.

An epistemic way of studying technology teacher education and teacher educators’ professional knowledge was presented in this dissertation. This study provided an analytical framework for the epistemic study of teacher educators’ professional knowledge and its development in an ontological way. The analytical

framework used in this study provides new tools for self-study research that open the third space, wherein the researcher's tacit knowledge, personal practice, and explicit knowledge are explored alongside the exposure of implicit actions (Pinnegar & Hamilton, 2009). Using self-study methodology to understand an epistemology of practice may provide new answers to the criticism that Borthwick and Hansen (2017) and others found with the TPACK model for defining teacher educator's knowledge and what they need to know related to technology to support the design of technology teacher education and guide professional development in the field. The analytical framework used in this study provides an epistemic way to document and analyze professional development and its improvement in a way that allows action to transform practice. TPACK was proposed as a way to understand the knowledge and skills for technology integration and professional development around the use of technology (Mishra & Koehler, 2006), and while TPACK intended to identify the nature of the knowledge needed by teachers for the successful integration of technology in teaching and address the dynamic and situated nature of teacher knowledge (Mishra & Koehler, 2006), Howland suggested that the models made heavy epistemological assumptions and did not focus adequately on learning (Howland, 2012). Aligned with Howland's (2012) thinking, Bullock (2013) suggested that TPACK, shaped after PCK, may be problematic as there is "little agreement as to the specific epistemology of PCK, or how to document and analyze the development of PCK" (Bullock, 2013, p. 153) and this made it challenging to articulate professional knowledge (Bullock, 2013). The analytical framework in this study offers a way to overcome the impoverished concept of content knowledge and articulate teacher educators' knowing-in-action, how teachers come to know (Howland, 2012), and to learn from their theories in action as a way forward from focusing only on what teachers should know in technology education but also how. The analytical framework also provides a way to think about teacher candidate's epistemologies and the changes in their perspectives in the development of an understanding of teaching (Howland, 2012). The analytical framework thus responds to Howland's critique of TPACK as it provides a way to "make meaningful recommendations about technology use" (Howland, 2012, p. 15) as the teacher candidates voices and changes in their theories of knowledge are considered in technology integration and the learning design of technology teacher education.

## 7.4. S-STTEP Methodology

Questions arise in the field about how the study of teacher education should move forward, particularly in the digital turn (Hamilton & Pinnegar, 2017), when teacher educators crave a greater knowledge base of teacher education (Hamilton & Pinnegar, 2000). This research provides some answers to moving forward in the field of technology teacher education using self-study methodology as educational research to answer questions about professional knowledge and its development, and how to improve practice. Self-study research supports the understanding of the tacit knowledge embedded in my teaching actions and allows me to recognize the ontological difference between my practice and action. Self-study methodology narrows the space in my practice where there may be “dis-juncture between our belief and our action” (Bullough & Pinnegar, 2001, p. 15) in order improve the educational outcomes for the benefit of student learning.

This study met the markers for a strong self-study as the process of the research is ontological and trustworthiness in the process of arriving at warranted assertions was made transparent. This study goes beyond my individual narratives to seek the general from the specific and label (Loughran, 2010) my professional knowledge and assertions for action and understanding that are contextualised within research conversations. Importantly, the study turned back on itself and used exemplars to reveal my “understandings of and assertions for practice that emerged as [I] questioned again the practices being used and what they revealed about what [I] now knew (Pinnegar, Hamilton, & Fitzgerald, 2010, p. 205).” And now, in making the research public, I am subjecting my work to feedback and criticism (Whitehead, 1989).

It is in the problem-finding (Schön, 1983) activity of my professional practice that I engage the artistry of my profession to cope with the uncertainty and complexity of my intermediate zone of practice. In this research, S-STTEP allowed for the theorizing of practice beyond the notion of a technical practice and allowed me to turn my knowledge of practice into action to make my tacit knowledge explicit. Further S-STTEP supported the access to the authority of practice and exposed my problems of practice (Schön, 1987) in a systematic manner that supported the arrival at warranted assertions for professional knowledge from the study of my theories of action (Argyris & Schön, 1974).

S-STTEP helped me to understand further that the nature of my professional knowledge is made explicit through interactivity with teacher candidates (Anderson, Imdieke, Standerford, 2011) and that interactivity is fundamental to my educative decision-making processes (Schraw & Olafson, 2002). While this research may have lacked the “requisite collaboration that is a hallmark of self-study” (Donnell, 2010, p. 229), namely: collaborative self-study involves a critical friend, the interactivity in this study stands in for collaboration and advances the pillars of self-study methodology. In this study, I did not have a collaborative research partner or a critical friend to engage with during the self-study research. However, I interacted extensively with teacher candidates and this provided me with an opportunity to communicate with them. This process of interactivity is different from collaboration, because with interactivity, one must draw the learning out of the experience themselves, whereas in a collaboration, people learn together. As such, collaboration and interaction are not equivalent methods in self-study research. However, through interaction with the teacher candidates and with the scholarship of the field, I found support for double-loop learning (Argyris & Schön, 1974) to alter my governing variables. The method of interactivity in this self-study was achieved through the design of the learning environment that sought diverse perspectives (Samaras & Freese, 2009). As a curriculum maker, I was reflexive and considered myself in relation to others and about how they spoke to me, and this makes a unique contribution to self-study research. I was purposeful in the learning design to create opportunities for constant reflection on my practice-with-others in how I mediate the learning environment and how I facilitated a method that is conducive for teacher candidates to learn collaboratively with-and-from each other, and for me to learn more about my how my practice influences the teacher candidates. My professional knowledge involves elements of collaboration, dialogue, and a community of practice that supports reciprocal engagement between me and the teacher candidates, and amongst the teacher candidates. These methods may serve to strength the pillars in self-study research as warrants that maintain the “momentum towards too much focus on the self-as-a learner” (Bullough & Pinnegar, 2001) and underpin the basis for knowing (Bullock, 2009) through interactivity to draw assertions from the research.

The interactivity uncovered my tacit knowledge and supported perspectival shifts because my knowledge did not remain tacit. This self-study is not carried out in isolation as the methodology simultaneously considered the involvement and role that *the other*

plays in my process of coming-to know and arriving in S-STTEP research (Pinnegar & Hamilton, 2009). It is through dialogue as a method that I am able to examine my practice for the purposes of improving it (East, Fitzgerald, & Heston, 2009, p. 55). The dialogue and interactivity with others are crucial to support how I framed and reframed (Hamilton, 1998) the tensions (Loughran, 2007) that I had in my practice. This active pursuit of understandings from different perspectives as I reframed my situations (Schön, 1983) is important in a self-study, and “demonstrate that different perspectives on teaching and learning situations have been sought and considered and to (again) minimize possibilities for self-justification or rationalization of existing practices and behaviors” (Loughran, 2007, p.16).

Another method of interactivity in this self-study is with the literature and through the method of writing. Writing as a method had affordances for providing authority over my ideas and empowered my reflective thinking during the understanding of themes as possible authorizers. Through sustained and continued writing, S-STTEP methodology supported me to trace the themes across all the data sources, and it is this process that supported the articulation of my professional knowledge. Writing about the authorizers enables the recursive part of the analysis and enhances the trustworthiness of my assertions.

Another contribution that this dissertation makes to advance self-study methodology is to introduce the concept of an authority of practice that belongs to the realm of teacher educator practices and inquiries into professional development. My authority of practice is entwined is my moral obligation to this research, to do “something beneficial in the world” (Wilson, 2001, p. 175) and “so that when I am gaining knowledge, I am not just gaining it in some abstract pursuit; I am gaining knowledge in order to fulfill my end of the research relationship” (Wilson, 2001, p. 177). The strong ontological stance in this study adheres to the pillars of self-study methodology and supports the improvement of my current practices, rather than deliver knowledge outcomes as the final product. Self-study methodology allowed me to theorize about practice and gain profound understanding about the why of teaching and learning, but this

is not an easy task for, as has been highlighted throughout the research on teaching literature, much of one’s knowledge of practice is tacit, so attempting to define and articulate such knowledge can be a difficult and

frustrating process. However, overcoming, rather than succumbing to such difficulties and frustrations is important in demonstrating scholarship in self-study (Loughran, 2007, p. 17).

Finally, this research offers assertions for action from the study of my pedagogy of technology teacher education that is useful to other teacher educators. But more than that, this study offers an analytical framework and helps me reveal my tacit knowledge in an epistemic way that connects to the broader field and that goes beyond my individual story or narrative to label the assertions drawn (Loughran, 2007) and reveal tacit knowledge in an epistemic way. It is one thing to engage in reflection-in-action during one's practice and another to reflect and describe it as professional knowing-in-action.

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## Appendix A.

### Reflection Paper: Assignment #1

Look back at the collective reflections you have written in class for the writing prompts. Think of these as a whole and write a reflective paper about your identity as a science and technology educator, with a particular view to how you might frame yourself as a *maker of curriculum*. What opportunities and challenges do you see as a new teacher? What support might help you?

The questions below may prompt your reflective thinking:

- What patterns can you recognize in your reflections?
- What does that say about your knowledge and learning?
- Have you shifted in how you think about teaching and learning? What has happened that surprised you the most?
- What are themes that you can draw from your reflections that are useful in another context?
- In what ways do you feel your expectations and personal learning outcomes are or are not being met and what might you do to support the achievement of these?

Please use a reflective writing style for this assignment as described by Moon on pages 185-188 and 214-216. Resources 5 & 6 also serve a good reference for this assignment. Remember, when writing a reflection that you need to go beyond the description of your thoughts and discuss how you may do things differently, what actions you might take, and discuss planning and considerations that will support you in the achievement of your learning objectives. Do not just talk about what you did, discuss what you thought about and learned from what you did!

## Appendix B.

### Reflection Paper: Assignment #2

Look back at your reflections as a whole and share how your views on learning and your views on the nature of knowledge may have shifted through your changing understandings of maker pedagogy and experiential learning. Discuss pedagogical insights afforded by *doing things, having experiences, and/or making things in a technological environment*.

Please consider alternative representations for your reflections - in that- you do not have to write a paper if you do not want to. You can demonstrate your reflections via podcasts, screen casts, mind maps, animations, infographics, and/or digital portfolio. Be creative!

The questions below may prompt your reflective thinking:

- What patterns can you recognize in your reflections?
- What does that say about your knowledge and learning?
- Have you shifted in how you think about teaching and learning? What has happened that surprised you the most?
- What are themes that you can draw from your reflections that are useful in another context?
- In what ways do you feel your expectations and personal learning outcomes are or are not being met and what might you do to support the achievement of these?

Please use a reflective writing style for this assignment as described by Moon on pages 185-188 and 214-216. Resources 5 & 6 also serve a good reference for this assignment. Remember, when writing a reflection that you need to go beyond the description of your thoughts and discuss how you may do things differently, what actions you might take, and discuss planning and considerations that will support you in the achievement of your learning objectives. Do not just talk about what you did, discuss what you thought about and learned from what you did!

## Appendix C.

### Assignment: Curriculum Design and Approach

The goal of this assignment is to provide you with an opportunity to explore a science and/or technology curricular learning experiences (i.e., that you had in the classroom) and to challenge to you think about this pedagogical experience and how you might teach that curriculum and/or concept differently.

Think of a learning experience you had in science and/or technology education that you feel could have been approached in a more hands-on or experiential manner. Please share your example of this science and/or technology learning experience. Remember to use a reflective approach when writing about your experience. Discuss the curriculum design features of this experience and use theory or theorist(s) and principles to unpack the characteristics and/or values of this learning experience. Be sure to integrate the sources of your thinking into your academic writing and cite the work.

Now, discuss how you might design the learning experience in a different way using a maker pedagogy or experiential learning approach. Consider the theoretical framework and principles of maker pedagogy and/or experiential pedagogy and the implications for design, development, and implementation of science and technology education using this approach. Please discuss the:

- Curricular design principles that you would apply to enhance the learning experience.
- Theories, theorists, and frameworks that inform how you might enact this learning experience.

Remember to focus on how the approach is connected to curriculum design and make specific references to how your ideas align to the BC K-12 curricular competences and/or Big Ideas. Be sure to integrate the sources of your thinking into your academic writing and cite the work.

## Appendix D.

### Q-Set

1. Knowledge is gained through experiences, for example doing or making something.
2. I use my experiences to develop my knowledge.
3. Before I make things or have an experience, I develop my knowledge by reading about it.
4. Knowledge comes from things that I read in books or articles and/or learn from lectures.
5. Knowledge can be gained from doing something in context only if you know a lot about what you are doing first.
6. I reflect about my knowledge while I am practicing and/or doing something.
7. I reflect on my knowledge and think about how I can use it in another context.
8. Knowledge can be gained by observing someone and listening to their advice.
9. Technology cannot be altered and should be used the way it is designed.
10. I can shape the purposes of the technology I use irrespective of how it was designed.
11. Having technical skills and being able to use tools develops my knowledge about technology.
12. Assembling technological projects develops my knowledge about technology.
13. Knowing about historical and philosophical developments in technology enhances my knowledge about technology.
14. My knowledge is bound to the context where it was developed and I do not feel that it is useful elsewhere.
15. I develop my knowledge when I create something, for example through the process of design and problem solving.
16. I develop knowledge through following steps outlined by my teacher or supervisor.

17. I develop knowledge about technology through playing and/or trying things.
18. I believe it is possible for experts to hold opposing opinions and that there can be multiple perspectives on an issue.
19. I accept knowledge from authorities (e.g., teachers or supervisor) without question.
20. I base my knowledge on evidence that pertains to the context where I learned it.
21. I base my knowledge relative to the context in which it is situated and constructed.
22. I feel that I can receive and reproduce ideas but that I am not able to create new knowledge.
23. I feel that truth and knowledge are personal and private, subjectively known or intuited.
24. My knowledge can be applied objectively to procedures for obtaining and communicating things.
25. Knowledge can be uncertain and everyone has their own opinions or beliefs.
26. Several scientists analyzing the same data will reach the same conclusions.
27. The information I find on the internet is trustworthy.
28. Experts can sometimes change their theories.
29. I can teach myself almost anything as long I have access to the right resources.
30. Teachers sometimes state incorrect facts.
31. I believe that new knowledge can be developed by working in collaboration with others.
32. I believe that the nature of knowledge is an individual pursuit.
33. I believe that knowledge can be implied or understood without being stated.
34. Conceptual/ abstract knowledge is as valuable as practical knowledge.
35. I believe that the construction of knowledge occurs through interactions-in-context.