Technological Immersion Learning:
A Grounded Theory

by

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Dissertation submitted to the Faculty
of the Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

in

Curriculum and Instruction

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26 January 2017
Blacksburg, Virginia

Keywords: Integrative STEM Education, Technology Education, Self-directed learning, Autodidactism, Learning theory, Technological Immersion Learning

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ABSTRACT

The *Technological Immersion Learning Theory* (*TILT*) was developed through a classic grounded theory study in the seminal tradition of Glaser and Strauss (1967) and Glaser (1978, 1992, 1998, 2001, 2007). The purpose of the study was to investigate an exemplary case of self-determined technology enthusiasts in the hopes of generating a substantive grounded theory that conceptualizes their experiences and concerns. Twelve unstructured interviews of amateur radio enthusiasts from the eastern United States provided the initial / primary data for this study. Experimenting and self-teaching in technological activities was highlighted as the main concern of the participants. The basic social process (BSP) of *technological immersion learning* (*TIL*) emerged as a theoretical construct and core variable that illuminates the experiences of individuals immersed in a community of practice, where hands-on engagement with technology is a primary activity. *Adventuring, Affirmation, Doing Technology, Experimenting, Overcoming Challenge, Self-teaching,* and *Social Networking* were properties of technological immersion learning that interact dialectically in an amplifying causal loop, with *Problem solving* and *Designing* as active sub processes in response to unmet challenges. *TIL* occurs cyclically in three stages, beginning with *Induction*, a credentialing stage wherein the neophyte is prepared with the necessary knowledge and skill to become a novice participant in an activity. The transition from *Induction* into the *Immersion* phase is a status passage whereby the novice is absorbed into the technical culture of the group and commences autonomous active participation in hands-on experimenting. Hands-on experiences with experimenting, problem solving and social interactions provide diverse learning and affirmation for the doer and multiple sources of feedback that promote sustained engagement. The transition into the *Maturation* phase proceeds gradually over time, with prolonged engagement and cumulative gains in knowledge, skill, and experience. *Maturation* is a quasi-stable state that remains responsive to new contexts as a random-walk process, wherein trigger events can initiate new cycles of technological immersion learning in a perpetually evolving process of personal development. *Engagement*, *Empowerment*, and *Self-Actualization* are underlying dimensions of the *TIL* basic social process that provide the impetus for continued persistence and personal development.

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GENERAL AUDIENCE ABSTRACT

This research was undertaken to investigate the unique phenomenon of people who successfully pursue complex technological activities as a pastime, yet may possess no formal training in their field. This example of informal learning is little charted and warranted deeper study through grounded theory research. The study was conducted utilizing the classic grounded theory method that was pioneered by Glaser and Strauss in the 1960s for the specific purpose of generating theory from empirical data. The outcome of the study was the *Technological Immersion Learning Theory (TILT)*, a new theory of learning that highlights the importance of technological activities as a foundation for transdisciplinary learning. *TILT* is an organic theory of learning rigorously grounded in data to conceptualize the latent behavior patterns of individuals immersed in a community of practice devoted to hands-on experimenting and learning through technology. The technical, social, and psychological attributes of *TILT* illuminate complex technological environments where sustained engagement and multidimensional feedback can promote learning and personal development. As a basis of learning, technology is intertwined with virtually every aspect of human experience, transcending the artificial boundaries of academic disciplines. *TILT* offers an empirical model for the study of technology as a foundation of education relevant for the modern technological world.

Dedication

For Diane,

I am quite certain that my wife, Diane, had no idea what she was in for when she married me all those years ago. She knew that I was a radio amateur, but did not foresee the engineering career, nor that I would someday undertake the long-delayed doctoral degree. Over the years, she became accustomed to the smell of solder smoke coming from the work bench, the faint sound of Morse code in the wee hours of the morning, the occasional electrical appliance in pieces being repaired on the kitchen table, and the frigid blast of my return in the night after stargazing in the dead of winter. She watched me fly away so many times during my pilot training and go off on business trips more often than either of us cared for. We built two houses together, built a life together, and have shared in Life's adventures all the while. The doctorate was a labor of love for me, but one that required untold hours apart in solitude. Somehow, she weathered it all and stood by me throughout Life's travails to celebrate this culmination of a long process of discovery. Thus, with humility and gratitude, I dedicate this work to my much beloved, Diane.
DSColeman

Acknowledgements

I have been around for a while and have lived far too long to make it possible to acknowledge all the people who have in some fashion helped to move me to this point in my life. However, at the risk of slighting many more people than I can possibly acknowledge, I own a special debt of gratitude to the following individuals who were pivotal in my doctoral research:

Dr. Mark Sanders, my committee chair and advisor of many years, has been unconditionally supportive throughout my graduate career. He took the leap of faith that I had the abilities and the temperament to do grounded theory research and persisted with me through to the end. His deep knowledge and passion for the Technology Education field has been an inspiration and his friendship and mentoring have been matchless throughout the convolutions of this dissertation.

Dr. Tom Sherman was instrumental in the genesis of this study, for this dissertation may not have happened at all had it not been for his far-reaching influence. Master teachers can have profound effects in the lives of those they teach—life changing effects, to which I can attest.

Dr. Brett Jones was also instrumental in the genesis of this study, as his work in motivation provided a key impetus for a mixed-methods pilot study that was the precursor of this research. In the beginning, Dr. Jones predicted that I would find five things in my study. He did not elaborate and I did not investigate until very near the end of the study and I found that there is indeed MUSIC in technological immersion learning.

Dr. John G. Wells, an early candidate for NASA's Teacher in Space program, was immediately supportive and enthusiastic at the prospect of my doing a grounded theory project, well before I was nearly as confident myself. I thank John Wells for his confidence, support, and friendship.

I also wish to thank the scholars of the Grounded Theory Institute for the resources provided to grounded theorists the world over. In particular, I thank Barney Glaser and Andy Lowe for their key suggestions in structuring this dissertation and Judith Holton for her helpful inspiration.

I also wish to recognize those radio amateurs who devoted their time and energies to participate in this study and express my sincere appreciation. While I was not acquainted with most of them before the study, I am now blessed with new friendships beyond the mutual fraternal bond that radio amateurs share. In order by call sign, I extend my thanks to Phil Foster, AJ4HJ; Joe Giacobello, K2XX; Dennis Peterson, K4CKD; Mike Herring, KE4RGY; Charlesanna Dill, KJ4DMS; Neal Kegley KR4BX; Glen 'Junior' Diamond, N4VL; Carter Craigie, N3AO; Kay Craigie, N3KN; Nathaniel Frissell, W2NAF; Glen Sage, W4GHS; and Larry McCoy, W4LWM. Thank you all for sharing your stories and making the theory of technological immersion learning possible. My thanks also go to the scores of other radio amateurs around the world who unknowingly participated in this study by virtue of the free and unfettered global reach of the hobby. It is not possible to acknowledge all the unwitting participants of this study, but I do acknowledge my debt to them and give my thanks for their presence on the airwaves.

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Chapter 1: Introduction

One of the imperatives of a democracy is an educated citizenry that is capable of functioning in the modern world shaped by science and technology (Dewey, 1916, 1942). During the last century, the symbiotic relationship of science, technology, engineering, and mathematics has not only increased our knowledge of nature, but also enormously multiplied the capability of humans to alter their environments, even on a global scale. Increasingly, the future of our nation and all the other denizens of the planet Earth depend upon the wisdom with which humans use science and technology (AAAS, 1989). Our public education system is the logical vehicle for producing an enlightened populace that understands science and technology and the ramifications of our actions in our lives and on the Earth, but unfortunately, the evidence is mounting that our society is failing in that vital mission.

Background

The experience of the science education research community is instructive of the magnitude of the problem. Yager (1996) reported research that indicates over 90 percent of students do not attain scientific literacy and that nearly 90-percent of engineering majors cannot relate their preparation to the real world. Further reporting indicates that student interest in science declines across the K-12 years and that initial positive attitudes toward science declines the more that science is studied. Researchers also report that the typical study of science causes students to be less curious and diminish the creativity skills already possessed (Yager, 1996).

Perspective on literacy can be had through assessments that are designed to measure students' ability to apply knowledge in real-life situations. The Program for International Student Assessment (PISA) is one such instrument that is designed to measure students' ability to apply reading, math, and science in real-world contexts. The PISA is designed as a measurement of literacy, broadly defined as "the capacity of students to apply knowledge and skills and to analyze, reason and communicate effectively as they pose, solve and interpret problems in a variety of situations (OECD, 2004, 2010, 2011). As a broad measure of literacy, the results of the PISA show that U.S. students do not perform well in comparison to those of other developed countries. When the PISA was first administered to 15-year olds from the thirty OECD countries and the U.S., the results showed that U. S. students scored well below the international average and sixth from the bottom in mathematics, with about one-quarter of U.S. students failing to acquire even the most basic mathematical skills (OECD, 2004). The PISA has since been expanded to include 65 participating countries and economies, with the 2009 results showing U.S. students ranked as 24th in reading, 30th in science, and 32nd in mathematics (OECD, 2009, pp. 50, 131, 149).

The 2011 Trends in International Mathematics and Science Study (TIMSS) showed a similar disparity of scores. Whereas only 7% of America's eighth grade students scored at or above the Advanced International Benchmark, over 49% of eight graders from Chinese Taipei achieved the Advanced level, along with the students from Singapore, the Republic of Korea, Hong Kong SAR, and Japan, who scored of 48%, 47%, 34%, and 27%, respectively (Mullis, Martin, Foy, & Arora, 2012, p. 114).

Perspective on student performance can also be had through the long running National Assessment of Education Progress, or NAEP. Also known as The Nation's Report Card of the United States (National Center for Education Statistics, 2012), the NAEP has periodically assessed student performance in reading, mathematics, science, writing, history, geography, and other fields since 1969. As a long-term metric that is independent of the state curricula and standards, the NAEP provides a credible gage of long-term trends in student performance. The results from the NAEP indicate that, with only minor fluctuations, student performance has changed very little for over a generation (Stedman, 2009) and the level of student performance has remained essentially flat since the 1960's, despite decades of federal programs and billions of dollars spent to improve American education.

Since the advent high-stakes testing, e.g. the No Child Left Behind Act (NCLB) and Race to the Top (RTTP), the question of student proficiency has become more complex. Federal law mandates that all students will be proficient in reading and mathematics by 2014 and the individual states are allowed to set the proficiency standards and select the tests by which their students are measured. An unintended result is a wide disparity among the states in the achievement levels that are considered as proficient. The results of mapping the NAEP scores to the state proficiency levels data show that student proficiency levels vary widely from state to state, with most states' standard of proficiency falling below the NAEP Proficient standard, and many even below the NAEP Basic standard. "There is a strong negative correlation between the proportions of the students meeting the states' standards and the NAEP score equivalents to those standards, suggesting that the observed heterogeneity in the state's reported percentage proficient can be largely attributed to differences in the stringency of their standards" (U.S. Department of Education, 2007, p. iii).

An unintended consequence of the standards movement has been a narrowing of what is taught in the public schools (Resnick, 2010). Although there was initially an upward inflection of NAEP reading and math scores since 2000 (National Center for Education Statistics, 2012), the improvement is apparently related to a notable increase in the amount of instructional time devoted to the tested subjects and a corresponding drop in the nontested subjects (Center on Educational Policy, 2008). Since 2014, the high stakes testing model of education represented by NCLB and RTTT have shown little progress and, indeed, the 2015 NAEP reading and math assessment reveal a significant drop in test scores and an increase in the percentage of students scoring at the *below basic* achievement level (National Center for Education Statistics, 2015). Despite the rhetoric of education for 21st century skills, the evidence suggests that the accountability system now in place for public education actually suppresses the kinds of learning that the 21st century requires (Resnick, 2010).

The results from the high-stakes testing movement are disquieting, but not without precedent. The public education system of the United States consists of fifty separate education systems of the fifty individual states, without a national curriculum of any kind. Many attempts at education reform have been tried and failed, with the problems of public education remaining intractable as ever. In the light of low overall scholastic achievement from the school systems, the greater challenge of developing an educated populace capable of understanding and knowledgeably participating in our technological civilization would seem formidable or even hopeless. However, standing in contrast to low achievement in our public schools are groups of individuals who belie that dark vision and possess high levels of technological and scientific sophistication in fields where they may possess little or no formal training, yet may possess expert-level knowledge and proficiency. These nontraditional learners are highly skilled individuals who do what they do for the love of it, amateurs in the very best sense of the word.

The phenomenon of Interest

There are many examples of accomplished amateurs in the fields of astronomy, geology, biology, archeology, chemistry, mechanics, electronics, and computer science who independently and passionately pursue highly technical subjects and activities that require an uncommon measure of curiosity, drive, and confidence to take charge of one's own learning (Bouchard, 1993; Gibbons, 1980; Houle, 1988; Stebbins, 1992). These powerful, self-directed learning behaviors are arguably not typical outcomes of the public education system, but rather are personal learning behaviors that develop within some individuals. How these personal autodidactic learning behaviors come about and develop is poorly understood and an area that is little charted (Solomon, 2003). The striking examples of technologically sophisticated amateurs, with a wide range of interests and abilities, suggests a connection between technological activities and self-determined learning behaviors and gives the rationale for this grounded theory study.

Conception of the study: A personal reflection. The seed for this study was planted on a beach in the Florida Keys in the winter of 1994, long before I began my graduate work at Virginia Tech. It was late February and I had journeyed over one thousand miles to attend the Winter Star Party, an annual astronomy event that was held at a Girl Scout camp on West Summerland Key, a warm destination for telescope makers and star gazers amid the depths of the northern winter. That winter I made the trip from Virginia to the Florida Keys and pitched my tent in the shelter of a clump of mangroves beside a small beach, with an unobstructed view south across the Gulf of Florida toward Cuba. I was nearly as far south as one can be in the United States and I was looking forward to seeing sights in the southern sky that are not visible from my home in Virginia. The incident happened in the evening, just after sundown, as telescopes were being set up for the nights observing. I had set up my 13-inch telescope on the beach and was talking with people who wandered by and asked questions about the instrument and some of its unusual features. One of the people who stopped by noticed the lettering on my shirt, which featured my amateur radio call sign, *AB4I*, embroidered above the pocket. He grinned and introduced himself and gave his own call sign, as he was also a radio amateur who, like me, had traveled south to do astronomy in the Florida Keys. We talked for a quite a while and he asked questions about my homemade telescope and, from the nature of his questions and his comments, he was obviously technologically savvy. I asked him about his background and we discovered that he and I had quite a lot in common. Obviously, we were both stargazers; otherwise, we would likely not have been on that beach waiting for the stars to come out. We found that we also shared other interests in common; specifically telescope making, amateur radio, flying, and we both were electrical engineers by profession. Each of these pursuits is not especially common and we were pleased to find such a combination of interests shared by two forty-something astronomy buffs on a beach in the Florida Keys.

He and I were talking about the coincidence when two other observers, who had been setting up their telescope on the beach nearby, stopped what they were doing and strolled over to join the conversation. The older of the two gentlemen smiled, introduced himself and his friend, and gave his own radio call sign—another radio amateur! The second man spoke up and said that he had always had an interest in amateur radio too, but could never learn Morse code to the point he could pass the exams and become licensed.

During the ensuing conversation, the coincidence of improbable interests among the four of us was striking and has since given me food for thought in the ensuing years. The four of us were male and shared an interest in astronomy and amateur radio, but also three of us were engineers by profession, one was a physics professor, two of the four were amateur telescope makers, three were private pilots, two were building their own airplanes, and three of the four were sailors! That which had previously seemed an interesting coincidence now seemed rather extraordinary. What happened to draw these people to such a set of esoteric interests? Statistically, each of these technological pursuits is relatively uncommon in the general population and the combination of such rarities would seem to be wildly improbable, but then four examples came to be standing together on a beach in Florida waiting for the Southern Cross to rise above the Gulf of Mexico. Are some types of people drawn to such activities, or do technological activities somehow come to cognitively shape some individuals? Is there something unique about technological activities that have intrinsic value for promoting learning? This haunting experience serendipitously laid the foundation for what was to become this dissertation, when over a decade later it resurfaced as part of a novel idea for addressing a research problem.

Genesis of the Inquiry. The motivation for this research project did not begin with the surprising incident in Florida, but rather originated in connection to a problem discerned in a study of the literature of the field of Technology Education, a field that is organized around the idea of technological literacy as a component of the general education of all citizens.

The inherent value of technological activities in education has been a touchstone of a number of closely related fields that trace their lineage to the Manual Training movement after the American Civil War. Calvin Milton Woodward was a professor of mathematics at Washington University in St. Louis, who taught applied mechanics at the College of Engineering in the 1870s. As part of the instruction, Professor Woodward required his students to construct working models to help them to understand the mechanical principles of the lessons, but found that the students lacked the necessary skills with the use of tools to enable them to successfully construct the models. Woodward established a lab in which students were taught the necessary shop skills and, in time, conceived that such practical training was of general value and not just for engineers. Woodward's influence was instrumental in founding the Manual Training School of Washington University, which was opened in 1880 (Bawden, 1947; Bennett, 1937). Manual Training flourished in the United States for decades and evolved over time through multiple reinventions and reincarnations as the fields of Industrial Arts, Industrial Education, Industrial Technology, Technology Education, and the Integrative STEM Education movement (Sanders & Wells, 2010; Wells, 2013) at Virginia Tech and the STEM collaboratory initiative that has spread across the country.

Throughout its long history, the intrinsic value of technological activities for promoting learning has been one of the most closely held tenets fundamental to the study of technology. However, the evidence for that assertion is not reflected in the literature of the field and there is a dearth of research exploring the linkages between technological activities and cognitive development. Zuga (1996) commented in her review of research in the field that few claims made for technology education have been substantiated with structured research. Foster (2002) further commented on the lack of foundational research in the field and noted that a reasonable argument could be made that nearly all research in the field could be regarded as exploratory. Petrina (1998, p. 8) and Zuga (2004, pp. 80-82) both commented on the overall atheoretical nature of the field, with Zuga raising the intriguing possibility of creating theory relevant to the study of technology (Zuga, 2004, p. 85).

The dearth of foundational research in the field of technology studies as to the purported merits of the study of technology was the genesis of this research project and, like the larger problem of underachievement in general education, appeared to be another intractable problem that has resisted illumination. It was in thinking about the nature of intractable problems that brought the idea of *analysis of good* as a way to study such problems. *Analysis of good*, or ANOG, is a colloquial expression for a problem solving strategy used in industry for addressing problems that have defied conventional problem solving approaches. The premise of the technique is that when confounded with an instance of something not working as it should, it may be helpful to study a related case that is working well and, in the process, perhaps discover something that may be helpful for understanding the original problem. The memory of the striking example of technologically sophisticated individuals doing astronomy on a beach in Florida sparked the idea of analysis of good applied to social research. It was an intriguing idea, but how to proceed with such a research project was not at all obvious.

In my studies of teaching and learning and Technology Education, I had learned much about how people learn and of the myriad of facets to learning, motivation, and self-determination, but for me these studies had not been satisfying in terms of explaining some of what I had observed and experienced. Although there were certainly ideas from various fields would seem likely pieces of the puzzle, dark areas remained and the problem remained, but I became ever more convinced that the phenomena of nontraditional learners was indeed worthy of a doctoral level study.

Quite how to formulate a research design was perplexing, as the problem refused to coalesce into a satisfactory form that was amenable to research. Asking the right questions and finding a promising research methodology was daunting, with many attempts and conceptualizations of the study, several of which could potentially answer small pieces of the puzzle, but none satisfactorily addressing the nagging root of the problem.

An epiphany came when I realized that in attempting to formulate a research design I was unconsciously and uncritically allowing the positivism of deductive research to be an unquestioned assumption in my thinking. In assessing the problem, I was asking only questions that could be answered by quantitative methods. This realization opened the door to a lengthy and self-critical archeology of thought (Foucault, 1972) to explore my own intellectual identity and the orientations, motivations, and tacit understandings that were intrinsic to my intellectual framework and driving the direction of my research. This exploration of philosophy and the foundations of modern thought and of the research enterprise in general was extensive, but something that I had to do for myself as a personal exercise in reflexivity to examine my own scholarly temperament (Bollinger, 2005). One outcome of my epistemological deconstruction was the awareness that what was missing in my conceptualization of the problem was *theory*, a way of understanding the experience. In all my studies and wide reading of the literature in multiple fields, a satisfactory theory to account for what I had experienced was not to be found. The aim of my doctoral research then would be to find a way to study the haunting phenomenon of so many years ago and somehow develop a relevant conceptual theory. The immediate next question was how to go about creating a theory, when, in all my research courses, theory was among the givens and not a research outcome. How are theories created as a product of research? That was my path to grounded theory and a deep study of its primary texts before deciding on the feasibility of doing a grounded theory study.

The decision to undertake a grounded theory investigation was aided by a series of helpful questions posed by Streubert-Speziale (2007) with regard to evaluating the suitability of the grounded theory method for a particular research problem:

1. Does the current body of literature fail to capture or offer an oversimplification of the concepts relevant to the phenomenon under study?
2. Is there a need for a deeper understanding of specific phenomenon under study?
3. Has the phenomenon been previously investigated?

Answering the above questions supported the efficacy of doing grounded theory research. The literature was determined to be deficient, with a notable lack of theoretical development. There was a definite need for a deeper understanding of the phenomenon of interest, of which the amateur radio enthusiasts appeared to be an exemplary case. Finally, the conception of the problem appeared to be unique, which solidified the case for doing a grounded theory study.

Grounded theory studies are rare in the field of technology studies, as is theory-building in general, a virtual assurance of a unique contribution to the field. The problem remaining was to determine which of five conflicting versions of grounded theory were most appropriate for the goals of the research and the disposition of the researcher.

Research Methodology

The decision to do grounded theory (GT) research is nontrivial and fraught with complexity. As of this writing, there are at least five research methods called *grounded theory* that are actually very different and incompatible with each other on multiple levels. Which grounded theory method to choose for a research project is a weighty decision that must be approached with due diligence. Dealing with the convoluted epistemological quagmire surrounding grounded theory is on the critical path to the research and warrants careful consideration of the goals and disposition of the researcher. In my case, I conducted an empirical evaluation of the major variants of grounded theory before selecting Glaser’s classic grounded theory as the emergent methodology of choice for the study. American Pragmatism proved a very useful perspective for coming to terms with grounded theory and effectively collapsed much of the epistemological confusion surrounding the method since Kuhn (1970). Details of the foregoing analysis are presented in Appendix A as a critical reflection and synthesis of the researcher’s methodological and epistemological development in preparation for doing grounded theory research. The level of detail and phenomenological narrative presented throughout this dissertation is intended to lay bare the research in all its aspects and is presented in the interest of transparency and full disclosure.

The classic grounded theory (CGT) method was developed by Glaser & Strauss (1967) for the express purpose of generating conceptual theory from empirical data. The signature analytical process of grounded theory is the constant comparative method, a systematic process for uncovering latent patterns in data and generating a theory comprised of interrelated conceptual categories that are derived from data. Although grounded theory is often characterized as an inductive method, abductive inference and deduction also operate within grounded theory to conceptualize best-fit explanations of the data, as explained in Appendix A.

One of the upshots of grounded theory research is exposure to its complex and largely unavoidable jargon. This GT-speak is one of the barriers to understanding the various grounded theory methods, as most use the same or similar terminologies in different ways (Glaser, 2009). In writing this thesis, I have tried to be mindful of the pitfalls of such jargon and have attempted to clarify the language in many cases. Where GT technical terms are unavoidable, the terms are defined at their first usage and included in the terms and definitions at the end of this chapter,

One of the distinctive characteristics of classic grounded theory research is that the course of the research is surrendered entirely to the data. Any original conception of the research problem is necessarily set aside, because the initial problem that interested the researcher may have nothing at all to do with what is actually happening in the field. In grounded theory parlance, the actual research problem is *discovered* during the study and takes the form of the participants' main concern and how they continually resolve or process it. The concept of the *main concern* and *processing the main concern* are two central ideas in classic grounded theory. The manner in which the participants continually process or resolve what is highly important to them, i.e. the main concern, becomes the core of a substantive theory that is the ultimate outcome of the research. The focus of the research is on the concerns of those being studied and not the professional concern of the researcher or of an academic field. Classic grounded theory rejects preconceived professional interest concerns in favor of the "substantive interests of those being studied" (Christiansen, 2008; Glaser & Holton, 2004; Glaser & Strauss, 1967).

This grounded theory study evolved nonlinearly into an efficacious approach for addressing a research problem. The research also happens to be a life-cycle interest of the researcher. Such studies are relatively common in dissertation research and present several advantages to the researcher, not the least being high motivation to sustain a doctoral research project. Being an insider, the researcher may possess knowledge and access to data sources that may otherwise be untapped. Glaser commented further on life-cycle interests in dissertation research, saying:

> *"Most of these dissertations are motivated by studying the life cycle interests of the authors. The authors explain their drive or their driveness to discover an abiding interest in a substantive area. And they show how they are not afraid to give up whatever their pet theories may be that come from their life cycle experiences. And giving up their preconceptions does not kill their drive, rather their discoveries enhance it. They are getting ideas that help them understand" (Glaser, 1996, p. xi).*

A grounded theory study of an exemplary case of self-determined technology enthusiasts could illuminate ways of understanding the nature of people's engagement in technological pursuits. Such a study would seem a relevant and useful contribution to several fields that are devoted to the study of technology and perhaps be a counterpoint to the larger intractable problem of underachievement in our schools.

Purpose

The purpose of the study was to investigate an exemplary case of self-determined technology enthusiasts in the hopes of generating a substantive grounded theory that conceptualizes their experiences and concerns.

Research Questions

In accordance with classic grounded theory method, the formal research questions addressed by this study were intentionally abstract and nonspecific, in order that they might guide the study and persist throughout the investigation. In keeping with recommendations from the Fellows of the Grounded Theory Institute (Glaser & Lowe, 2010), four formal research questions were enunciated to initiate the study with a minimum of preconception, arbitrary restrictions, and conceptual bias.

RQ1: What are the core variables and the related sub-variables that are implicit in the data and account for most of its variability?

RQ2: What are the issues and concerns of the participants in the pursuit of their activities?

RQ3: Which aspects of the main concern have the most potential to be transcendent across a wider range of other contexts?

RQ4: How are these issues and concerns resolved or processed?

The research questions are worded in the abstract technical lexicon of classic grounded theory. The reason the research questions were asked in the manner they were is that every CGT study answers these four questions in a manner appropriate to the substantive area under study. These questions allow for explanations as to how the participants are driven and how they continually process their main concern. These questions are fundamental to the grounded theory method and should persist throughout the inquiry, even if the study should take a radically different direction from what was originally conceived. These research questions are constant reminders of the goal of the research and guide the study, without preconceiving or unduly constraining the inquiry.

Population

The population for this investigation was the global population of amateur radio enthusiasts. Of the various groups that were considered for this study, radio amateurs collectively possess a number of characteristics that make them uniquely suited for this research. As a group, radio amateurs tend to exhibit a rich concentration of the behaviors that are of interest in the study, specifically tending to be self-determined, self-directed learners, with relatively high engagement in diverse scientific and technological pursuits. The experience of the researcher is that radio amateurs also frequently engage in multiple technical hobbies besides radio, often as amateur scientists, telescope makers, computer programmers, pilots, photographers, sailors, mechanics, and wood workers, a fact that is potentially useful for the theory building that is the aim of this study. Further, this group also possesses a characteristic that makes it especially amenable to the practical requirement of identifying and contacting would-be participants for the study. All radio amateurs are licensed by their respective governments and have unique radio call signs that are public information and easily accessible via electronic databases, along with the licensee contact information. This attribute simplifies the task of identifying possible research participants with characteristics that are relatively rare in the general population. Radio amateurs are a special population that have been largely neglected in social research, but present a wealth of opportunities for studying a wide range of human behavior and culture.

The development of the theory of *technological immersion learning* was methodologically true to the precepts of Glaserian grounded theory, but with inherent limitations imposed by the practical requirements of empirical research. The research focused on a global cultural group, but all the participants were necessarily English speaking, a requirement imposed by a limitation of the researcher. The participants in the study were all older individuals and predominantly male, with younger people in the minority—a generational artifact that is characteristic of amateur radio today. As a group, the average age of radio amateurs in North America is now past mid-fifties and increasing every year, which does not pose a limitation to theorizing, but suggests an opportunity for further research. The average age of the study group was 59-years and all were college educated, three with doctorates. The gender mix of the study group was 10:2, male/female, which approximately reflects that of the subject population as a whole.

Significance of the research

This thesis adds to existing knowledge and theory by investigating the experiences of individuals engaged in complex technological activities and conceptualizing their experiences as a grounded theory. The resulting *technological immersion learning theory* (*TILT*) details a regenerative learning process that is relevant to the field from which it was derived and, being a grounded theory, is also abstract of time, place, and people and will have a range of applicability beyond its origins. As a basic social process, the theory provides at least a tentative indicator of the inherent value of technological activities for promoting learning, with potential significance to several fields, such as those concerned with learning theory, technology studies, and motivation.

This study is also significant in that the structure of the theses provides a phenomenological account of the process of learning and applying the classic Glaserian grounded theory method. The first-person detail presented throughout this thesis is intended to unmask the complex undertaking of doing grounded theory research and is presented in the hope of easing the transition of other would-be researchers into doing grounded theory research.

Assumptions and limitations

At the beginning of a grounded theory study there is no preconceived theory in mind, nothing assumed to be relevant, research questions are only tenuously held, and beyond the initial data, the researcher may have no idea from where the next data is coming. There are, nonetheless, several inherent assumptions that are essential to conducting this type of research, most of which relate to the abilities and sensibilities of the researcher.

A fundamental assumption is that there is a main concern of the participants that can be revealed by empirical research and that it will emerge during the inquiry, if the researcher remains open and sensitive to the data. A related and necessary assumption is that the researcher possesses the necessary discipline and theoretical sensitivity (Glaser, 1978) to allow the main concern to emerge. A further assumption is that the researcher is capable of abstracting that main concern and the manner in which it is continually resolved into a parsimonious set of concepts and hypotheses that are integrated into a theoretical construct that is abstract of time, place, and people. As researcher, I took the leap of faith that these assumptions could actually be true.

The grounded theory method and philosophy necessitates a high tolerance for ambiguity on the part of the researcher. All elements of the emergent theory must be grounded in the interpretation of data, even to the point of jettisoning research questions and lines of inquiry that are found not to reflect the realities and concerns of the participants and asking new questions and taking new directions that reflect what is happening in the field. Everything about the research is emergent and the researcher must be open to the discovery of the unexpected. As researcher, I had to have confidence in my abilities to cope in the face of uncertainty.

This introduction to the research retains much of its pre-study conceptualization and was updated only sparingly as the study progressed. As researcher, I chose to preserve the initial tentative character of the study to emphasize the point that ambiguity is part of the process and Glaser's admonition to "trust to emergence" is good advice for doing grounded theory. Grounded theory is a nonlinear process that does not follow the sequence of more traditional research methods. The traditional model of research poses a question, reviews the literature, collects data, performs an analysis, and presents the findings and conclusions in a thesis—in that linear sequence, with distinct separation among the phases. Grounded theory research has no such clean and linear demarcations among the questions, literature, data, and the analysis and presents challenges for structuring the thesis. If this thesis were structured to reflect how the research actually happened, the reader would be figuratively led through the convolutions of a labyrinth, complete with false starts, cul-de-sacs, switchbacks, and wandering about collecting clues, with the outcome only learned at the very end. The expedient taken in structuring this thesis was to methodically present the fruitful developmental lines of the theory, an approach which has the advantage of clarity of presentation, but gives an illusion of linearity of process when the reality was very different.

Terms and definitions

The following terms are used throughout this thesis and are defined below:

Amateur radio service: a technical hobby practiced by individuals who are licensed by their respective governments to conduct non-commercial radio communications and experimentations on internationally allocated frequency bands (ARRL, 2014). The Federal Communications Commission (2008) describes the Amateur Radio Service as “a voluntary, non-commercial radio communication service authorized for the purpose of self-training, intercommunication and technical investigations carried out by licensed persons interested in radio technique solely with a personal aim and without pecuniary interest.” Amateur radio operators are also variously known as radio amateurs, ham radio operators, and wireless experimenters.

Amplified causal loop: a theoretical construct whereby an action can produce a result that reinforces and strengthens the impetus of the original action. Positive feedback in a regenerative causal loop strengthens the impetus to produce positive results, whereas a degenerative causal loop produces a stronger and escalating negative reaction to an initial negative action.

Autodidactism, or *autodidacticism*: a term that means approximately, but not precisely, the process of autonomous learning or self-education as an autodidact.

Basic Social Process: a theoretical construct detailing a social phenomenon that occurs over time and involves change over time, with discernable breaking points to the extent that stages can be perceived (Glaser, 1978, 97-98).

Category: a concept generated through comparisons of incidents occurring in empirical data, which conceptualizes and abstracts the meaning of the data.

Classic grounded theory: a research methodology pioneered by Glaser and Strauss (1967) and further developed by Glaser (1978, 1992, 1998, 2007) as a general research method intended to systematically generate a conceptual theory derived from empirical data.

Core category: the central concept to which all the other concepts relate in a grounded theory study. The core category is the kernel of the emergent theory, integrates all the other categories, and conceptualizes how the main concern is continually resolved.

Designing: a sub process of technological immersion learning invoked in response to a challenge that have requires the development of new technology.

Dialectic: the natural selection of ideas through a process of resolving contradictions that arise in the conjectures and refutations that are inherent in human experience (Popper, 1963).

Dimension: a specifiable aspect of a concept, e.g. *experimenting* might be specified in terms of a *skill* dimension, a *curiosity* dimension, an *engagement* dimension, etc. Dimensions represent the variable aspects of a concept under study.

Doing Technology: a process of active hands-on involvement with doing technological activities as intrinsic enjoyment, exploration, experimentation, problem solving, utility, or creativity within a particular domain of interest.

Empowerment: the act or process of gaining the ability to make something happen (operational definition)

Engagement: a property of technological immersion learning that embodies the state of active personal involvement and absorption in tasks undertaken for their positive physical, mental, and emotional attributes for the doer (operational definition).

Heuristic: involving or serving as an aid to learning, discovery, or problem-solving by experimental and especially trial-and-error methods (Merriam-Webster, 2016).

Indicator: a sign of the presence or absence of a concept manifested in empirical data

Interchangability of indicators: an analytical procedure utilized to evaluate a concept by examining the indicators in empirical data for similarity and differences.

Main concern: a classic grounded theory term for the dominant factors or interests that are most important to the people involved in a substantive situation under study.

Problem solving: a sub process of technological immersion learning that is invoked in reaction to a failure to meet expectations, or an attempt to resolve a problematic situation.

Property: a classic grounded theory term for a generated concept that characterizes, explains, defines, or elaborates the meaning of a category.

Self-actualization: is a continual process of self-discovery, re-creation, and self-expression from all the actions, activities, and myriad contexts of being human in a complex social and technological world (operational definition).

Self-directed learning: a process by which individuals take the initiative for their own learning needs and, with or without the help of others, identify resources for learning and choose and implement appropriate learning strategies and evaluate the learning outcomes (Knowles, 1975, p. 18).

STEM fields: an acronym referring to a large number of disciplines associated with science, technology, engineering, and mathematics (STEM) and identified by the U.S. government as key to national competitiveness. The STEM Education Coalition was organized to support STEM education in the U.S., http://www.stemedcollition.org.

Technology: literally, craft (*technē*) informed by knowledge (*logos*). A more comprehensive definition derived from the *Standards of Technological Literacy* (ITEA, 2000) and *Science for All Americans* (AAAS, 1989, 1993) is that technology is the sum total of all the tools, materials, devices, and knowledge that are created and used by people to extend our capabilities and the reach of our hands, voices, and senses.

Technical culture: a term from the Study of Technology and Science (STS) community that refers to a culture that emphasizes technical knowledge and skills, with positive attitudes towards technology that are reflected in the interests, engagement, language, and skill in technical activities (Haring, 2007; Lib, 2010).

Technological immersion: an experiential environment created by the complex amalgam of humans and technology interacting in a real-life situation.

Technology studies: a term that nonspecifically refers to a number of academic fields that study technology for various purposes, including general education (Technology Education), vocational and career education (Industrial technology), historiography (Science and Technology Studies), and as the technology component of STEM Education.

Technological immersion learning: The basic social process (BSP) discovered during this study, whereby learning and personal growth take place for individuals who are immersed in a technical culture and are afforded affirmation from multiple sources of feedback.

Theoretical sampling: a purposive, non-probability sampling procedure that is utilized in grounded theory research to promote theory development.

Chapter 2: Method

This chapter presents the research design and methodological details of this study, which adhered as closely as possible to the precepts of classic grounded theory (CGT) as put forth by Glaser (1965, 1978, 1992, 1994, 1995a, 1995b, 1996, 1998, 2001, 2002, 2005a, 2005b, 2008, 2009). The distinctive elements of classic grounded theory research are briefly outlined in this chapter and the methods and procedures employed in the study are presented in detail.

Classic grounded theory

Classic grounded theory is a research method that enables the researcher to develop a theory that offers an explanation about the main concern of the population of a substantive area and how that concern is resolved or processed (Glaser, 1978, 1992, 1998; Glaser & Strauss, 1967). As such, classic grounded theory applies a unique solution to the problem of whose "story" to tell by insisting that the main concern of the participants and their way of continually resolving their main concern be allowed to emerge with as few constraints and preconceptions as possible. This so-called finding of the core variable and its recurrent resolution amounts to the discovery of the actual research problem and resolves the potential issue of many equally justifiable interpretations of the same data. Preconceived theoretical perspectives and professional interest concerns are rejected entirely in favor of the emergence of "the substantive interest of those being studied" (Christiansen, 2008; Glaser, 2005b). The hallmarks of classic grounded theory that set it apart from all the other variants of the method are:

1. Insistence that all concepts must emerge from data
2. Discovery of the main concern of those being studied—the actual research problem and related to an emergent core variable
3. Discovery of the manner in which the main concern is continually resolved—which becomes the core of an emergent theory
4. *All is data* (Glaser, 2007) to be analyzed, a grounded theory dictum that everything that happens in a research situation is fuel for conceptualization and theorizing

Conducting a classic grounded theory study requires a high tolerance for ambiguity on the part of the researcher. In the beginning, the scope of the study is essentially unbounded, nothing can be assumed to be relevant and, beyond the first sample, where the next data are coming from is not known. The research questions and original perception of the research problem are only tenuously held, as the problem that we begin with may not be the problem that we end with. The data collection and analysis are continual and responsive to what is happening in the field. Everything about the research is emergent and none of it can be preconceived—only discovered in the analysis of data. A high tolerance for uncertainty melded with patience, discipline, and theoretical sensitivity are essential attributes of grounded theory researchers. Theoretical sensitivity is something that develops and grows throughout the study through deep immersion with the data and following up hunches, insights and questions from previous experience (Stern & Poor, 2011; Strauss, 1987, p. 51) and reading the literature (Charmaz, 2006), (Glaser & Strauss, 1967), (Stern & Poor, 2011), (Strauss & Corbin, 1990).

At the outset, a classic grounded theory study is open-ended and has only minimal restrictions on its scope, which makes the delimitation of such a study an important procedural concern. Delimiting the study is addressed by the grounded theory method itself. Although the study begins with few restrictions, there is rapid convergence in the data collection to those data that are relevant to concept development. The integration of the theory around a core category serves to delimit the theory and thereby delimits the research. The delimiting proceeds on two levels by a process of reduction that occurs both in the theory and in the categories from which the core variable descends. As the theory develops, solidifies, and becomes more parsimonious, it condenses into a smaller set of higher-level concepts with increasingly effective explanatory power. Similarly, the categories undergo reduction to include only those that are relevant to the core variable. Theoretical saturation serves to further delimit the categories to only those that are tightly integrated into the burgeoning theory. Thus, the delimitations of this study are theory-based, rather than derived from any of the more typical methodological concerns of testing a theory, generalizing to any particular population, or of qualitative description. A grounded theory study is delimited by the convergence of a conceptual theory that effectively explains the phenomena at the focus of the study (Christiansen, 2008; Glaser, 1998, 2001; Glaser & Holton, 2004).

The process of executing a classic grounded theory study is outlined below, based on that of Simmons (2013) and presented with expanded detail. The six stages of a GT study are initially sequential, but inherently become simultaneous and iterative once a study is underway.

Preparation. Preparing for a classic grounded theory study requires maximizing the theoretical sensitivity of the researcher, defined by Glaser and Strauss (1967, pg. 46) as the researcher's ability to have theoretical insight into an area of research, combined with an ability to make something of those insights. Wide reading in many unrelated fields can expose the researcher to ideas outside the substantive area of interest and counter parochial perspectives that could limit the research. Any initial conception of the research problem should be set aside in order to be responsive to what is happening in the field. The decision to do a classic grounded theory study requires that the focus of the research be on the main concern of those being studied and not the professional concern of the researcher or of an academic field. The actual research problem is the main concern of those being studied and the manner in which it is continually resolved. In-depth literature review is typically delayed until relevant literature can be identified, usually only after the research is well advanced.

Data Collection. In the initial stages of a study, the researcher should seek out those who are in the best position to inform them about the phenomenon (Glaser, 1978). Data collection begins with an initial criterion sample selected by the researcher as an opportune beginning of the study, but beyond that first data sample, nothing else can be known *a priori*. Unstructured interviews are the most common data in grounded theory studies and often combined with participant observation. The analysis of the first data determines where to go and what to look for next. Data collection is driven entirely by the ongoing analysis and the requirements of developing theory, a procedure known as *theoretical sampling*. The first data sample begins the ongoing interactive and iterative cycle of data collection, constant comparative analysis, and memo writing.

Constant Comparative Analysis. The constant comparative method is the inductive core of classic grounded theory. The analysis begins immediately with open coding of the very first line of the very first interview. The *unit of analysis* is the *incident* observed in the field of study. The constant comparative method relates data to ideas and then ideas to other ideas in the search for patterns in the data. Initially, the researcher codes for anything and everything as ideas arise in the methodical study of data. *Substantive codes* summarize the empirical essence or substance of an incident. Groups of related incidents are *indicators* of a higher-level *category*, as illustrated by the Concept-Indicator model of Figure 1 (Glaser, 1978, p.62). Conceptualization abstracts data and makes them comprehensible as indicators of a more general concept.

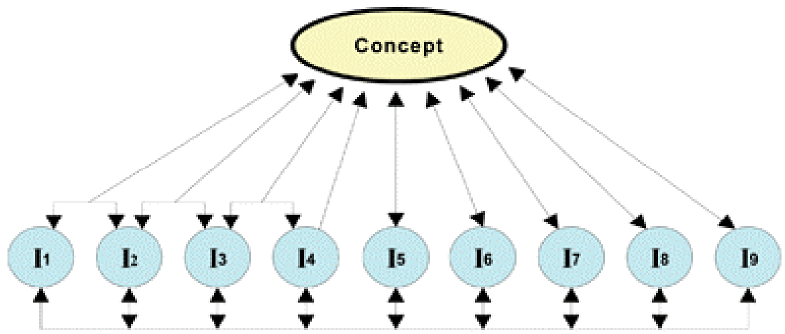

***Figure 1*. The Concept-Indicator model**

Often categories arise as *in-vivo* concepts from the substantive area of study—terms adopted from the language of the participants. The analyst always queries the data with a mantra of three questions (Glaser, 1978):

1. What is this data a study of?
2. What category does this incident indicate?
3. What is actually happening in the data?

The results of comparative analysis drive further data collection to maximize the variation in the data and saturate the categories and their dimensions. Eventually, the main concern of the participants will be found that explains most of the action in the research area and a core variable will be determined. The discovery of a core category "is our grounded answer to the perennial research problem of which focus" (Glaser, 1978, p. 94). Once a core category is determined, open coding ends and *selective coding* begins, with coding only for the core category and related categories. Further data collection is driven by the requirements of the developing theory, i.e. with *theoretical sampling* to fully saturate the core category and the related categories. A core category reoccurs very frequently in the data, is related to most of the other categories and takes more time to saturate, has grab and explanatory power, is completely variable and a dimension of the problem, and it can be any kind of theoretical code (Glaser, 1978, pg. 94-96). All the while, memo writing has been a constant activity, with *theoretical memos* written to explore every aspect of the data. Ultimately, the categories and their dimensions become saturated as no new properties or dimensions are found. A search for relevant literature can be useful at this point as another data source. *Theoretical coding* ensues to explore the relationships among the categories in terms of high-level *theoretical codes* that can integrate the theory and account for the range and variability in the data. Theoretical coding is the end stage of theory development, as the emerging theory condenses and becomes more parsimonious and abstract and effectively explains the action in the research area (Glaser, 1978, 1992, 1996, 1998).

Memoing. The writing of theoretical memos is the core stage of theory generation and the bedrock of doing grounded theory (Glaser, 1978, p. 83). Clarke (2005, p. 85) described memos as 'intellectual capital in the bank'. Throughout the study, ideas will occur about the data and possible theoretical relationships within it—ideas that are to be captured in theoretical memos. Once written down, ideas are data and can be analyzed at any time, but until then they are fragile and can be forever lost or subsumed in the flood of ideas sparked by grounded theory. The cardinal rule is that when such ideas occur, they must be captured in a memo as soon as possible, no matter what is interrupted to do it. Data collection, analysis, and memoing are activities that occur cyclically and overlap, with memoing *always* taking precedence. Theoretical memos are the theorizing development of the researcher's ideas as they occur and are fundamental to doing grounded theory. According to Glaser, "the four goals of memoing are to develop *ideas* with complete *freedom* into a memo *fund* that is highly *sortable*" (Glaser, 1978, p. 83) (emphasis in original). Memos are written in a stream of consciousness fashion, free form, with no concern for grammar, spelling, or anything else that could derail the stream of thought. Memo writing captures the frontier of the researcher's thoughts throughout the study and is an effective tool for catching the fleeting thoughts, hunches, intuitions, abductive insights, and inspirations that produce new knowledge.

Sorting & Theoretical Outline. Eventually, a study reaches the point when nothing new is found among the developed categories and no new theoretical relationships are emerging with continued analysis. When the study has reached the point, the *sorting* process begins and the memo fund is literally cut apart and sorted into conceptual groups. Sorting is not a data sort, but is a sort by theoretical concepts. The completed sort is in essence a conceptual outline of the emergent theory. Often the first sort results in more memo writing, more data collection and more analysis. Relevant literature can become useful data at this point, to be analyzed like any other data, and still more memos written, which are ultimately cut apart and sorted as well. Sorting is complete when stable relationships have emerged and nothing more is forthcoming (Glaser, 1978, 1992, 1996, 1998).

Writing. After the memo are cut apart and sorted into a conceptual outline, the completed sort essentially constitutes the first draft of the write-up of the theory. Finishing the write-up is a matter of refinement into a final draft. The foregoing six steps of the classic grounded theory process are generally sequential, but grounded theory is not a linear methodology. According to Glaser (1996), grounded theory is highly structured and rigorous, but nonlinear and variable in its pacing. There is a delayed action phenomenon that happens within the researcher as pre-cognitive processing that paces the study. Some elements are sequential and can be more or less scheduled, but sometimes many things happen simultaneously, such as data collecting, analysis, and memoing. The study is always cooking within the researcher, who has to be open to the serendipitous when it happens (Glaser, 1998, p. 51).

Credibility and rigor

Rigor in research is tied to the abstract concepts of reliability and validity (Morse, Barrett, Mayan, Olson, & Spiers, 2002), broad overarching concepts that three decades of paradigm (Kuhn, 1970) debates have muddled and confused to the point that researchers are now obliged to explicate how rigor was sustained in their research. The fallout of the paradigm debates since Kuhn (1970) and the technical differences between quantitative and qualitative research practices has resulted in a confused landscape of conflicting rigor criteria, with no standards or even common definitions for reliability and validity that are applicable across the multitude of social research methods. The conventional canons of internal and external validity, reliability, and objectivity that are standards for positivist quantitative research are inconsistent with qualitative inquiry. Lincoln and Guba (1985) proposed generic criteria for rigor in qualitative research that parallel the four positivist terms and are useful reference for qualitative research:

Qualitative criteria	**Quantitative criteria**
Credibility	Internal validity
Transferability	External validity (generalizeability)
Dependability	Reliability
Confirmability	Objectivity

The rigor criteria of Lincoln and Guba (1985) are generic and helpful guidelines, but are not universally accepted among qualitative researchers. Classic grounded theory in particular has its own standards of rigor, maintaining that *fit*, *workability*, *relevance*, and *modifiability* as hallmarks of rigorous GT research (Glaser, 1998). In other words, a grounded theory is to be evaluated on its own practical merits with respect to the research problem. However, doctoral studies also have the practical procedural requirement to demonstrate the rigor of the research. The issue of how to demonstrate rigor in a ground theory study is a seemingly straightforward question, but one that is complicated in practice (Cooney, 2011). The strategy adopted for this study was to preserve an audit trail of field notes, interview transcripts, and memos in order to chronicle a timeline of the evolution of the theory. The study began with a research notebook that was quickly supplanted by the electronic data storage capabilities of the ATLAS.ti computer software utilized in the study (Muhr, 1991; Scientific Software Development, 2006). The database preserved file creation and modification dates and allows a timeline of the study to be reconstructed, particularly with respect to the writing of memos. The ATLAS.ti database ultimately grew to over 100 megabytes in size and the entire data structure of all the files related to various aspects of the research exceeded two-gigabytes.

Procedures

The procedural details as to how the study was conducted are presented below, including preparations for the study, an introduction of the social group that was the subject of the research, data collection strategies, analytical details, and key milestones along the way of developing a substantive theory. It was not possible to capture the long and convoluted path that led to the Immersion Theory of Technological Learning, but in the following narrative, the journey is punctuated with key points and analytic events such that the reader may understand the progression of the study.

Preparations. Ideas are fragile and can be quickly forgotten, and may never recur if they are not captured in some way. At the outset of the study, I adopted several strategies and personal accommodations in the interest of capturing thoughts as they occurred for later review. I kept a small notebook and 3”x5” index cards carried in a shirt pocket, I made notes in my daily planner, or used a digital audio recorder, or in some instances, a telephone voice mail message to myself with a brain dump as a thought was occurring and I had no other convenient way of recording it. I also kept a small clipboard with an amber LED at my bedside to record thoughts in the night that had to be captured or be lost. Often and sometimes several times a day, notes were word processed as rich text format (RTF) files for later incorporation into the study data archive.

Qualitative research can generate a great deal of data and quickly become labor intensive and time-consuming, a task that can be simplified by appropriate software tools. Modern computer-aided qualitative data analysis software (CAQDAS) can simplify data management, but Glaser (1998, p.185-186) perceives a risk that software can become a technological trap that could actually impede the development of a grounded theory by promoting thick description rather than supporting conceptual development. Prior to beginning this study, I evaluated three CAQDAS packages for suitability for grounded theory research and selected ATLAS.ti over NVivo and MaxQDA as being the most flexible and supportive of grounded theory methods. The closeness of the data and excellent memo interface were the primary factors for selecting ATLAS.ti over the other CAQDAS packages. I used only a small subset of the features of ATLAS.ti, preferring only the most basic tools that were intuitive and transparent. Field notes, interview transcripts, substantive codes, theoretical memos, and network diagrams were all kept in the ATLAS.ti database and all highly accessible. New memos could be initiated by a single mouse click and the data was likewise as accessible. Incidentally, a fair amount of data analysis was actually done manually on hard copy outside the software, a personal strategy to promote analytical diversity. Fruitful results were subsequently transferred into the ATLAS.ti database in the interest of consistent project management. To be clear, CAQDAS packages do not actually do qualitative analysis, despite the implication of the CAQDAS acronym. Effective qualitative analysis takes place only in the mind of a researcher immersed in data.

Participants and Data sources. The focus of this research was the global population of amateur radio operators, a cultural group over 3-million strong and present in nearly every country on Earth. As a group, radio amateurs tend to exhibit a rich concentration of the behaviors that are of interest for the study, specifically tending to be self-determined, self-directed learners, who are often engaged in diverse scientific and technological pursuits. The experience of the researcher is that radio amateurs also frequently engage in multiple technical hobbies besides radio, often as amateur scientists, telescope makers, computer programmers, pilots, sailors, photographers, mechanics, and wood workers—to name but a few. A study of amateur radio operators taps into a diverse range of other activities, a fact that is potentially useful for the theory building that is the aim of this study. Further, as a practical matter of research, this group possesses a characteristic that makes it especially amenable to the practical requirement of identifying and contacting would-be participants for the study. All radio amateurs are licensed by their respective governments and are assigned unique radio call signs that are public information and easily accessible via electronic databases, along with the licensee names and addresses. This characteristic simplifies the task of identifying possible research participants with characteristics that are relatively rare in the general population.

Multiple data sources were utilized in the study, beginning with formal unstructured interviews and evolving to include a variety of other data. Verbal data included twelve formal interviews and numerous informal conversations with many individuals and observations of radio club meetings and workshops. Written sources included books, magazines, Internet web pages, chat groups, blogs, and email. Field notes and memos were written to capture the interactions and observations of incidents, the text of which became fodder for comparative analysis. In the interest of full disclosure, I myself am a radio amateur, a fact that likely afforded me insider access and sensitivity to phenomena that may have been difficult to acquire otherwise. Twelve formal interviews were the primary data of the study, supplemented by data from other sources, including observations of individuals and incidental comments and behaviors.

Participant selection plan. A grounded theory study begins with a nonrandom criterion sample of those best positioned to inform the research. A selection plan was developed to begin the research by identifying potential candidates for in-depth interviews, which was the initial data source for the study. As a cultural group, the subjects of this research represent a small minority of the general population, about one in three thousand globally, one in five hundred in United States, and one in one hundred in Japan. However, as uncommon as they are in the general population, amateur radio enthusiasts are easily identifiable because of the global nature of their telecommunications activities and their unique radio call signs. The actual problem of identifying research subjects was one of delimiting the selection to a practical scope.

The identification of potential subjects was a behavior based criterion sample for those radio amateurs who were actively engaged in a particularly challenging aspect of amateur radio. The aspect chosen was that the subject must be active on the 160-meter amateur band, which was characterized by one of the participants as “the Mount Everest of amateur radio.” Identification of such individuals was accomplished by three complementary methods: 1) direct reception of their radio signals off the air on the 160-meter amateur band, 2) via their presence on the ON4KST internet chat group, and 3) via real-time data from DX packet clusters, the latter two methods available via the internet. This search strategy allowed identification of individuals currently active in the hobby and coincidentally may be inclined to participate in the study.

The following example demonstrates the selection process using DX cluster data to identify radio amateurs active on the 160-meter band. DX packet clusters are near real-time data networks that are utilized by radio amateurs to facilitate radio contacts. In this example, the DXSCAPE packet cluster (JA4PXC, 2009) was accessed via the Internet at http://www.dxscape.com/ and interrogated for activity on the 160-meter band. The search results were filtered to isolate ten events for the purpose of this example shown in Figure 2, with the call signs as the key information of interest.

The interpretation of the data in Figure 2 is that the leftmost column contains the call signs of amateur radio stations that were heard at the indicated date and time and frequency by the station listed in the right column, with optional remarks in most cases. These call signs are public information that is generally accessible by way of online databases. Among the more popular amateur radio call sign databases is http://www.qrz.com/, which aggregates many other databases and is freely accessible. Other online databases include Buckmaster (2009) at http://www.hamcall.net/. The call signs captured in Figure 1 were entered into the QRZ search engine and the results are summarized below in Table 1. The call signs found in this example were those of radio amateurs in the United States, France, Japan, Russia, Martinique, and the Chesterfield Islands of Australia. All the radio amateurs were identifiable from online databases, all but one with a published email address—thus, eighteen individual radio amateurs were identified from ten packet cluster entries.

DX CLUSTER Database search:		Band=160M		1113Z 16Nov09	
Callsigns	**YY/MM/DD**	**UTC**	**FREQ**	**Remarks**	**Reporter**
TX3A	09/11/16	1109z	1830.6	cq cq down 5	K8EUR
K3UL	09/11/16	1056Z	1830.6	cq cq down 5	N1EU
K8OQL	09/11/16	1051Z	1821.0	PSE for W.A.S.	K3SEW
JA8ISU	09/11/16	1047Z	1813.1	Peak 599 in NV	W6NF
W0FLS	09/11/16	1044Z	1821.5		N3NA
RX0AE	09/11/16	1004Z	1819.5	Zone 18 nice signal on peaks	W3UR
FM5BH	09/11/16	0958Z	1825.0	Nil en France. 73 Laurent	F5HB
JA7NI	09/11/16	0948Z	1820.5	CQ	AA1K
AA1K	09/11/16	0944Z	1820.6	cq dx gm Jon	WK3N
TX3A	09/11/16	0651Z	1834.8	569 on m inv vee	KA9FOX

***Figure 2*. Demonstration of access to DX packet cluster data**

Table 1

Call signs and contact information from online database

Callsign	Name, Address	Email
AA1K	Jon Zaimes, Felton, DE.	aa1k@arrl.net
AA7JV	George Wallner, Miami Beach, FL.	gwallner@the-beach.net
N1EU	Barry Gross, Delmar, NY.	Barry.n1eu@gmail.com
K3NA	Eric Scace, Charlestown, MA.	eric@k3na.org
K3SEW	Ronald Klock, Howard, PA.	k3sew@arrl.net
K3UL	Robert Garrett, Williamsport, PA.	rgarrett5@comcast.net
W3UR	Anthony McClenny, Glenwood, MD.	bernie@dailydx.com
WK3N	James Scott, Hartstown, PA.	w3kn@hotmail.com
K8EUR	Alex Dolgosh, Parma, OH.	al.dolgosh@hamradio.org
KA9FOX	Scott Neader, La Crosse, WI.	ka9fox@QTH.com
W6NF	Jack Parker, Reno, NV	vhfplus@gmail.com
W0FLS	David Raymond, Earlham, IA	daraymond@iowatelecom.net
F5HB	Jeannaud Bernard, Pauillac, France.	f5hb.bernard@orange.fr
FM5BH	Laurent Bellay, Ducos, Martinique.	fm5bh@wanadoo.fr
HA7RY	Tamas Pekarik, Budapest, Hungary.	HA7RY@invitel.hu
JA7NI	Kunikazu Togashi, Kamioka Akita, Japan.	ja7ni@arrl.net
JA8ISU	Kazuo Okamato, Abashiri Hokkaido, Japan.	okamato@mx6.et.tiki.ne.jp
RX0AE	Petr Bobrovsky, Divnogorsk, Russia.	rx0ae@yandex.ru

The DX packet clusters comprise an active global network that is used by thousands of active radio amateurs in nearly every country on Earth. While remarkable for its international scope, it was necessary to restrict this very large pool of potential study candidates by applying the geographic criteria that the individuals must reside in the eastern United States and be within 500-miles of the researcher in order to facilitate in-person interviews and site visits. Those geographic criteria are partly inherent in the system by which amateur radio is regulated by their respective governments, which systematically assigns call signs by national prefix and also numerically by call areas. For example, the call areas within the United States are shown in Figure 3. A simple alphabetical sort of call signs obtained from a packet cluster concentrated the call signs by country and by numerical order within the country. Applying this procedure to the call signs identified in the Figure 2 and Table 1 allowed the U.S. amateur in the eastern United States to be readily identified. The reduction of the foregoing pool of eighteen individuals identified earlier produced a list of eight individuals within the tentative 500-miles radius of the researcher and thereby potential candidates for the study.

***Figure 3*. United States amateur radio call sign districts**

These foregoing results confirmed a useful selection technique and prompted a systematic effort to compile a practical list of potential research candidates by accessing the DX packet clusters, the ON4KST Internet chat page frequented by 160-meter aficionados, and by direct reception of off the air signals on the 160-meter band. Data was collected over a period of weeks resulted in a large amount of data from the packet cluster, over one hundred users of the low-band chat page, and nearly as many stations heard live off the air. The three lists were sorted alphanumerically and selected for the 1st, 2nd, 3rd, 4th, and 8th call areas of the United States and then cross compared to identify stations appearing on at least two of the lists. Ultimately, about thirty individuals were identified as being promising candidates for the study and it was a matter of selecting one individual with which to begin.

Interviews. Unstructured interviews were the primary data source of the study. Twelve interviews were conducted in total, with six interviews conducted during home visits, four were conducted at intermediate sites, and two were conducted by telephone. The gender mix was 10:2 and dominated by males. Audio recordings were made of the interviews as a complement to the researcher's field notes and analysis commenced with the acquisition of the first data. The interviews were unstructured and were always initiated by a single opening question that was phrased as an open-ended request:

> *Please tell me about your career as a radio amateur, beginning with how you became interested in wireless.*

Follow-up questions were formulated as needed, driven by the overarching goal of understanding that which was important to the participants and explore the nature and range and variation of their activities and experiences.

Summary

This chapter has presented the methodological details of the investigation, beginning with a basic outline of the classic grounded theory method and followed by the procedures utilized to identify prospective candidates for the study. The details of the iterative process of data collection and concurrent analysis are presented in Chapter 3, with key events and evolving concepts noted in the progressive development of the theory.

Chapter 3: Data Collection & Analysis

"Do not go where the path may lead, go instead where there is no path and leave a trail."
Ralph Waldo Emerson

Data collection and analysis are not separate events in grounded theory research, but instead are concurrent, interwoven, and evolve together during the investigation. This chapter presents the details of the data collection and comparative analysis in order to expose the process and details by which the grounded theory of technological immersion learning was developed.

Identifying the first participant in the study was relatively easy and fortuitous. When I began compiling call signs of active amateur radio stations in the effort to identify would-be participants for the study, there was a notable signal that I often encountered on many of the amateur bands, including the 160-meter band. The radio amateur in question was very active and often heard, so I suspected that they might live nearby. The online FCC database confirmed that the station was indeed nearby and within easy driving distance, so when the time came to officially recruit participants for this study, I contacted the individual by email to introduce the study and asked for his participation. The affirmative response was immediate and enthusiastic and arrangements were made for a site visit and an in-depth interview.

When I visited Carter's home to conduct the interview, it was obvious that allowances were made to accommodate his radio hobby. The two-story frame house was on a large wooded lot – a double lot, as I was told, that was purchased expressly to have space for radio antennas. I half-expected to see the stereotypical antenna tower when I arrived, but instead found a simple vertical antenna to the side of the yard, a few small VHF antennas on masts and several wire antennas installed among the trees. There was also a large propane tank to the far side of the house, along with an emergency generator and a remote weather station. There were two automobiles in the driveway, one a Toyota 4WD SUV Hybrid and the other a Toyota four-door sedan, both with amateur radio license plates.

We conducted the interview in the radio shack[1], which was not actually a shack, but was instead a large and comfortable room over the garage. There were two operating positions along two of the walls, with a workbench and office along a third wall. The collection of radio equipment and computers in the room represented a significant investment and suggested that the radio hobby had been practiced for some time. There were modern commercially made high-frequency transceivers, several radios made from kits, VHF/UHF transceivers, as well as numerous commercial and homemade support equipment. I was especially intrigued by the several kit-built radios, one of which was in progress on the workbench. Numerous operating awards adorned the walls: certificates and plaques, along with maps and QSL cards—the travel posters of amateur radio. Several bookshelves held a sizable collection of books that were devoted to radio.

Carter was a retired sociology professor who came to amateur radio in his college days, after being a short wave listener for some years. As a youngster he listened to late night radio on the AM broadcast band and eventually acquired a short wave receiver and began to listen to

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[1] The terms *radio shack* and *ham shack* are historical terms for the site of an amateur radio station. Originally, the equipment was actually located in a small shack separate from the home, because the equipment was large and often dangerous. Nowadays, most amateur radio stations are in the home, often in a room dedicated to the activity.

international radio broadcasts. He later became interested in amateur radio and began learning CW, i.e. Morse code, and then became involved with the local amateur radio club. He earned the Novice license in 1982, progressively went through the FCC licensing levels over a number of years, and was now an Extra class licensee, the top ranking of American amateur radio licenses. He has remained an active and enthusiastic radio amateur for nearly thirty years and engaged in many of the aspects of the hobby.

I elected to record the interviews for this study, against advice to the contrary by Glaser (1998). It may be that an experienced grounded theorist may be able to conduct interviews and have adequate data capture solely with field notes, but as a novice researcher I felt that the risk was too high to rely only upon field notes. I elected to maximize the chances of success by recording the interviews for later transcription. The procedure for all the interviews was to formally describe the study, execute the informed consent form, start the audio recording, and chat for a moment before getting underway. There was never a hint that any of the participants were concerned about recording the interviews and the small digital audio recorder was quickly forgotten as I asked the only fixed question of the study, which was phrased as an open-ended request:

> *"Please tell me about your career as a radio amateur, beginning with how you became interested in wireless."*

Invariably, no other prompting was needed and all the participants seemed to enjoy telling me about how they became interested in radio, how they became licensed, what they enjoy so much about the hobby, their aspirations, their accomplishments, and what keeps them engaged in doing what they do. The interviews were unstructured, with only the single introductory question to begin the conversation, with occasional follow-up questions as needed.

Immediately after the first interview, I expanded my spare keyword notes into verbose field notes that captured my impressions, thoughts, and observations of the interview. The intent was to capture as much of the essence of the interview as possible, independent of the audio recording. The most important concerns of the participants should be close to the surface and frequently occurring, which suggested that field notes could be sufficient alone, but I was not willing to take that leap of faith. Neither did I care to rely solely upon audio recordings for subsequent analysis, which is to run the risk of complacence during the interview. The participant used a number of words that recurred in telling the story, which suggested ideas that could useful in-vivo codes in their own right. Among these words were: adventure, building, challenge, discovery, Elmer, experimenting, fraternity, learning, operating, rewards, social aspects, and technology. Some of these words sparked the first memos of the study, most being just brief budding thoughts on a particular subject. Particular memos begun at this time were on learning, social aspects, and the satisfactions of the radio hobby—all topics that were important to the participant. I hand-coded my field notes prior to transcribing the interview as an experiment to compare my post processed expanded field notes, versus a replay of the event through digital audio technology. The result proved the value of using both techniques.

Coding. I transcribed the audio recordings myself, to both revisit the interview and convert it to text form for analysis, as well as to spark ideas that could be captured in memos during the transcription process. The transcription process entailed listening to the playback of the interview in stereo headphones using the Olympus DSS Player software and typing into a text editor. The software allowed the speech to be slowed down nearly into my touch-typing range without appreciably changing the speech frequencies and provided for close control of the recording from the computer keyboard. I kept ATLAS.ti open while transcribing and could initiate a new memo or edit an existing memo with the click of the mouse. The ability to listen deeply into the recording while transcribing the text was invaluable and often sparked ideas and memories that resulted in the spontaneous creation of many analytical memos while transcribing. Transcribing the digital recordings was very time consuming and added many months to the project, but resulted in much better data than was captured in my field notes. As time consuming as it was, the use of audio recording was overall a positive experience that resulted in excellent data and bolstered the confidence of the researcher with respect to correlating the words of the participants with the ongoing analysis and eventual theory.

The completed transcript was saved as a rich text format file and imported into ATLAS.ti as a primary document to be coded. The essence of coding the document was a meticulous line-by-line, sometimes word-by-word, appraisal of the text to extract meaning from the words. The mechanics of coding a document entailed selecting a section of text of interest and determining a descriptive name that best captured the meaning of the text and creating that code within the code manager. The codes thus created, e.g. such as in the screen capture shown in Figure 4, appear in the margin to the right of the text in a manner reminiscent of coding a text document by hand, but minus the tactile sensations of paper and pencil. The codes are actually hyperlinks into the ATLAS.ti database of source quotations in the text, which greatly simplifies the task of tracing the chain of evidence supporting a particular code or category. All the data—the primary documents, quotations, codes, and memos are immediately accessible from within the ATLAS.ti software through drop-down lists and search tools. The closeness to all the data encouraged deep familiarity and supported making comparisons and category classifications, along with fast and frequent memo writing (Muhr, 2009).

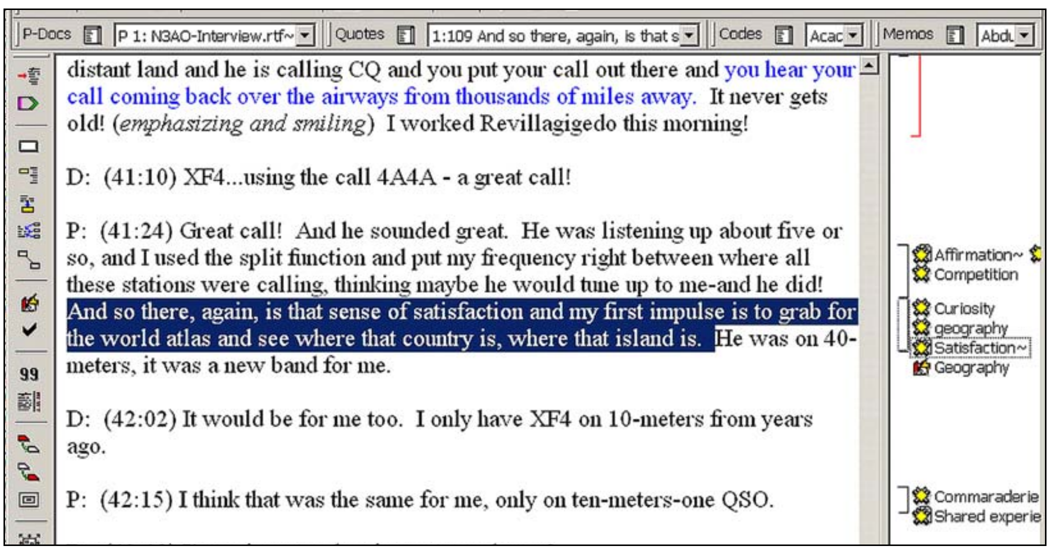

Figure 4. **Screen capture of open coding of transcript within ATLAS.ti**

The first interview produced 120 quotations, about sixty codes, and the first memos of the study. I elected to keep my field notes separate from transcripts for coding purposes, as I wanted the substantive codes to be linked only to the words of the participants, rather than my own. That stance is not a requirement for doing grounded theory, but a strategy to focus as closely as possible to that which was important to the participants.

Where to go for the second interview was a question that was serendipitously answered by a chance email from Joe, a radio amateur from the second call district, who had noticed my Virginia Tech email address on a listserv devoted to 160-meter operations and contacted me just to say hello. Joe was a Virginia Tech alumnus who also happened to be on the condensed selection list of 160-meter operators, so I introduced the study and received ready agreement for an interview. We met at a library that was convenient to both of us and enjoyed a wide-ranging interview that lasted about 90-minutes. My field notes summarized the highlights of the interview and noted some recurring themes in both interviews. After completely transcribing the interview for analysis, the transcript was coded in a manner similar to the first, with 115 quotations highlighted in the coding. After coding the second transcript, both interviews were compared for similarities and differences. Comparisons of data and codes resulted in some codes being renamed and some quotations were recoded when a more satisfactory code was found. The concept of interchangability of indicators was useful in comparing incident data for similarities and differences. All the indicators of a category should be representative of that category and any that are found to be significantly different in some way may indicate the presence of a dimension of the concept or other category that requires further study.

Some of these category names were *in-vivo* codes—terms adopted from the language of the participants. Such in-vivo terms often point to common experiences within the group and important concepts for understanding their world. For example, *Elmering*[2] is an in-vivo term used by radio amateurs to mean the same as mentoring, but the practice is so important that the group has its own special word for it. Other frequently occurring in-vivo codes included *Experimenting*, *Homebrewing,* and *Operating,* all of which encapsulated a range of incidents in the data and pointed to commonalities in the experiences of the first two participants.

In-vivo words tend to indicate practices that are important on the scene and can provide useful category names to group similar data. However, such words can also mask data behind a descriptive label with unquestioned assumptions, a thought that prompted the writing of a memo to capture thoughts on the category *Operating* to examine the category and its many indicators. The memo writing in turn resulted in an ad hoc spreadsheet analysis of the constitute elements of *Operating* to unpack the category and compile a list of its indicators. The memo and spreadsheet are reproduced as Memo-1 and Table-2, respectively, to demonstrate the thought process and the categorical analysis.

Comparisons of the indicators of the category did not reveal any new properties, but the categorical analysis suggested that *Operating* was likely a property of some other categories. To that end, some of the categories from the previous analysis of two interviews also worked in the categorical analysis of Table-2, notably *Experimenting*, *Challenge*, and *Adventure*, which

[2] Note: Analytical codes from the study are generally italicized in the text and usually capitalized, except in cases where other italicized terms or titles are present or clarity is improved by the use of lower case terms.

seemed to be related somehow and to co-occur. The final realization was that more data was needed in relation to these categories, an indication that theoretical sampling had begun.

Memo 1: Analytical memo on *Operating* as an in-vivo code

Is *Operating* really a useful code? It’s a word from the language of the participants and important to them, so it seemed reasonable to use their word as an *in-vivo* code. It's also a gerund, which is usually a useful action word, but how much does it really say in this case? For radio amateurs, Operating is a word that encapsulates the experience of going on the air and communicating with fellow radio amateurs in the myriad of ways that hams communicate with each other. It is an historical term that has been used by generations of radio amateurs as a convenient shorthand for their on-the-air activities and it is an important concept, hence the special word that exists to name it. However, I realized that in adopting an old familiar old term that encapsulates so much of the experience of being a radio amateur I was stopping short and neglecting to further the analysis by comparing the indicators of a category to test for fit and to look for properties and dimensions of the category. It is time to correct that oversight and compare the indicators of Operating and have a fresh conceptual look.

I had several indicators for Operating, but went to the literature and compiled a list of additional terms related to Operating. The result was far from exhaustive, but it was an interesting vignette into what it is that radio amateurs do when they operate: AM, aurora, contesting, county hunting, CW, digital modes, DXing, DXpedition, DXCC, Echolink, FM, gray line, grid square, IOTA, long path, meteor scatter, microwaves, mobile, mountain topping, moonbounce, traffic nets, packet, pedestrian, public service, portable, QRP, ragchewing, repeaters, RTTY, satellites, SSB, SSTV, troposcatter, VOIP, and WSJT. It's a fair list of what radio amateurs do, but what is going on in the data?

In comparing the indicators, there is a good deal of diversity in the data, but several of the terms suggest range variables in several categories. There are some activities that are fairly exotic and entail a significant degree of challenge, whereas others have little or no challenge, but have other attributes. Is Challenge a dimension of Operating? Ragchewing suggests no great technical challenge, but it is a very popular activity, so there is motivation in the action. Some things are just simple pleasures and maybe ragchewing is something like that. There is a social element to many of the activities, such as ragchewing, net operations, AM phone, FM through the local repeater, and especially VOIP, which does not entail getting on the air at all, but is Internet based. A more structured analysis is in order so I took a detour to make an Excel spreadsheet to map these words against terms that seemed to be reasonable words for contrast and comparison. Some of the categories feel right: Challenge, Experimenting, and Adventure all seem to be good-fit terms that seem to capture the essence of some of what is going on. There is also a strong social element to these activities, but I need a better term--maybe Social Connection. There are specialized skills involved in most of these activities and some take a long time to develop, such as CW operating. Skill smacks of a dimension of a category. Intrinsic motivation seems to apply to everything as a label for aspects of an activity that are pleasurable or fulfilling in some way, but is it analytically useful or just an academic label?

Theoretical sampling. The categorical analysis suggested that more data was desirable relating to the experimental aspects of the participants, data that could likely be provided by someone who was a consummate experimenter. Consummate experimenters are not common in the general population, but are quite common among radio amateurs, who often write of their experiences in on-line forums. There were several potential candidates on the 160-meter selection list, but my attention was particularly drawn to Dennis, a gentleman from South Carolina whose call sign was one that I encountered often in my research. I contacted Dennis by email to introduce the study and received an immediate and enthusiastic agreement to participate in the research. Dennis was indeed a consummate experimenter, who freely shared his story and experiences in a ninety-minute telephone interview and in many other subsequent conversations and emails to follow. The interview was transcribed, analyzed, and compared with the two previous interviews, with many features and recurring themes found in common with previous data, particularly with respect to experimentation and learning.

Table 2
Experimental ad hoc analysis of *Operating* in-vivo code

Activity	Nostalgia	Novelty	Social Connection	Challenge	Experiment	Intrinsic motivation	Adventure	Skill	Altruism
AM	X		X		X	X			
Aurora		X		X		"	X		
Contesting			X	X	X	"	X	X	
County hunting			X	X		"			
CW				X		"		X	
Digital modes				X	X	"			
DXing				X	X	"	X	X	
DXpedition		X	X	X	X	"	X	X	
DXCC				X		"	X		
Echolink			X		X	"			
FM			X			"			
gray line		X		X	X	"	X	X	
Grid square				X		"	X		
IOTA		X		X		"	X		
Long path		X				"	X	X	
Mesh networking				X	X	"			X
Meteor scatter		X		X	X	"	X	X	
Microwaves				X	X	"			
Mobile			X			"			
Mountain topping				X	X	"	X		
Moonbounce		X		X	X	"	X	X	
Net operations			X			"			
Packet					X	"	X	X	
Pedestrian				X	X	"	X	X	
Public service			X			"	X		X
Portable				X	X	"			
QRP					X	"	X		
Ragchewing	X		X			"			
Repeaters			X			"			
RTTY				X	X	"		X	
Satellites		X		X	X	"	X	X	
SSB						"	X		
Slow-Scan TV		X		X	X	"	X		
Traffic handling			X	X		"		X	X
Troposcatter		X		X	X	"	X	X	
VOIP			X		X	"	X		
WSJT		X		X	X	"	X	X	

The first three interviews produced over 300-quotations and 175 substantive codes, with about thirty categories strongly represented and interrelated in various ways. Several codes were very similar and were merged into a single code. Still other codes were obviously more descriptive than conceptual, but still useful markers for frequently occurring data. After ruminating on the data for some time and pondering categories, properties of categories, and the dimensions in which a property can vary, I became convinced that multiple interrelated processes were present and set about clarifying the relationships. Diagramming was a useful technique for exploring possible relationships among the data, a task that was aided by the networking tools within the

ATLAS.ti software. The network view manager provided tools to relate codes and memos and link them by relational operators in a graphical workspace (Muhr, 2009).

Figure 5 illustrates the interrelations of the codes and linkages that were used to develop the abstract concept of *Affirmation*, which was conceived as the substantive effect of the positive motivational aspects that were identified in the data of the study. The academic concept of motivation is relevant to the question of why people do what they do, but as a code Motivation lacked the range needed to fit the positive attributes found within the data. The metaphor of positive affirmation was a better fit for the data so *Affirmation* was adopted as the category name for the positive experiences of the study participants in doing what they do. All the nodes shown in the ATLAS.ti network diagram (Muhr, 2009) are codes linked to quotes in the data and the relational operators shown allowed the researcher to explore possible relationships among the indicators of Affirmation.

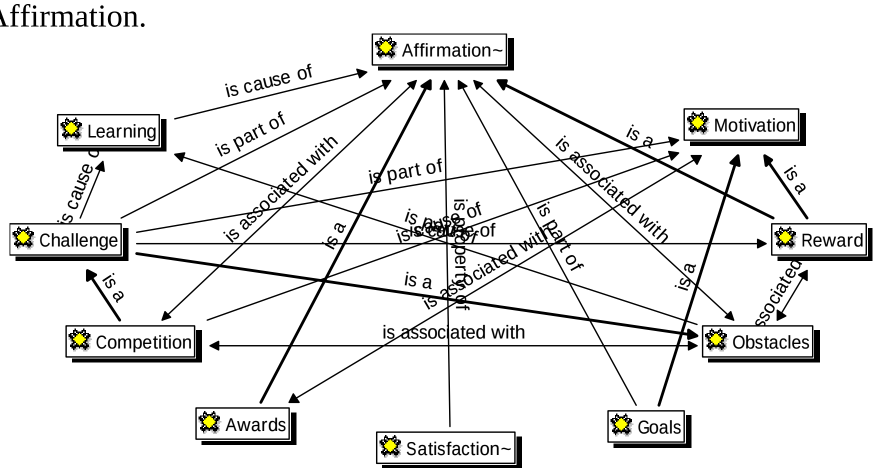

***Figure 5*. Network diagram interrelating codes that define a category**

Diagramming in software was helpful, but not the primary means used for developing ideas. The primary means of exploring data and thoughts was still the written memo, augmented by hand sketches on paper, notes pinned to a cork board, sticky notes stuck to my office wall, and images and data posted for more subtle consideration. The delayed action of the grounded theory method requires that the mind receive data and stimulation for subsequent pre-conscious processing, which in my case are best served by using all my senses. Glaser writes that the study is always cooking within the researcher (Glaser, 1998, p. 51), who may go for some time without making the connections that allow conceptualization to take place. Then, quite suddenly, the connections happen and ideas come fast and furious. When this happens, some grounded theory researchers will write for days, unwilling to stop. Glaser calls this experience “the drugless trip” and it happened several times during the course of the study. The high of the drugless trip is exhilarating and vindicates the long periods of tedious comparisons deep in the thicket of data.

At this stage of the study, there were many codes interrelated in various ways and the major task was to solve the puzzle of how they could fit together to conceptualize the main concern of the participants. Finding the right substantive words to abstract a swatch of data advances the study and, as conceptualizations that are more effective were found, the code list condensed into a shorter list of more powerful concepts. The previous illustration of how *Affirmation* came about as a motivational concept is an example of the development of a concept. The code manager in ATLAS.ti has two helpful metrics that are useful for evaluating the frequency of individual codes. The Grounded and Density parameters in the code manager respectively tracked the number of quotes assigned to a particular code and the number of relational links the code has to other codes. The code rankings change continually as the analysis proceeds and concepts evolve, but always give an indication of the most frequently occurring codes in the data—codes that should be close to the main concern of the participants. Of the 175 codes existing after the third interview, the codes listed in Figure-6 were the most frequently occurring, ranked in descending order by the Grounded value of the codes in database.

1.	Learning	6.	Building
2.	Technology	7.	Self-taught
3.	Affirmation	8.	Experimenting
4.	Adventure	9.	Challenge
5.	Elmering	10.	Social connection

***Figure 6*. Category ranking after third interview**

It is important not to read too much into the practice of counting quotes assigned to codes or the number of connections that a particular code has to other codes in network diagrams. Such metrics can be informative as to interests and concerns, but are not to be construed as any kind of criteria for theory development. Word counting is commonly used in hermeneutics and other qualitative methods, but the practice is antithetical to doing grounded theory. In the interest of full disclosure, I used ATLAS.ti for its data handling facilities and eschewed most of its other tools that were better suited to conventional qualitative analysis and not classic grounded theory.

The categories listed in Figure 6 were present in all the interviews to varying degrees. *Learning* was the strongest category in all three interviews, with *Elmering* and *Self-taught* as strong codes, both related to learning. Likewise, *Technology* was consistently a prominent general category and accompanied by many codes that were associated with the practice of technology. At this point in the study, the generic term *Technology* was being used for lack of a better word for the relationship between the participants and their technological activities. *Experimenting* was a category that often co-occurred with *Learning*. *Social connection* was an important category that conceptualizes the culture of the group and the social nature of their activities. *Affirmation* is a code that refers to the positive affirmations that practitioners receive from doing what they do. Finally, *Adventure* is a recurring code that suggested the character of the activities of the group, but again using a generic word for lack of a better conceptualization at this point. These categories were frequent in the data and interrelated in ways that were still unknown, but the main concern of the participants must be very near the surface at this stage and somehow embodied within these categories. I could feel that something was starting to coalesce, but more data and more analysis were needed to further the study.

The fourth participant of the study was a highly accomplished radio amateur from southwestern Virginia and known as a role model and mentor to generations of radio amateurs. Junior's wide diversity of interests and years of experience made him an excellent candidate for the study and he readily consented to an interview. The interview was conducted in the radio shack, which occupied much of the basement level of his home and a good indicator of this gentleman's commitment to his hobby. The wide-ranging interview took place surrounded by the artifacts from decades of life of this gracious radio amateur who so freely shared his story to help with my study. The deep engagement of this participant in all the technological and social aspects of his hobby was impressive, sufficiently so that the term Renaissance man seems a fitting descriptor for this remarkable individual. The interview was highly satisfactory in all aspects and came at a critical point in the study. When the interview transcript was coded and analyzed, ninety-two additional quotes were added to the data, bringing the total to 414 quotations and very rich data were added to all the main categories, but no new categories were found. This first indicator of the progression toward saturation implied that the primary issues and concerns of the participants were embodied in the data at hand and that the main concern was among them. In effect, the data were in-hand to answer several research questions, but unfortunately, the state of the analysis lacked conceptual clarity. Several categories were similar and overlapped and others were simply generic, a clear indication that further analysis was required to resolve the categories.

Resolving the categories. *Learning* and *Technology* were two category names that encompassed much data, but were only passive generic terms that did not capture the range and active nature of what the participants were saying. Conceptualizing the actions of people is intuitively best served by the use of active terms, particularly gerunds, although limitations of language can make finding the right words a challenge and can be an iterative process. Much time was expended reviewing data and searching for best-fit wording that explained what was happening in the data. How ideas arise is illusive, but memos can capture developing thought and provide a glimpse of how ideas occur and evolve. For example, Memo 2 and Memo 3 are excerpts of memos that led to development of *Doing technology* and *Self-teaching* as active concepts that abstracted and subsumed a number of related categories. The reduction in categories resulted in a more compact set of distinct concepts that encompassed much of what was happening in the data and helped to clarify my thinking on the relationships among the variables. The notion of *Self-teaching* provided the needed link for conceptualizing the main concern of the participants.

Memo 2: Genesis of the *Doing Technology* category

Up until this point I have used the category *Technology* as a generic label for the interaction of humans with technology. I have been looking for a better category name for months and today I began thinking in terms of *Doing Technology* as a higher-level construct for abstracting the interactions of people and technology. What triggered this memo was a conversation in the lab with Lee, KB8ETX, as we were discussing newly licensed radio amateurs and what they were actually doing with their new licenses. We were both concerned about helping newcomers to become active and engaged after receiving their ham licenses, particularly with the technical hands-on aspects of being a ham. Lee made a statement that grabbed my attention when he said, "*The DOING is the best part. That's where it's at!"* I was quite struck by the way in which he emphasized the word *DOING*, and then he said, "*Actually being able to make stuff that works is the very best part*!" Perhaps *Doing Technology* can be a useful way of thinking about the interactions of humans and technology.

What is it about *Doing technology*? What are its properties and dimensions? Doing technology for radio amateurs is a major activity and not just on the air contacts. For many, radio can be just passive listening, expanding their world. It is an Extension of Self. There is Curiosity and Discovery. It is an exercise of Power. It is entertainment too. It is an exercise of knowledge and skill. Doing technology is something that can be goal driven. Improving ones effectiveness as an operator is a motivation for exploring technological solutions. Exploring different kinds of technologies is fascinating. Experimenting with different software, using tools, test equipment, measurement and materials. Power. Doing radio technology is especially rich and also allows access to interesting natural phenomenon for long distance radio propagation. One gets interested in what the Sun is doing. One wonders about what other hams in the world are doing around their sunrise and sunset times. Geopolitics. Caring. Skills. Doing projects. Doing technology would seem to be a useful concept, with *doing technological activities* as a descriptive synonym.

Memo 3: Development of *Self-teaching* as a category

I was driving to work this morning and thinking about an email from Dennis, K4CKD, telling me about his recent experiments with learning how to do soil conductivity measurements. I was thinking about that incident and several others that were related to learning and decided that the generic category of *Learning* was simply inadequate. I then had an idea that induced me to call my office and do a brain dump voice mail message that resulted in this memo that explores the idea of *Self-Training* as a category for learning.

I have been thinking about the various kinds of learning that takes place for radio amateurs as they work with technological activities. A lot of learning happens, but *Learning, Self-taught,* and *Self-education* are just lukewarm generic terms that do not have the needed range. *Doing Technology* requires knowledge and skills that have to be acquired somehow, often by *self-study* with the help of a mentor. Knowledge and skill are both required, but proficiency is also in the equation and seems to require a larger scope. Training, on the other hand, implies the learning of useful knowledge and skills, but also implies the honing of skills to improve proficiency and performance. With technological activities, or perhaps most activities in general, one may be able to receive training from a mentor, but in the end it is up to the individual to internalize the knowledge and hone skills in order to develop proficiency. It was the proficiency part that was weak or missing previously, but is implicit in the term s*elf-training* and a better fit for the data.

In terms of the code list, *Self-Training* encompasses a range of analytical codes that were all related to learning in some way. *Curiosity* figures prominently in the initiation and exploration of a technological activity, as does *Problem-solving, Ingenuity,* and *Discovery*. *Mentoring,* aka *Elmering* for radio amateurs, entails shared learning through a social network. *Mastery* entails the development of knowledge and skill that can only be attained by personal commitment and practice. *Self-Training* works as a concept and encompasses all these dimensions, but *Self-teaching* was ultimately adopted with an operational definition to encompass the variations in the category.

The Main Concern. It was apparent that learning was an important concern of all the participants, but whether it was a main concern, in grounded theory speak, was unclear until the various learning categories were consolidated as properties of *Self-teaching*. At that point, the association between *Self-teaching* and *Experimenting* was apparent and resulted in the tentative hypothesis that the main concern of amateur radio was experimentation and self-teaching with technology. This idea as a main concern seemed plausible and was well supported by quotations from the data:

- *For me, doing what we do is all about continuous improvement. Experimenting is fundamental to what we do and how we learn and improve.*
- *Amateur radio has introduced me to a lot of the technology and the opportunity to learn and to experiment with it and to actually build projects that work.*
- *I am constantly experimenting and learning, which is what amateur radio is all about.*

Further support for the tentative main concern was also serendipitously found in the literature, with a notable statement by U.K. radio amateur, Roger Barker, G4IDE (SK)[3], who succinctly expressed his philosophy that: "*the essential elements of amateur radio are self-training and experimentation*" (Barker, 2002). Barker's concise statement of philosophy fit the tentative main concern and bolstered the confidence of the researcher in the study.

[3] SK is an abbreviation for Silent Key, meaning that the operator is deceased and the Morse key is now silent.

The stability of several major categories and the statement of a main concern suggested a degree of progress toward answering some of the research questions. Accordingly, the next stage of the research was to take stock of the inquiry with respect to the research questions posed in Chapter 1 and evaluate the status. The four research questions were reviewed in the context of the current analysis and are presented with commentary, as follows:

RQ1: *What are the core variables and the related sub-variables that are implicit in the data and account for most of its variability?*
At this point in the study, seven stable categories accounted for most of the variation in the data. The seven categories or variables were: *Adventuring, Affirmation, Overcoming Challenge, Doing Technology, Experimenting, Self-teaching*, and *Social Connection*, all of which were interrelated and all had several sub-variables that were likely to be parameters and dimensions of the categories.

RQ2: *What are the issues and concerns of the participants in the pursuit of their activities?*
The subject group engages in a range of technical activities that are inherently complex and present ongoing issues and concerns for the participants. As an egalitarian cultural group with a unique technical culture (Haring, 2007) that highly regards knowledge, experience, skill, and achievement in a wide range of activities, practitioners are constantly challenged to improve their own knowledge and skills in the diverse aspects of the art. The evolution of technology and culture continually bring evolving challenges that require personal adaptations and commitment to learn and master.

RQ3: *Which aspects of the main concern have the most potential to be transcendent across a wider range of other contexts?*
Of the numerous challenges and opportunities that are inherent in the activities and culture of the subject group, the question of how they adapt and learn would seem to be an important one that may transcend the local context. Understanding the exemplary case presented by the radio amateurs in negotiating their own evolving technoculture may provide useful insights into how people learn in their interactions with technology in other contexts.

RQ4: *How are these issues and concerns resolved or processed?*
This research question is the heart of the study. The manner in which the issues and concerns are continually resolved is, in essence, the core of the substantive theory that is the aim of grounded theory research. At this point in the study, a tentative main concern had been identified and the manner in which that main concern was continually resolved was yet to be determined.

The study began by identifying experienced radio amateurs who were highly engaged in a particularly challenging aspect of their hobby. This useful beginning readily produced a set of concepts that abstracted the actions of the participants and gave the first tantalizing hints of a theory involving experimenting and learning in some way. However, as Research Question #3 suggests, a truly useful grounded theory should have a range and scope that has the potential to be transcendent, implying that a more expansive view was needed in order to broaden the inquiry. More data was needed and ideally with maximum diversity from the full range of experiences among a wide cross-section of radio amateurs. The local amateur radio clubs provided the means to identify individuals with varied backgrounds, interests, and experience levels to illuminate dark areas in the study. The hope was to gather data from individuals on a continuum of experience and engagement in order to understand the variable dimensions of the problem. The study proceeded with the goal of maximizing the diversity of the data, with additional participants recruited and interviews conducted over the course of a year to explore the wide range of experiences among radio amateurs. Each new participant was selected for their potential to shed light on some particular aspect of the spectrum of experience that was deficient in the data or the analysis.

Phillip was the fifth participant in the study, recruited because he was relatively new to the hobby and may have had experiences and perspectives that differed from those of practitioners with decades of experience. I met this soft-spoken gentleman at the annual club Field Day outing and observed his evident enthusiasm and contributions to the activities of the group. After working together on Field Day, I later invited him to participate in the study. We conducted the interview on a summer afternoon at a city park near his place of employment and he shared his story as we chatted on a park bench. I was struck by the familiarity of his story with respect to very early childhood experiences and the later development of multiple technical and scientific hobbies. One of Phillip's comments revealed a curious nature and a drive to learn that began at an early age:

> "I always see interesting things that I would like to either build myself or check out…. I mean, I am a learner. From the time that I can remember being in elementary school, from a very early age, five or six years old, like second grade, I just want to know things. Whether I put it to benefit or use or not, I just want to know it. I don't consider myself to be an ambitious person. I am not learning to necessarily better my position, *but I just want to know things."*

After fully transcribing the interview and coding for anything and everything it was evident that all the major categories previously found in other interviews were also present in this interview. When compared to the four previous interviews, the relative inexperience of this participant was evident, but all the major categories were also evident to varying degrees. *Social Connection* was not particularly strong, but all the other major categories were well represented. *Challenge* and *Self-teaching* were quite strong with this autodidact and he received *Affirmation* from his varied activities. The variable nature of the categories was an important realization that emerged with this interview. That there could be stable patterns in the data that manifest in differing ways is an important concept with implications for the development of theory.

Theoretical sampling continued with the sixth participant, who was selected because of his casual comment that disavowed having "any significant technical knowledge." I found the comment intriguing, since Larry was a long time radio amateur and a dentist by profession, so I recruited him for the study. Larry's participation enhanced the diversity of the sample, which to that point included a retired sociology professor, a chemical engineer, a retired Air Force veteran, a business owner, and an electronics technician. We conducted the hour-long interview over lunch on a business day when he happened to be near my place of employment. The interview was very satisfactory in all respects and provided rich data in all the major categories discovered thus far. No new categories were found, but many thoughtful comments from this participant brought the total number of quotes in the database to beyond the six hundred mark.

The story of Larry's early interest in wireless was a familiar one, with a very early exposure to shortwave listening and AM radio as a child. He also developed an early interest in electricity, although he could not remember any specific trigger event that could have initiated it. Larry developed an interest in amateur radio while he was in elementary school and began studying for the license exam. Larry's experiences indicate autodidactic tendencies from an early age, with a curiosity and a drive to learn that has persisted throughout life. He became a radio amateur and over time built electronic projects of all kinds, some kit and some homemade, and continued to experiment and explore the radio art ever since. *Experimenting* and *Self-teaching* were strong categories in this and all the other interviews, but *Adventuring*, *Affirmation*, *Challenge*, *Doing Technology*, and *Social Connection* were always present as well and all the categories seemed to be interrelated and mutually supportive. This result added more fuel to a growing awareness that there was larger conceptual game afoot. The analysis had condensed nearly two hundred substantive codes to a small number of variables and a promising main concern, but how the various categories fit together to explain how the participants continually resolve the main concern was not so obvious. What was lacking was theoretical integration, which is the object of *theoretical coding*, the single most demanding element of the grounded theory method.

Theoretical coding. In my readings of the literature of classic grounded theory, I had gradually become accustomed to Glaser's characteristically dense writing style. However, the subject of theoretical coding remained especially dense up until the point that I realized that the larger conceptual game that I was looking for in the analysis were actually theoretical codes to provide structure to relate the substantive codes to each other as hypotheses in a theory. Substantive coding and theoretical coding are often confused, although substantive codes and theoretical codes are conceptually quite different. Intellectually, I felt that I understood the differences from my readings, but the realization of the relevance of theoretical codes to my analysis was an epiphany that crystallized my understanding. Mark Twain once remarked that, "A man who carries a cat by the tail learns something he can learn in no other way." From my experiences with grounded theory, I understood Twain's metaphor quite well, as well as Glaser's assertion that the only way to learn grounded theory is to *Just Do It* (Glaser, 1998).

The analysis done to this point in the study entailed *substantive coding* devoted to finding latent patterns in the data and naming those patterns as abstract categories. All the main categories were developed in memos after a long process of continuously comparing data, trying on ideas for fit, recoding, thinking a lot, waking up in the middle of the night to write, struggling through no small number of sleepless nights, and consolidating ideas in what was a convoluted process that lasted many months and consumed untold hours. The categories at that point conceptualized the data very well, but the categories were abstract and disconnected. What was needed was theoretical structure, which is what is provided by theoretical codes. Theoretical codes "...conceptualize how the substantive codes of research may relate to each other as hypotheses to be integrated into a theory. They, like substantive codes, are emergent: they weave the fractured story back together again. Without substantive codes they (theoretical codes) are empty abstractions" (Glaser, 1978). I finally understood what Glaser meant. Theoretical coding was the next step, but there were scores or hundreds of possible theoretical codes that could be useful for integrating a theory. Theoretical codes were emergent, which meant a return to the data and staying open to whatever theoretical code may be relevant. Much more reading was in order and I found Glaser's book *Theoretical Coding* (Glaser, 2005a) to be especially helpful, along with *Staying Open* (Glaser, 2005b), Chapter 6 of *Theoretical sensitivity* (Glaser, 1978), and *Grounded Theory Perspective, III* (Glaser, 2005a). While reading on theoretical codes and hoping for a spark of insight, I also realized that still more diversity was needed in the data with respect to individuals with differing levels of engagement and interests. I continued with theoretical sampling and ultimately conducted six additional interviews with participants who were selected based on their individual activities or experiences as a radio amateur that could clarify some aspect of the study.

The study changed in several aspects with the seventh interview. The interview came about because I attended a meeting of the local amateur radio club and met a young radio amateur who stood out as the youngest individual of the group. I learned that Mike was comparatively new to the hobby and appeared to be enthusiastic and engaged, judging by the number of antennas that festooned his SUV. Several factors made Mike a valuable informant for the study, so I recruited him and we subsequently conducted a lengthy and far-ranging interview at the kitchen table in his apartment. The interview was rich and complex and helpful with the saturation of several categories. It was at this point in the study that I transitioned to *selective coding*, a procedure whereby coding is done only for those categories that were related to the core variables with the intent to fully saturate the categories through theoretical sampling. The interview was selectively transcribed only for the data that was relevant to particular categories.

Mike's interview provided excellent data in all the major categories as previous interviews, with *Social Connection* noted as especially well represented, particularly *Childhood Experiences* and *Mentoring*. As a young child, Mike received mentoring from an engineer role model and became engaged in hands-on technical activities from quite a young age. As Mike told me:

> "I started building things really early—six, five maybe, in kindergarten. My kindergarten teacher, you can ask her today, what I put on my Christmas list, the word was so*ldering iron*—she had to go look it up! In the first grade, I was a six-year old with a soldering iron. I still have the scars!"

As with the previous interviews, *Experimentation*, *Challenge*, and *Affirmation* were all strong categories and this participant was deeply engaged in hands-on technical projects. Mike became a radio amateur at an early age and continued to learn and experiment in the complex hobby and eventually studied engineering in college and became an engineer by profession. The interview was very rich and gave important data, but no new concepts emerged. I was at a critical juncture in the study, with many categories apparently near saturation, but needing theoretical integration—a synthesis to bind the study together under a transcending concept, an answer to the fourth research question: "How is the main concern continually resolved?"

What followed was months of struggle, exploring the data and the dimensions of how the categories varied, making models, sketching, visualizing relationships and writing scores of memos, and continual reading. Memoing was critically important and took priority over every other aspect of the study. Some memos were only a few words to capture an idea, while others were thousands of words long to explore ideas in depth. Several attempts were made to integrate a theory around the major categories, but all attempts failed as too narrow to encompass the diversity of the data. It was during this time that I realized that Glaser's concept of the *drugless trip* had a dark side and that one could spend months mired in the data thicket and finding no way out. Grounded theory takes time for the preconscious processing necessary for abductive insights to occur and the analyst has no choice but to persevere. At this point in the study, the coding of transcripts and field notes had produced nearly one thousand quotations and about two hundred basic codes that comparative analysis ultimately abstracted into seven main categories, of which *Experimenting* and *Self-teaching* were identified as the participant's important main concern. There were numerous interrelationships among the categories, but quite how the main concern was continually resolved was not obvious.

A significant advance occurred while experimenting with 2D mapping as a way to explore inter-relationships among categories. *Challenge* and *Experimenting* were prominent in the data, but varied widely, essentially ranging from low to high in both categories. When *Challenge* and *Experimenting* were mapped as continuous variables on an X-Y Cartesian plane, the result was a way to visualize variations in learning potential that was consistent with the data. Figure 7 illustrates examples of such mapping, with 1) Variations in learning as a response to *Challenge* and *Experimenting*, and 2) A classification of the *Skill Level* component in response to *Challenge*. In both mappings, the time dimension was implicit, with developmental transitions and stages throughout the phase space—a phenomenon that was entirely consistent with the data.

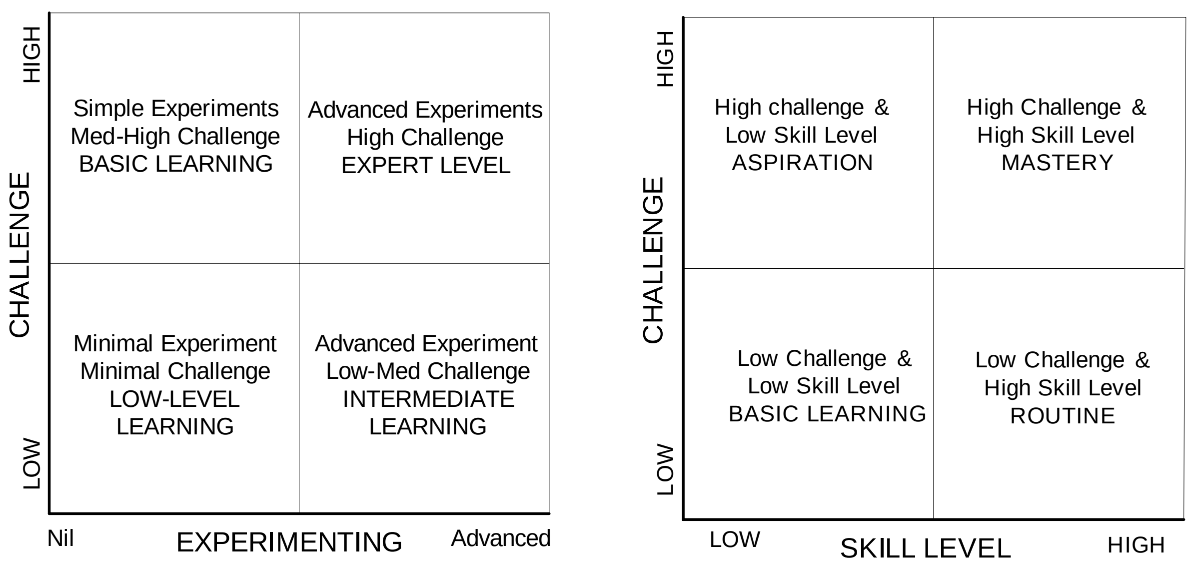

***Figure 7*. Conceptual mapping of learning variation**

The exploration of the variability and interactions among categories depicted in Figure 7 produced the first glimmer of theoretical structure evolving within the study. The key insight was that the topology implied by the mapping was indeed supported in data and the participants tended to experience developmental transitions that occurred over time and in stages—the hallmark of a Basic Social Process (BSP). The BSP was the first of three theoretical codes that evolved into the theoretical framework of the theory of technological immersion learning that was the outcome of the study. It is not possible to provide a blow-by-blow account of how the theoretical structure evolved over the course of a year, but it is possible to provide the key insights that led to the crystallization of the theory and completion of the study. Each of the three theoretical codes is outlined below and incorporated into the theoretical synthesis that is presented in Chapter 4.

Theoretical coding: Basic Social Process. A Basic Social Process (BSP) is a theoretical code denoting a social phenomenon with a particular set of characteristics. According to Glaser (1978, p97), in order for a variable to be considered a BSP it must meet several criteria:

1. The phenomenon is a process that takes place over time and has developmental transitions.
2. A BSP reflects an evolving nature and a "sense of motion", often characterized as a gerund, such as becoming, resolving, cultivating...and learning.
3. Basic Social Processes possess at least two stages that "differentiate or accounts for variations in the problematic pattern of behavior".

The results met all of the above criteria with ease and spurred the consideration of the interactions among the seven major categories as properties of a BSP. Because *Self-teaching* and *Experimenting* with technology were an important main concern of the participants, along with the fact that learning in general is such a strong category in the data, the working name adopted for the new basic social process was *Technological Immersion Learning*, a distinct process for learning as a result of engagement with technological activities in a social setting. As a construct, the *Technological Immersion Learning* BSP had the potential to integrate all the categories, but a great deal of work was in store to develop a theoretical synthesis that accounted for all the variability in the data.

The realization of a basic social process brought about the reassessment of all the previous data. Of particular note was *Affirmation*, a pervasive category that was related to all the other categories in the study as the reaction to positive feedback associated with performing an activity. Feedback in general is a driver of regenerative processes and multiple sources of positive feedback were apparent in the data. Memo 4 develops the idea of multiple sources of positive feedback as a driver of behavior in an *amplifying causal loop,* which was the second theoretical code identified in the study.

Theoretical coding: Amplifying Causal Loop. The amplifying causal loop is a theoretical code for a behavior pattern whose outcome reinforces the likelihood that the behavior will be repeated (Glaser, 1978). Feedback is a necessary condition for an amplifying causal loop and the *Affirmation* category is defined in terms of positive feedback. The concept of a basic social process operating as an amplifying causal loop with multiple sources of positive feedback fit the data very well and gave a unifying structure for the theory.

In many memos and comparisons, the concept fit the data and worked to distill the experiences of the participants over the range of variability in the data set. However, as good as the fit to the data was, there were segments of the radio amateur community that were sparse in the data. The technical and experimental aspects of the hobby were well represented, but practitioners with other priorities, such as public service, contest operations, and the basic social dimensions of the hobby were less prominent. Female radio amateurs were notably absent from the sample, as were the young, and those with minimal experience in the radio hobby. Maximum diversity of data was a research priority, so sampling was broadened specifically to include aspects of the radio hobby that were relatively deficient in the data.

Memo 4: *Affirmation* and positive feedback

Affirmation is a code that conceptualizes the positive experiences that participants receive in doing what they do. The academic construct of *motivation* goes part way to that end, but is neutral and lacks the needed range, aside from carrying significant academic baggage. The word Affirmation is appealing, in part because of the metaphor of positive affirmations. Webster defines Affirmation as: " *the act of confirming something to be true, e.g. an example of affirmation is reminding a child that she is smart. Noun: something affirmed, positive declaration; assertion; something declared to be true; a positive statement or judgment; confirmation; approval*". I would operationally define *Affirmation* as a category that encapsulates the rewards, satisfactions, and enthusiasms associated with doing an activity. The affirmations that result from doing an activity is a positive motivation or reward, or in engineering parlance, positive feedback in response to an action.

A network diagram for Affirmation is very dense, with over thirty codes linked to Affirmation in various ways. All of the most densely Grounded categories are all linked to Affirmation, e.g. Learning, Doing technology, Adventuring, Elmering, Experimenting, Making, Social connection, Discovery, and Challenge, as well as to the more abstract, but analytically rich, Altruism, Skill, Power, Reward, Pleasure, Personal Identity, Recognition, Personal Agency, and Empowerment. The experiences behind these distinct codes are the positive feelings associated with accomplishing a particular activity—positive feedback that the activity is worth doing.

People practice avocations because of certain attributes that an activity brings to their lives. In the case of radio amateurs, the positive attributes associated with the activity are often sufficient to keep many practitioners engaged and active in the hobby for a lifetime. Positive feedback is certainly a factor in such prolonged engagement, but I suspect the story is more complex than just simple positive feedback. The dense interconnections of Affirmation to so many other categories suggest multiple sources of positive feedback are probable and several may happen simultaneously. Multiple sources of positive feedback in an amplifying causal loop would be a powerful mechanism for sustaining a regenerative process driven by feedback.

The concept of the *Technological Immersion Learning* BSP functioning as an amplified causal loop with *multiple sources of positive feedback* combines two theoretical codes to create a model for a regenerative learning process that accounts for the fascinations and long-term engagement of many technology hobbyists.

The search for greater diversity led again to connections with the local radio clubs, which provided avenues to meet new people and opportunities to interact with the groups. Participating in the annual Field Day event was particularly fruitful, as it exposed virtually the full gamut of engagement in the radio hobby. This microcosm of the radio art provided opportunities to observe and participate in the interactions of a large group of radio amateurs. These experiences in turn became fodder for theoretical memos and provided the necessary contacts for the final interviews of the study. The remaining interviews included three male and two female participants, each recruited because of their specific experiences that illuminated underdeveloped areas in the study. No new categories were discovered in the final interviews, but each one contributed more data to further refine and fully saturate the categories and helped to mature the theory.

By the twelfth interview, the data and the analysis had been stable for some time and nothing new was emerging or suspected. *Theoretical saturation* seemed probable and the time had arrived to begin the *sorting* process, a somewhat traumatic procedure whereby mature memos are printed out and literally cut into fragments with scissors and sorted by hand into boxes, bins, and piles—not by data, but by concepts. The sorting procedure breaks apart scores of memos written over time and coalesces related ideas that were dispersed across many memos into what essentially constitutes a rough draft of the theory. The sorting process was time consuming, but inevitably sparked more ideas and more memos, which where in turn cut into fragments and sorted into the appropriate conceptual bins. Among the ideas that occurred while organizing the sorted memos into what ultimately became Chapter 4 of this dissertation was that a third theoretical code provided a way to understand a pattern in the data among the more accomplished and experienced participants—that of a biased random walk.

Theoretical coding: Biased Random Walk. This theoretical model is a variant of the biased random walk theory of cellular biology that describes how movement can preferentially take place in certain directions, with only random inputs to the supporting variables. When an individual is very proficient in a particular technological discipline, most of the variables of technological learning may show only minor fluctuations and no predictable pattern over time. However, learning still takes place, albeit in the manner of a biased random walk. In the case of technological learning, executing an activity with advanced skill brings *Affirmation* to the doer, an experience that is analogous to the flow experience (Csikszentmihalyi, 1990). In such a state, where there are few disturbances in the properties of technological learning, i.e. no new challenge or adventure, no new explorations, and a quiet social network, only *Self-teaching* and *Affirmation* remain to progress learning by the engagement and self-volition of the doer. This quasi-stable pattern could persist for long periods, but is an open-ended process that can be disturbed by a novel experience that sparks curiosity. When such an event occurs, such as a new challenge or adventure, all the variables of technological immersion can set into motion another iteration of the regenerative causal loop of immersion learning, with *Induction* and *Immersion* into a new activity, eventually progressing to a new *Maturation* stage, enriched with new experience and learning.

As the theory evolved and coalesced around the amplifying causal loop of a basic social process, the great mass of data collected in the study made sense and several new modes of understanding emerged that were revelations to the researcher. Not only were the stages of the basic social process quite evident, but the theory also provided surprising explanations of the wide range in the engagement and persistence of radio amateurs. As outlined in Chapter 1, radio amateurs where chosen for the study as exemplary examples in the hopes of learning how and why they do what they do. As a long time radio amateur myself, with decades of experience immersed in the technical culture of the hobby, I was not especially surprised when learning did emerge as a strong category in a grounded theory study. The prospect of a learning theory was always a tantalizing possibility, but an improbable one and not a result that could be predicted. I was skeptical that a learning theory was actually emerging and actively rejected the idea until the evidence was overwhelming that there was a new basic social process for how people learn while immersed in a technical culture. The word *immersion* serendipitously became the name for the main stage of the basic social process and later evolved into a theory of *Technological Immersion Learning*, which is presented in Chapter 4.

Theoretical integration. When to consider a grounded theory as complete is an inexact procedure that is dependent upon the judgment of the researcher. The emergence of key properties of categories and modes of understanding is an indicator of reaching *theoretical saturation* in a grounded theory study (Glaser, 1978). That point was reached when the theory provided useful and unexpected understanding of the data. As the analysis progressed, the theory became denser and its explanatory power increased as the categories evolved and merged, condensing into a smaller and more parsimonious set of concepts that were the properties and dimensions of technological immersion learning. Eventually, no new theoretical insights were forthcoming for some time, which is another indicator of theoretical saturation. At that point, the theory possessed the hallmarks of a grounded theory originally put forth by Glaser and Strauss (1967) in that it *fit* the data, it was *relevant* to what was going on, and it *worked* to explain what was going on in the field. The theory was further refined and *modified* as the write-up progressed and additional data was available—the fourth hallmark of grounded theory noted by (Glaser, 2005a). The outcome of the study was a grounded theory of *technological immersion learning*, which is presented in detail in Chapter 4.

Summary

This chapter has presented the analytical progression of the study. In doing this research, I have endeavored to discursively make the process as transparent and open as possible, with all due care to highlight the significant events that ultimately led to the theory of technological immersion learning. I have outlined the circumstances of how particular abductive insights came to be and have presented a critical path timeline in the evolution of the theory. In the interest of full disclosure, the critical path narrative related in this chapter omits the many untold fruitless false starts, unproductive threads, and cul-de-sacs that did not contribute to the theory, but were certainly part of the process nonetheless.

Chapter 4: Findings

This chapter presents the study results in three parts, beginning with an examination of the findings with respect to the four research questions. The second part of the chapter presents the complete *Technological Immersion Learning Theory* (*TILT*), fully abstract of people, place, and time and with minimal reference to its empirical origins. The remainder of the chapter presents empirical grounding of the concepts of the theory to provide a chain of evidence for the research.

Research Questions: Summary of findings

RQ1: *What are the core variables and the related sub-variables that are implicit in the data and account for most of its variability?*
The major categorical variables were found to be: *Adventuring, Affirmation, Doing Technology, Experimenting, Overcoming Challenge, Self-teaching* and *Social Networking*, with *Designing* and *Problem-solving* as sub-variables.

RQ2: *What are the issues and concerns of the participants in the pursuit of their activities?*
The subject group is a community of practice that engages in a wide variety of technical activities that are inherently complex and present ongoing challenges for the participants. The community highly regards knowledge, experience, skill, and achievement as practitioners are constantly challenged to improve their own knowledge and skills in the diverse aspects of the art.

RQ3: *Which aspects of the main concern have the most potential to be transcendent across a wider range of other contexts?*
The main concern was identified as learning through self-teaching and experimenting with hands-on technological activities. Learning, as a main concern, is a high-impact variable that should be transcendent across contexts.

RQ4: *How are these issues and concerns resolved or processed?*
The participants continually resolve or process their concerns through a process of *Technological Immersion Learning (TIL)*, a new basic social process that takes place in stages and operates within a feedback-driven amplified causal looping structure. Theoretical saturation of constructs produced the *Technological Immersion Learning Theory* (*TILT*) as a fully saturated and complete grounded theory derived from the analysis of empirical data.

The major outcome of this study is the *Technological Immersion Learning Theory* (*TILT*), a conceptual level theory that transcends the particulars of the specific substantive area of origin to conceptualize a social pattern (Glaser, 1978, 1998, 2001, 2002, 2005b; Glaser & Strauss, 1967). As such, the theory is capable of providing a conceptual overview of social interactions in environments where engagement with technology is a primary concern.

Technological Immersion Learning: A Grounded Theory

Figure 8 graphically illustrates the evolution of the study as a rising set of abstractions developed from data, as was detailed in Chapter 3. Thousands of pieces of raw data, the indicators of the concerns of the participants, were abstracted into over 200 open codes that captured the essence of what was happening in the field. Further analysis by comparison of indicators abstracted those open codes into seven major categories that conceptualized how the participants went about doing what they do. The interactions of those seven categories were integrated through theoretical coding to the core variable of the study, *Technological Immersion Learning*, an emergent basic social process (BSP) that occurs in stages as a regenerative amplified causal loop, where multiple sources of positive feedback provide affirmation to the doer and promote sustained engagement in doing technological activities.

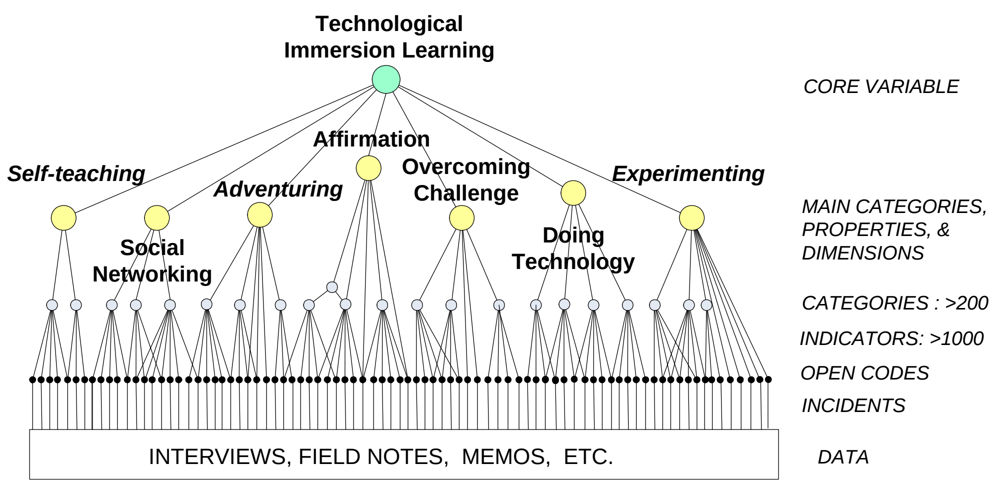

***Figure 8*. Emergence of the technological immersion learning BSP**

A summary of the primary attributes of *Technological Immersion Learning Theory (TILT)* include the following:

- *TIL* occurs iteratively in three stages: *Induction*, *Immersion*, and *Maturation*
- Seven properties and two sub processes interact in an amplifying causal loop: *Adventuring, Affirmation, Doing Technology, Experimenting, Overcoming Challenge, Self-teaching, Social Networking,* with *Designing* and *Problem solving* sub processes.
- A community of practice exists with stewardship of a field of technological activity
- Hands-on, minds-on, interest-driven activities involve technology, experimenting, and learning
- Activities are multidimensional and provide multiple sources of affirmation
- Multidimensional feedback promotes regenerative learning and persistence in the activity

The architecture of the theory of technological immersion learning is presented in Figure 9 as a causal diagram illustrating the interrelations among the attributes, with feedback shown by convention as directional arrows. The technical properties and social properties are color coded as yellow and blue, respectively, for contrast.

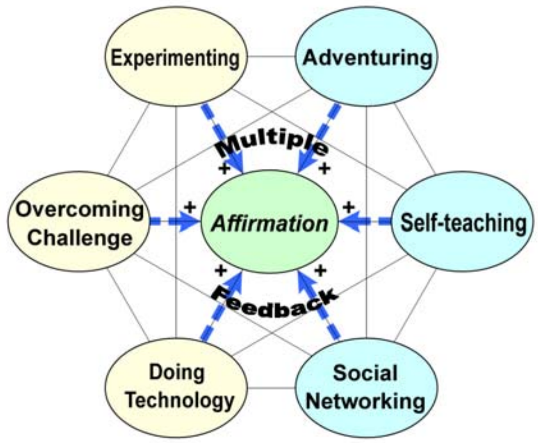

***Figure 9*. Technological Immersion Learning through multiple affirmative feedback**

Interpreting the Model. Graphical models are inherently limiting in what they can reasonably convey, particularly with respect to complex grounded theories that are best presented in narrative. However, a graphical model can provide a map to the general architecture and features of a theory and serve as a useful visual reference. Such is the case for Figure 9, which portrays the properties of *Technological Immersion Learning* as woven into an interconnected causal diagram, with *Affirmation* at the center. The essential concept that the model is intended to convey is the idea of multiple affirmations received from multiple sources of positive feedback. *Affirmation* is the centerpiece of the model, centrally located at a nexus of feedback (dotted arrows) from all the other properties. Second, all the concepts of technological immersion learning are connected and mutually influence the others, as indicated the black interconnect lines in the diagram, a feature that is difficult to depict in a simple two-dimensional structure. All the nodes of the model are mutually interdependent in a dialectical relationship. Third, the clustering of the technical triad of *Experimenting*, *Overcoming Challenge*, and *Doing Technology* and the social triad of *Adventuring*, *Self-teaching*, *Social Networking* emphasize the technical and social aspects of the theory. The interconnection of the nodes carries implicit permutations and interactions of the properties of *Technological Immersion Learning* and its underlying dimensions, sub properties, and processes. Although limited, this simple visual model is useful to convey the general concepts for a more detailed discussion of the theory to follow. Figure 10 presents the operational definitions of the *Technological Immersion Learning* BSP and the seven major properties that compose it.

Most of the attributes of *Technological Immersion Learning* either are *in vivo* codes or are derived from *in vivo* codes. This is a natural result, since strong terms used by the participants in a substantive area are often strong concepts that can earn their way into an emergent theory. The main concern of people is always near the surface and it is logical that elements of that concern should be built into the language. Glaser (1978, p. 70) describes *in vivo* codes, as “taken or

derived directly from the language of the substantive field.... In vivo codes tend to be the behaviors or processes, which explain how the basic problem is revolved or processed".
An immediate advantage of *in vivo* concepts is that very often the terms are familiar words that require no definition or only minimal operationalization. Words such as adventuring, experimenting, challenge, technology, and social connection or networking invoke imagery and seem immediately familiar, whereas words such as empowerment and affirmation are less familiar or vivid. Still other words may be unconventional, since a grounded theory researcher must at times be a lexicographer in the naming of concepts that may not have a convenient descriptor. One such concept is *Technological Immersion Learning*, which is defined in this study as integrative learning that takes place for individuals who are immersed in a technical culture, where experimenting with technology is a primary activity. The concept of *Technological Immersion Learning* effectively captured the essence of the process of learning through deep engagement in a technical culture. The concept appears to be unique in the literature, although a related term, *technological learning*, is used in other fields in loose association with technology transfer and innovation in industry.

TIL occurs in three stages: *Induction*, *Immersion*, and *Maturation*, stages that occur time-and-again with changing contexts. The term *Immersion* refers to both the main stage of the BSP and is a metaphor to emphasize the genesis of the theory from a social group that is immersed in a complex, diverse, and interconnected technical culture. The theoretical structure of the theory is based upon three theoretical codes: an amplifying causal loop, a basic social process, and a biased random walk (Glaser, 1978). These theoretical constructs provide the analytical framework that integrates the elements of the theory, provides explanatory power, and serves as a basis for generating hypotheses. Each of these theoretical constructs is outlined below to provide background for the discussion to follow.

Technological Immersion as an Amplifying Causal Loop. Feedback is a powerful modifier of human behavior and is a primary driving mechanism of technological immersion learning. Positive feedback is operationally defined as a result that reinforces a beneficial pattern of behavior. Activities and events that occur within each element of *TIL* provide affirmation to the doer that the activity is worth doing. Multiple sources of positive feedback drive *Affirmation,* the centrally located property in the topology of Figure 9 and interlinked with all the other properties. A technical culture affords its practitioners with multiple sources of positive feedback that are mutually reinforcing and provide the impetus to sustain engagement in the activity. Positive feedback that strengthens an initial action is a regenerative process known as amplified causal looping.

The concept of an amplified causal loop is that an action can produce a result that can reinforce and strengthen the impetus of the original action. As a variant of the causal theoretical code family, Glaser (2005b, p. 10) notes, "As consequences become continually causes and causes continually consequences, one sees either worsening or improving progressions or escalating severity". The regenerative mechanism of technological immersion learning is a positive feedback amplified causal loop, where positive results promote positive actions. The negative case of a degenerative causal loop was not present in the data.

Technological Immersion Learning: a basic social process of integrative learning and personal development that takes place for individuals immersed in a technical culture where experimenting with technology is a primary activity. Technological immersion learning occurs in three stages, *Induction*, *Immersion,* and *Maturation*, with seven interconnected properties, which operate in an amplified causal loop. The properties of technological learning are defined as follows:

- **Adventuring:** engaging in an exciting or unusual experience that has an uncertain outcome and entails some degree of risk. Uncertainty and active engagement are essential elements of adventuring, with discovery and surprise as possible outcomes.
- **Affirmation:** psychological confirmation that an action or activity has value and is worth doing. As a property of technological immersion learning, affirmation integrates all the emotional attributes resulting with performing an activity.
- **Doing Technology:** to actively engage in the full spectrum of the knowledgeable use, exploration, and creation of technology within a domain of interest, with attendant transdisciplinary development of knowledge and skill.
- **Experimenting:** to try new methods or strategies for doing something or to explore an unknown area. In technological immersion learning, experimenting entails a wide range of hands-on minds-on activities that relate to the use, creation, and adaptation of technology, particularly in connection with problem solving and exploring new ways and means of doing.
- **Overcoming Challenge:** a recursive process of confronting a challenge, where success or failure depends upon the knowledge, skill, and abilities of the individual. Success brings affirmation and failure can initiate problem solving, experimenting, and learning while exploring possible ways to succeed. A challenge may originate from personal volition or can be a result of external influences, with the knowledge, skill, and ingenuity of the individual as key to the outcome.
- **Self-Teaching:** to engage in self-directed study of a domain of knowledge in order to gain desired experience, knowledge, and skill, and to improve proficiency and performance in particular aspects of interest. Self-teaching encompasses a wide range of learning behaviors, including the autodidactic what, how, and when to learn, the mental and physical elements of training, and the experiential elements that can be learned in no other way.
- **Social Networking:** to engage in social connection and interaction with individuals who share a common interest or goal, particularly with respect to beneficial information flow, mutual reinforcement, affirmation, and self-worth. Social connection can take place as direct interactions within a personal network or in association with a larger community of practice that is devoted to stewardship of the domain and possessing a shared identity and intent.

***Figure 10*. Properties and definitions of Technological Immersion Learning**

Multiple regenerative causal loops can develop among any combination of attributes due to interactions among activities and events in a technological immersion environment. For example, an activity may simultaneously touch the senses, emotions, and intellect on multiple levels. Technological activities in particular tend to be multidimensional and dynamic, engaging the senses and emotions by empowering the doer through expansion of physical capabilities. Change is inherent and dynamic, which present challenges to be overcome through pragmatic problem solving and experimenting. Technology and culture are interconnected, with social interaction and collective learning in response to challenge. Engaging in technological practice can entail adventure and discovery in exploring the unknown, with new experiences and learning as a result. All the experiential elements of doing technology are interconnected and provide multidimensional experiences and learning and multiple affirmations that sustain and enhance the knowledge and abilities of the doer.

Technological Immersion Learning as a Basic Social Process. *Technological Immersion Learning* is a distinct basic social process (BSP) that occurs when individuals are immersed in a technical culture. In order for a core variable to be considered as a BSP, it must meet several criteria:

1. The phenomenon is a process that takes place over time and has developmental transitions.
2. A BSP reflects an evolving nature and a "sense of motion", often characterized as a gerund, such as becoming, resolving, cultivating—and *learning*.
3. Basic Social Processes possess at least two stages that "differentiate or accounts for variations in the problematic pattern of behavior" (Glaser, 1978, p97).

TIL has three stages and multiple status passages that develop over time and account for wide variation in data, one of the most difficult and daunting aspects of developing the theory. The culture of the subject group is complex, diverse, and variable and includes people whose engagement ranges from minimal and transient to those who develop a lifelong passion. The properties and dimensions of *TIL* provide a continuum of variability that accounts for the range and depth of behavior present in the data. Table-3 describes the three phases of technological immersion learning and Figure 11 illustrates the progression and iterative nature of the process. The stages are discussed in the following.

Table 3
Stages of Technological Immersion Learning

TILT Stage	*Features*
Induction phase	Credentialing phase for learning basic concepts, lexicon, rules, regulations, licensing, and social conventions for an activity.
Immersion phase	Autonomous engagement with experimenting and learning with technological activities, with multiple affirmation by feedback.
Maturation phase	Advanced achievement and advanced skill level. Random walk pattern of technological immersion learning.

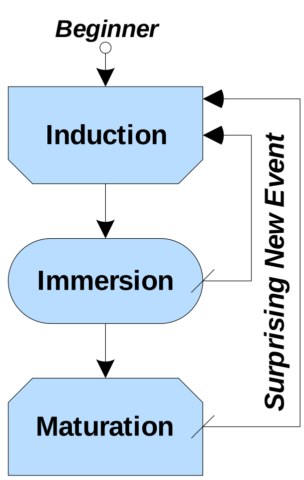

***Figure 11*. Technological immersion learning basic social process**

Induction Stage. The *Induction* phase begins when a budding interest inspires the will to learn more about a new activity. Social networking plays an important role in beginning the process of learning basic concepts, vocabulary, rules and conventions, since technology and culture are inextricably interwoven together in a techno-social amalgam. Mentoring and group activities can be highly beneficial for the neophyte in learning and earning the necessary credentials to begin active participation in the activity of interest. In the *Induction* phase, the neophyte gains the minimum necessary credentials to begin a technological activity. The credentialing process can be informal and casual or it could be a formal process with a defined stage gate, such as official licensing or certification. A basic requirement is an orientation to the language and learning a minimum set of fundamentals as preparation to becoming an active participant. The *Induction* stage prepares the initiate with credentials to begin, which can range from an informal affirmative to formal credentials, such as a learners permit to drive, a student pilot license to fly, an apprenticeship to a trade, or in the case of radio amateurs, passing the licensing exams and receiving their unique radio call sign. All are status passages that signify the end of the *Induction* stage and the beginning of the *Immersion* stage. By this point, the initiate has received initial exposure to some of the properties of *TIL* and possibly has received positive feedback from multiple sources. The elements of the causal loop is in place and responsive to the actions and personal volition of the initiate and the culture of the group. All the variables have an engagement dimension that allows a wide range of responses that are dependent upon the drive of the initiate.

The transition into the *Immersion* stage is often a rite of passage, as the neophyte begins autonomous engagement in the technological activity of interest. The solo flight of a student pilot, the first road trip as a new driver, the first contact as a licensed radio amateur, and first light through a homemade telescope are life-changing events and just as life affirming as when a creative act is accomplished or when a collection of electronic components come to life on the workbench. These are affirmations that signify a host of positive feelings for the doer that these activities are good and have value.

Immersion Stage. The *Immersion* stage is a status passage whereby the novice begins active engagement in an activity and is free to participate and explore a new area of interest. The study and learning required to become oriented is followed by more study, learning, and hands-on experience to reach the point where active participation in complex technological activities is possible. *Doing Technology*, i.e. doing hands-on, minds-on, technological activities, has varying degrees of complexity, often with a significant learning curve to master the concepts, techniques, materials, tools, equipment, and the hands-on and personal skills necessary to become fluent. Learning progresses incrementally as the neophyte learns to experiment with technology, with immersion within the culture of the group. The regenerative causal loop of *Technological Immersion Learning* is fully active at this point and individuals are exposed to the results of their engagement in self-selected activities. Participants act on their self-selected activities and receive feedback from multiple aspects as they progress and develop proficiency. The fraternity afforded by the social connections within the group is an affirmation and signals belonging and the status of being special. Technological activities are grounded in the real world and are authentic and conducive to high engagement as the participant autonomously selects activities that they care about and consider to be worth doing. The challenge of learning new concepts, technologies, and skills is an affirmation and an adventure for the participant on multiple levels.

Sharing in the knowledge base of the group and experimenting with technologies affords a rich learning environment that is responsive to individual volition. All the dimensions of *Technological Immersion Learning* are variable and have other dimensions that account for variation and complexity of the process. For example, among the various attributes encountered in the act of *Doing Technology* are *Challenge* and *Skill Level*, both of which are variable over a continuum ranging essentially from nil to very high. Mapping these dimensions in phase space, as shown in Figure 12, reveals a dynamic of possible responses to varying levels of *Challenge*, depending upon the *Skill Level* of the doer.

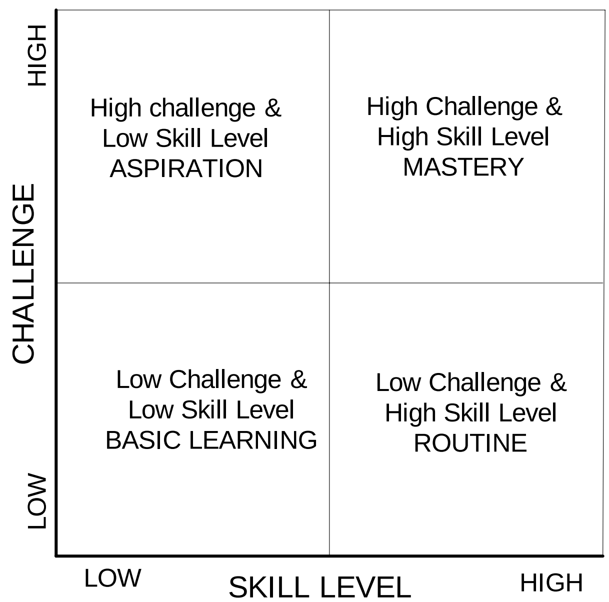

***Figure 12*. Dynamic variation of skill level and challenge**

With reference to Figure 12, neophytes initiate a new activity in the low-skill/low-challenge quadrant, with basic learning of the fundamentals of the activity. From the beginner's perspective, the activities in the high challenge quadrants may be daunting, as the scale and complexity of the field become evident. The role modeling of those who are proficient can serve to inspire the newcomer to explore and develop in knowledge and skill. The social network of technological activities can provide feedback and affirmation to the newcomer, but individual growth and development are dimensions that are highly dependent upon personal volition and drive. *Technological Immersion Learning* rewards the autodidact and provides the impetus and mechanisms to support experiential learning.

In time, mastery may be achieved as the individual matures in knowledge and skill and is able to meet high challenge with high skill and expertise. Figure 13 (left) illustrates the expansion of the Skill-Challenge dynamic by mapping skill levels across the diagonal. The skill levels shown are those of the Dreyfus model (S. E. Dreyfus, 2004), which ranks skill acquisition in five stages, a ranking coincident with those found during analysis of the empirical data of this study. The Dreyfus model is likewise empirical, derived from the training of Air Force pilots and arguably intensive technological activity that might itself be an example of technological immersion learning. The study data reflects the progression from Novice to Expert and the Dreyfus criteria provides a way of understanding the progression of technological immersion learning. Also shown in Figure 13 (right) is the progression from Novice to Expert mapped into the stages of *TIL BSP*. The temporal component is implicit in the natural progression of learning a complex subject and developing the necessary experience and skills. The learning that takes place in the *Immersion* stage is regenerative, transdisciplinary, and transformational in an ever changing techno-social environment.

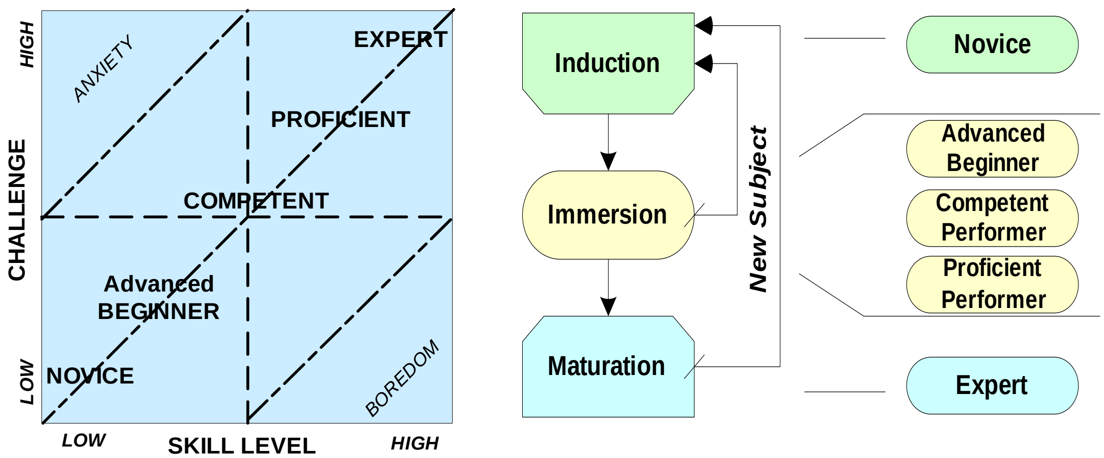

***Figure 13.* Progression of skill development and stages of BSP**

The *Immersion* stage is a broad and persistent state with no clearly defined exit point, but is characteristically cyclical as new interests develop as indicated by the looping structure in Figures 10 and 13. Practitioners in the *Immersion* stage exhibit large variations in proficiency levels, much of which can be understood in the time dimension as the natural progression of learning a complex subject and developing the requisite skills and experience.

Maturation stage. The *Maturation* stage is characterized by achievement of knowledge and expertise in many aspects of the technological activity and participation in a wide range of activities. The transition into the *Maturation* stage of technological immersion learning is a status passage that can take various forms. For several of the radio amateur participants of this study, becoming an Elmer (mentor) to others marked the transition. For others, it was the attainment of a significant personal goal that required time, perseverance, knowledge, skill, and experience to accomplish. For radio amateurs, *Maturation* was marked by attaining a high level of proficiency in a challenging aspect of the technological hobby, such radiosport competition, developing proficiency in high-speed Morse, or the completion of a major technical feat, such as hearing the echoes of one's VHF signal returning after reflection off the Moon. The pleasure of completing a complex project that required sustained hands-on commitment to accomplish was a milestone for many. For others, it was gradually attaining the status of elder statesman among one's peers, with the recognition, respect, and social connections marking their maturity. While attaining the *Maturation* stage, the regenerative causal loop of *technological immersion* remains active, but with gradually diminishing flux in the variables until an advanced stage of development is reached, at which time the *Technological Immersion Learning* causal loop can take on a random walk behavior.

Technological Immersion as a Biased Random Walk. As individual becomes very proficient in a particular technological discipline, most of the variables of *TIL* may show only apparently random fluctuations and no predictable pattern over time. Learning still takes place, albeit in the manner of a random walk. This theoretical model is a variant of the biased random walk theory of cellular biology that describes how movement can preferentially take place in certain directions, with only random inputs to the supporting variables.

Executing an activity with advanced skill brings *Affirmation*, which can be described as intrinsically motivating and possibly an experience analogous to the FLOW experience (Csikszentmihalyi, 1990). In such a state, where there are few disturbances in the properties of *TIL*, i.e. no new challenge or adventure, no new experiments, and a quiet social network, with only *Self-teaching* and *Affirmation* remaining to progress experimenting and learning by the engagement and self-volition of the doer. This quasi-stable pattern can persist for long periods, but is an open-ended process that can be disrupted by a novel experience that sparks curiosity. When such an event occurs, such as a new challenge or new area of interest, all the variables of *Technological Immersion Learning* can immediately be set into motion. Venturing into a new area of interest initiates a new *Induction* stage to begin learning the basics of the new interest, with shared knowledge from social networking, with *Self-teaching* and *Mentoring* to develop the necessary knowledge and skill to begin immersion into the new area of interest. Assimilating new technologies provides new challenges and adventure, with *Experimenting*, *Problem solving*, and *Designing* as the sine qua non of *technological immersion learning*. All the properties of *TIL* are active in the new *Immersion* stage and provide multiple affirmations to the doer in a regenerative causal loop. In time, the individual can progress, gain experience, and develop the experience, knowledge, and skill and eventually to mature in a new context, with the *Maturation* stage of *Technological Immersion Learning* broadened by new experiences.

Dynamics of Challenge, Problem solving, and Design. When *Doing Technology*, one of the routine satisfactions of technical activities is the hands-on exercise of knowledge and skill for which the individual receives affirmation from the doing. The activities are selected for the positive attributes they bring to the doer, particularly where an element of uncertainty exists and success is dependent upon the knowledge and capabilities of the doer. When confronted by a challenge, all the previous knowledge, skills, and experience are put to the test. Success brings *Affirmation* and failure can initiate a recursive process of *Overcoming Challenge,* where multiple strategies can be brought to bear on a problematic situation.

Problem solving is a natural result of experimenting and using technology, with problem solving often becoming a design problem to create better technology in the process of exploration and experimenting. *Problem solving* and *Designing* are sub processes within *TILT* that exist as dynamics in the interplay of the successes and failures that result from attempting to surmount a challenge. Therein lies a distinction that can be understood in terms of the model shown in Figure 14, which illustrates the relationship of the *Problem solving* and *Designing* sub processes that interoperate within the technical triad of *TIL,* with *Problem solving* and *Designing* as alternative responses to varied feedback from technological activities. The possible reactions to a challenge are dynamic and driven by the outcomes of the successes and failures in the actions of the doer.

***Figure 14*. Dynamics of problem solving and designing**

Success dynamic. A challenge that is faced and successfully met can provide positive feedback and feelings of affirmation to the doer. In success is the *Affirmation* that is part of the pleasure of *Doing Technology*, when the technical faculties, knowledge, and skill of the doer are sufficient to accomplish the goal. This scenario is generally satisfactory until an occasion arises in which the faculties, knowledge, skill, or circumstances of the doer are inadequate to surmount the challenge. Failure is feedback to the doer, not necessarily negative, but neither is it positive and instead of the desired affirmation from an action, a problem is perceived instead. This state brings about a problem-solving mode in an effort to resolve the discomfort.

Problem solving dynamic. Failing in the attempt to meet a challenge constitutes a problem that begs a solution. *Problem solving* is a process associated with most of the categories of *TIL* as a reaction to the failure to meet expectations or newly rising expectations. There is an implied range of responses in reaction to a problem, indicating that problem solving has an engagement dimension. A minimal response would be no problem solving effort at all and the extreme case would be deep root cause analysis and corrective actions. The practical middle ground suggests a range of responses, the output of which would be a probable cause and some kind of action plan, ranging from simply trying again, improving knowledge and/or skill, or making a technical or procedural improvement. The learning that results from this effort could be incidental or could require overt *Self-teaching* to accomplish the goal. Testing the efficacy of a solution can bring affirmation or could bring another failure. Another failure may result in more retrying, fixing, refining, and more problem solving, or the realization that a better response is needed—and initiate the *Designing* of a better solution.

Designing dynamic. Persistent failure in the face of problem solving efforts suggests that another solution is desirable—a designed solution to resolve the problem. Thus, *Designing* is an alternate response to *Overcoming Challenges* and closely related properties of *Experimenting* and *Doing Technology*. Like *Problem solving*, *Designing* tends to be an iterative process, with many considerations and trade-off decisions that are weighed and balanced to arrive at potential solutions that is ultimately constructed and tested. *Experimenting* with the new capabilities afforded by the designed solution may bring the affirmation of success after previous failure, or may initiate problem solving, retest, iterative solutions or multiple design cycles to arrive at a satisfactory result. Neither designing nor problem solving are linear processes, but are dialectical in the resolution of contradictions.

Engagement, Empowerment, & Self-Actualization

The high incidence of *Engagement* and *Empowerment* as variable dimensions within all the properties of *Technological Immersion Learning* suggests another possible theoretical code in the mechanism of the BSP: *Self-Actualization*. Self-Actualization is a variant of the Identity-Self coding family (Glaser, 1978, 2005a, 2005b) and related to identity and self-realization, codes that were present in the analysis and evidenced in empirical data. The concepts of engagement, empowerment, and self-actualization form a motivational triad that borders on formal social theory, but posits a plausible hypothesis as impetus for *Technological Immersion Learning*. Figure 15 illustrates the relationship, which is further discussed in the text below.

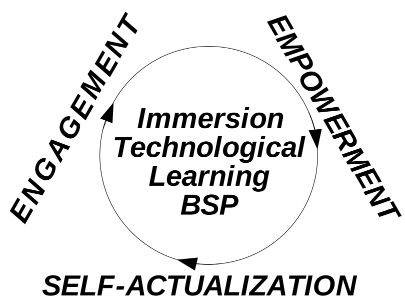

***Figure 15*. Motivational triad of Technological Immersion**

Engagement was a pervasive dimension of all the properties of *Immersion* and accounts for the range of variability in actions of personal volition. The concept of engagement is grounded within the actions associated with the various aspects of technological activities. *Motivation* was a useful early low-level code used in the analysis, but *Personal Volition* emerged as a best fit to the actions of the participants. The distinction between motivation and personal volition is that motivation is the simple desire to do something and volition is a steadfast commitment to achieving a goal—an act of will. Engagement is a necessary component of volition and provides the essential means for attaining a goal. All seven properties of *Immersion* entail engagement; all seven properties are interrelated; and all provide positive feedback to the individual. Acts of engagement and personal volition were frequently observed among the study participants and representative of a wide range of behaviors and experiences of the technical practitioners.

Empowerment emerged in the study from consideration of the dynamics of power that were present in the data. Humans utilize technology as a means of enhancing our physical abilities and extending the power and range of our actions and, indeed, *Power* and *Extension of Self* were among the substantive codes associated with the use of technology. Power is the ability to do something (O.E.D., 2016), an ability that is enhanced by the use of technology. The use of the word *empower* is apropos in this case, as "in or of power" is an etymology that dates at least from the time of John Milton and *Paradise Lost* (1667). Adopting an operational definition of empowerment as a process of gaining the ability to make something happen, i.e. 'in and of power', prompts the question of "where's the power?" in circumstances where empowerment is invoked as a construct. The probing question of "where's the power?" in *technological immersion learning* produced a dense web of interconnections that supported the relevance of empowerment in connection with technological activities.

The ability to do something or make something happen is a prime mover of technological activities and an overt act of power. To empower is to support the ability or capacity to make something happen, i.e. to make change possible. The ability to utilize technology is arguably empowering for the doers, and most of the dimensions associated with performing a technological act can likewise be considered as instances of empowerment. The ready access to knowledge, materials, tools, and processes, along with the demonstration of knowledge and skill in experimenting and confronting challenges can rightly be considered as empowering for the doer who has gained the ability to make things happen. Power is manifested in the application of the intellect and skill in solving problems in uncertain circumstances or when adventuring into the unknown. The execution of a skill with mastery, an overt act of power, is arguably a satisfaction for the doer, as is the influence of recognition by peers within the social group. The social connections afforded within the group supports a sense of personal identity, of community, and of belonging, and supports positive changes in self-concept. Mentoring is a shared empowerment for the mentor and the mentored, with caring and altruism providing a sense of giving back and enhancing self-esteem. The expansion of knowledge and skills by self-directed learning enhances self-efficacy and promotes a sense of self-determination, autonomy, and freedom to act. These connections stem from incidents that were observed during the study and support the concept of empowerment as the capacity to act and affect change engendered by the process of *Technological Immersion Learning*.

The final element, *Self-Actualization*, emerged as a conceptualization of a tacit process of individual action that was a persistent presence within the subject group, but one that remained undefined until it crystallized as an integrating concept late in the study. The origin and original usage of the term self-actualization was by Kurt Goldstein in his book, *The Organism* (Goldstein, 1939) and later popularized by Abraham Maslow (1943) in a hierarchical theory of human motivation. Goldstein defined self-actualization as "the tendency to actualize, as much as possible, individual capacities"(Goldstein, 1939, p. 46) and Maslow couched self-actualization in terms of "the desire for self-fulfillment" (Maslow, 1970, p. 383) on the esteem level of his hierarchy of human needs. The popularity of the concept has led to numerous other definitions of self-actualization in the literature that are divergent and conflicting, with no clear consensus as to the meaning of the construct. In the face of such a nebulous concept with numerous overlapping and contradictory definitions, an operational definition was required to clarify the meaning of self-actualization in the context of the study.

The concept of *Self-actualization* and its operational definition are grounded in the behavioral patterns of the study participants. The actions of the participants that sparked self-actualization as a fourth-level abstraction in the study included instances of altruism, aspiration, caring, creativity, curiosity, discovery, exploring, fraternity, identity, interest, learning, and sharing in the multiple contexts of their engagement with technological activities. Self-actualization is operationally defined as a continual process of self-discovery, creation, re-creation, and self-expression through all the actions and activities and myriad contexts of being human in a complex social and technological world. Self-actualization is a perpetual process of becoming that borders on the transcendental[4], but is very much in and of the real social and technological world.

The psychological nexus presented by *Engagement*, *Empowerment*, and *Self-actualization* provides a useful way of understanding the regenerative nature of *Technological Immersion Learning* and the long persistence of radio amateurs in their technical hobby. Taken in isolation, these concepts are empty abstractions and devoid of context—a bread sandwich without substance, but in the context of technology, they provide a higher-level understanding of technological activities as a particularly rich vehicle for self-actualization through the basic social process of *technological immersion learning*. The desire to achieve a budding ambition that is sparked by the potential of a technological activity, i.e. to self-actualize in the sense of Maslow (1943) entails a personal act of volition. *Engagement* in the milieu of the problem and immersion in the process provides the ways, means, and opportunities to achieve the budding ambition. The successes and failures in the effort are a growth process and empowering for the doer, with affirmation of the worth of the endeavor as an act of self-actualization. In the context of technological immersion, engagement, empowerment, and self-actualization are a perpetual loop with no exit condition. The positive attributes of experimenting and learning through technology provides a complex and rich environment for learning and personal development that contributes to an ongoing process of self-actualization.

Empirical basis of Technological Immersion Learning

The following is a *grounded description* (Glaser, 2016) of the concepts of the study that were generated from empirical data. The text was generated in the comparative analysis prior to theoretical coding and represents conventional qualitative data analysis and data description of the substantive area under study. This discussion is presented to unmask the lower-level analysis underneath the higher-level abstractions of the *Grounded Theory of Technological Immersion Learning* and presented to provide a chain of evidence for the doctoral-level research project. However, grounded theory is the *study of a concept* and not a descriptive study of a descriptive problem. The concept names a pattern and becomes the core of the theory that is derived from data, but transcends the data as a conceptual-level theory. The following presents the empirical grounding of *TILT* and offers a vignette into the substantive world of the radio amateurs who were the genesis of the theory.

Doing technology. Naming a process of active hands-on doing of technological activities for all the reasons that people do technological activities was surprisingly difficult. The modern baggage accompanying the word ‘technology’ is an issue. The word *technology* in the modern vernacular is an ambiguous term used in reference man-made objects or systems and often mistakenly conflated with science or applied science. Technology is a complex concept

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[4] In the literature, self-actualization is often confused or conflated with *self-realization*, a concept that is descended from Eastern religious practice and entails coming to know oneself through disengaging and transcending of the physical world, an altogether different perspective than the actualizing of self in the physical world.

with a specific deeper meaning than the common colloquial usage. The etymology of the word descends from ancient Greek, from *technē*, meaning arts or crafts, and *logos*, meaning reason or logic. Thus, technology is actually a binary concept of *craft* guided by *knowledge of the craft*, which belies the simplistic unary reference of technology as physical artifacts. Technology as a meld of craft and knowledge goes to the essence of how humans have come to extend their physical capabilities by developing the knowledge and ability to manipulate the physical world. The concept of *Doing Technology* is a trinary concept that invokes the Greek heritage of the root words and combines active hands-on minds-on doing with the technical and the logical, i.e. doing with ability and understanding—the basis of real learning.

The physical and intellectual elements of technical craft were present throughout the study, a natural result since the study participants were highly engaged in practicing technical activities. The physical elements of craft include the myriad artifacts, tools, materials, and processes that are of interest to the doer. The mental elements encompassed the requisite knowledge and skill of the doer, which was less tangible, but nonetheless vital for understanding and success. The diversity of technology likewise entails diversity in technical lexicon that is often unique and specialized to a particular discipline. The language of technology enthusiasts is typically saturated with specialized vocabularies that reflect the diversity of their technical interests and activities. However, although the technical interests of the participants were diverse and the physical and intellectual elements of the technologies were variable, the psychological dimensions of caring, interest, and passion were consistently strong elements that were common among all the study participants. People engage in pastimes that interest them and that they care about—concerns that were reflected in incidents coded as *Caring*, *Challenge*, *Interest*, *Passion*, and *Engagement* that were evident throughout the study.

Doing Technology highlights active hands-on engagement in technological activities, with emphasis upon doing and understanding. Among the substantive codes that were associated with deep engagement with technological activities were *Hands-on*, *Skill*, *Passion*, *Pleasure*, and *Utility*—all attributes that relate to the level of engagement of the study participants. *Empowerment* is likewise an element of *Doing Technology*, an indicator of the capabilities afforded by technology applied with knowledge and skill as an extension of mind and bodies. *Doing Technology* entails overt acts of *Power*, as was reflected in the substantive codes *Extension of Self* and *Action at a Distance*, which in the case of the radio amateurs of this study, included the routine global reach of communications by radio.

The following comments by study participants illustrate the engagement of these individuals with their technical hobby:

- "Finding the right solution requires a lot of hard work and it's a learning process too. In the end there is real satisfaction in the result. There is some second-guessing too, little flaws that happened, or an idea that would have made something a little better. But it is an act of creation and it is satisfying to make something that works. I always seem to learn something new."
- "If I were to sum it up, ham radio has just opened so many possibilities for me. So many things that I never knew existed. I had no idea that there were radio waves everywhere that I could actually play with them. That I could DO things. That I could be an ambassador for

the United States of America. It has been a key that unlocked a door, which was just solidly closed."

- "Ham radio has introduced me to a lot of the technology and the opportunity to learn and to experiment with it and to actually build projects that work. It just opens your mind."
- There is always something that someone is trying that has not been done before, or at least has not been published or anything, but makes me think, "Hey, I could do that. That would come in handy!"
- I've run thousands of pieces of gear across this bench down through the years, trying to keep the local's ham radio gear going.

Doing Technology emphasizes active engagement and empowerment in the use of technology, with knowledge and skill as an extension of self and an act of power and personal volition. Caring about a particular domain provides the impetus for engagement, exploration, and experimentation that is responsive to the personal volition of the doer.

Self-teaching. The importance of learning as a major concern of the study participants emerged very early in the research and became densely linked with many other categories. *Self-teaching* emerged as the best-fit conceptualization of learning whereby the doer is engaged in a self-directed study of a domain of knowledge in order to gain desired learning, experience, and skill and to improve proficiency and performance in particular aspects of an area of interest. As an analytical category, Self-teaching encompassed a wide range of learning behaviors, including the autodidactic what, how, and when to learn, as well as the mental and physical elements of training in skill development and experiential elements that can be learned in no other way. Self-teaching and experimenting with technology emerged as the main concern of the study participants and was reflected in their commentary on the nature of learning:

- "Listening, building things, and doing things with my hands—that's how I learn."
- "There are still people with lots of curiosity who want to learn and explore... but to me curiosity is one of the things that opened up the door, not only in radio, but in learning in general, especially in science."
- "Unfortunately, I had no mentor for studying for my radio license, so I had to go it alone."
- "You know, half of the battle of a lot of new technology or new areas of interest that you may have is learning the vocabulary. That's half the battle."
- "Actually seeing Morse put to use made me want to do this. I really need to figure out how to do this. *I need to learn what I need to learn so I can do this!*"
- "It takes long time to and a lot of practice to develop real skill. You can't just read a book and expect to be proficient. It takes time, practice, and experience to train yourself to the point that your responses are automatic and you do not have to think about the mechanics."
- "I have always just been sort of geared toward the technical side of things. If I'm reading a book, 90% of the time it's going to be some kind of a technical book, whether it's a textbook, a how-to book, or just something related to something technical in nature. That's just what it is. I guess that's just the way that I am wired."
- "One of the fascinating things for me is that there is always something that I want to experiment with or something new to learn or experience or a goal that I set for myself. I

got interested in DXing and that maybe more than anything else has driven me to do all kinds of things. To learn things, to build things, to improve things, and to develop skill is what this is all about."

- "I am starting to learn how antennas work. It is starting to open the door to general electromagnetic things. Now I want to know how cell phones work, how cell towers work, just generally to become more to the Now generation, for a 72-year old. How do things work? That to me is an offshoot of all of this. Not just radio waves, but how do other things work?"

Learning can be advanced through formal instruction or by enlisting the services of a mentor, but in the end, it is up to the individual to internalize knowledge and develop and refine skills in order to develop proficiency. Self-teaching conceptualizes the latter aspect of learning and is characterized by the dimensions and properties that the category subsumes and abstracts. *Creativity*, *Curiosity*, *Discovery*, *Ingenuity*, *Improvising*, *Persistence*, and *Problem solving* were all lower level codes that related to the learning responses of the participants. The higher level cognitive concept of metacognition (Bransford, Brown, & Cocking, 1999) was likewise present in the autodidactic behaviors of learners who experiment with technology and manage their learning behaviors with respect to the current demands and aspirations with respect to their technological activities. The variable nature of personal volition in self-teaching is reflected in the engagement and empowerment dimensions that are present in nearly all the properties of *TIL* and represent a range of possible responses to the problems and opportunities presented by learning through technological activities.

The affirmations of learning entail more than just learning some new idea or fact. The affirmations of learning something new in a technological context can be multidimensional and highly interconnected with other knowledge. The affirmation of learning something new could be accompanied with a new physical skill and new abilities. For radio amateurs, a new idea may also entail new abilities and positive feedback in the form of being successful in challenging circumstances, contacting new countries, receiving prized QSL cards, recognition by peers, and the satisfaction of enhanced personal agency. The affirmations of learning in a technological context are many and varied and more than just the good feelings of learning something new. That something new can positively enhance the reach and power of the individual.

Experimenting. All the study participants were experimenters to varying degrees. *Experimenting* is a fundamental property of *TILT* whereby the doer attempts new ways or strategies for doing something or explores an unknown area of interest. *Experimenting* entails a range of hands-on minds-on activities that relate to the use, creation, and adaptation of technology to particular purposes, especially in connection with problem solving and exploring new ways and means of doing. Some of the basic low-level substantive codes associated with *Experimenting* are *Building*, *Curiosity*, *Discovery*, *Ingenuity*, *Making*, and *Measuring*. *Curiosity* was a strong component of *Experimenting*, as was reflected in the following comments made by the study participants:

- "I am always experimenting. I wanted to know why you could hear this and why you could hear this. I always followed the question with Why and I carried that with me, because it seemed like the most logical question to ask."

- “You can read all the books you want and everything that it says in those books is virtual reality, it is an idea, it is a starting point. But it’s not etched in stone. What works for one person in one place is not necessarily going to work for another person some place else. So I learned that you take bits and pieces of the information that you learn and apply them for your particular location and make it work for you there.”
- “I have learned something new every day by experimenting. It just never ends. There is always something new to do and learn.”
- “I guess the reason why we are doing what we are doing is because we like thinking, learning, and experimenting.”

In *technological immersion learning*, *Experimenting* entails a wide range of hands-on, minds-on activities that relate to the use, creation, and adaptation of technology, particularly in connection with problem solving and exploring new ways and means of doing. The essence of experimenting is to try new methods or strategies for doing something or to explore an unknown area of interest.

Overcoming Challenge. The intersection of humans and technology is fraught with problems and complexity. *Overcoming Challenge* is a recursive process of confronting problems and challenges, where success or failure depends upon the knowledge, skill, and abilities of the individual. Success brings *Affirmation* and failure can initiate experimenting, problem solving, and learning, while exploring possible ways to succeed. A challenge may originate from personal goal or can be a result of external influences, with the knowledge, skill, and ingenuity of the individual as key to the outcome. Substantive codes associated with *Overcoming Challenge* are *Problem solving*, *Creativity*, *Designing*, *Improvising*, and *Persistence*. The participants commented on the nature of goals, challenges, and problem solving with respect to their technical hobby:

- “The solving of problems is really fun.... When I figure something out and it works—that is the real learning. That is where it’s at. I will fight with something until I get it to work. ... Solving problems with radio—I won’t give up! Now, sometimes I do have to call on help, but I will work on it until I get it done.”
- “You just got to find a way to make it work. You don’t give up. Amateur radio has taught me that. Giving up or quitting is the easy way out—and I am not a quitter.”
- “In the middle of the night I wake up and I keep working on it. My thinker does not go to sleep somehow. I really want to get something to work. I really want to learn the things that I need to do to get something to work. That reward is really important to me.”
- “Well, success is good, but failure motivated me more.”

The challenge of using technology inherently brings about processes to address problematic situations that inevitably develop in the human-technology relationship. *Problem solving* and *Designing* are sub processes within Technological Immersion that exist as dynamics in the interplay of the successes and failures that result from attempting to surmount a challenge.

Social Networking. Technology and culture are innately social activities that are mirrored within the technical and social elements of *technological immersion learning*. *Social Networking* conceptualizes the interpersonal elements that stem from social connections within a cultural group that has shared interests, knowledge, skills, and experiences that set the group apart from the norm. The fraternity of the group extends to mutual respect, shared learning, mentoring, altruism, and a camaraderie that enables a fertile ground for learning and personal development. The substantive codes that make up Social Networking reflect the meaning of the category, such as feelings of *Belonging, Comradeship, Competition*, and the *Social Connection* that membership affords, with a sense of personal *Identity* that comes from being a member of the group. *Altruism* was also a strong characteristic within the group, with *Caring* and *Mentoring* exhibited among members and in *Public Service* extended to general society. *Social Networking* provides positive feedback to the doer and is supportive of all the other properties of *TILT*. The social aspects of the activities encountered in the study and conceptualized as *Social Networking* are exampled by participant comments below on the social nature of being a radio amateur:

- "The social aspect of radio really keeps me going at it. I like to make something so I that can have contact with people. Amateur radio for me is inclusive. It doesn't work unless you have got somebody with a tin can at the other end of the string. You need people. 'Can you give me a signal report please?' That's why I started out making this antenna, because it is the one that I will take to the 5th grade class demonstration. You need somebody to tell you how well you are making it to Kansas, or Florida, or Cuba. So, the social aspect of making the contact and possibly forming a new friendship is worth the effort. That to me is worth it all."
- "You meet so many great people in ham radio. It has been a blessing. Most of my friends I guess are ham radio operators, really. Most of them are nice guys. Love talking with them, visiting with them, go out and eat with them.... Like an extended family."
- "It is not just a hobby, it is an avocation and becomes like a way of life. Sort of like your vocation does."

Altruism was found to be a strong characteristic among the amateur radio community and well reflected in the tradition of mentoring newcomers. Mentoring is sufficiently important to the amateur radio community as to have its own unique word: *Elmering*. An Elmer is a more experienced peer who guides, teaches, or shares their expertise with another. The words mentor and Elmer are not exactly synonymous, as an Elmer is considered a peer—an equal, whereas the word mentor has no pretense of equality in power relations. The egalitarian nature of amateur radio is so central to the hobby that the use of the term Elmer tends to dominate over the more generic term, mentor. In the interest of clarity, the more recognizable term *Mentoring* was adopted in the analysis to promote understanding and clarifying the concept of shared learning in a community of practice.

The Technology Learning Center (2015) preserves a story of mentoring by a particular radio amateur who mentored young people in electronics with notable success. The story goes that radio amateur and electronics enthusiast Larry Lang was an engineer at Hewlett-Packard who mentored kids in his neighborhood—Steve Jobs among them. Jobs later spoke of the experience he and his friends had working alongside Mr. Lang, while building electronic kits:

- "It gave me a tremendous level of self-confidence, that through exploration and learning, one could understand seemingly very complex things in one's environment."

Jobs' statement is in concurrence with incidents observed throughout this study. The examples above illustrate the social nature of tribal knowledge and shared experience in a community of practice. The social connections and collective activities afforded within the *Social Networking* aspects of *TIL* provide avenues for personal growth and development through active engagement in a technological fraternity devoted to hands-on experimenting and learning.

Adventuring. *Adventuring* was an inherent constituent of the technological activities of the participants of this study and one of the most engaging aspects of *technological immersion learning*. An adventure is an exciting or unusual experience that moves the doer into unknown or unfamiliar situation that has an uncertain outcome and entails a certain element of risk. Active engagement, uncertainty, and surprise are essential elements of adventurous experiences, which can create physical and emotional excitement for the doer and can produce serendipitous results.

Adventuring is the abstraction of a number of substantive codes that were present to varying degrees in all the interviews. *Action at a Distance, Discovery, Exploration, Magic, Surprise,* and *Uncertainty* all captured aspects of adventurous experiences. As with all the properties of *TIL, Adventuring* has an engagement dimension whereby the doer is actively engaged in the doing and has a stake in the outcome. The success or failure of the activity depends critically upon a complex symbiosis of knowledge, skill, and the technological acumen of the doer to achieve the desired end. *Uncertainty* is inherent, success is not assured, and the unknown element of chance can present opportunity or impediment in the process. Success in the face of uncertainty and adversity provides affirmation to the doer and promotes a sense of personal agency and the power to act in the world.

The activities and experiences of the participants of this study contained an element of adventure, such as was conceptualized as *Action at a Distance*. In the most general sense, technology extends the power and range of action of our physical bodies to achieve some desired end. In the case of the radio amateurs of this study, the range of action was literally global, as their technological hobby enabled unfettered worldwide radio communications using only personal equipment and natural radio phenomena. The phenomenon of *Action at a Distance* was often casually described by the participants as *Magic*—not at all in the sense of supernatural, but of a feeling of wonderment. Rubin (1998) eloquently wrote of the magic of radio with the following passage:

> "I don't believe in magic, but I do know that sitting in my car in the middle of Mississippi and listening to a signal that has traveled more than a thousand miles, over nearly a dozen states, and came down into my car through a metal pole antenna and two paper-cone speakers, was as near to a magical experience as ever I am likely to have."

The participants spoke of their activities in words that reflected the diverse aspects of adventure, which could generate intellectual, emotional, or physical excitement, as well as feelings of uncertainty in the face of challenge and risk:

- “What followed was my first ever radio contact and the indescribable thrill of hearing my own call sign being sent back to me over the air. It was exciting and scary, with my heart pounding and my mind racing as I exchanged Morse signals with an operator in South Carolina. The first contact is a rite of passage and an unforgettable event for every radio amateur. I still remember those feelings very well and the memory has remained strong all these years. Even today, it is always a rush and gratifying to hear my own call sign coming back to me from another part of the world. This is part of the magic of radio that just never gets old."

- "I did not even have the chassis together, but I had to try it, and the first contact was with New Zealand! For almost 45 minutes 30-meters held up and the guy is telling me, it was daylight where he was, and he said, "I'm sitting under the grape arbor on my veranda and I can see the sheep and I can see our two Corgis", and he gave me the name of the two Corgis, and I'm having a glass of iced tea and that sort of thing.... And that was a rig that I had built with my own hands...and it worked. The first time. It is magic!"
- "I have always enjoyed talking with people in other parts of the world about their world. It is a way of being transported practically to a different country. It's like bang—set down in a room where you can talk face to face. It's always interesting when you get the QSL card back. You build an image of what you think the person looks like and they are always different on the card, if they have a picture of themselves on the card, than what you imaged in your mind. Learning from other cultures has been a learning experience."
- "Some of what we do can be a little risky. Working with high voltage, using sharp tools and hot irons, climbing and hanging from high places, taking radio equipment into some tough places... There is some risk there, but I love it."
- "It was hard to do what I did. It was hot and the rain had come in and got on my power supply, on my wiring and power strip. It was bucketing where the roof met the porch line and I said, "I'm going to die!", but I had to unplug it from the wall. So I pulled the plug, but this rainstorm came up where I was and all of a sudden it was bucketing. My car window was down and the rain got in my car and it was windy and the sand blew. Then it got hot! But, it was all worth it, and I would do it again too!"

Adventuring is the abstraction of all the foregoing experiences of the participants in the course of performing the hands-on, minds-on activities of their technological hobby. Adventuring tests the capabilities of the doer in uncertain situations where the knowledge, skill, and technical acumen of the doer make the difference between success and failure.

Affirmation. As implied by its central position and multiple interconnections to other properties shown in Figures 9 and 14, *Affirmation* is a pivotal element of *TILT*. *Affirmation* is a variable that conceptualizes all the positive attributes that can arise from action and experience, a continuum ranging from the most basic simple pleasure to the most positive life-affirming experience that are reminiscent of Nietzchean affirmation (Nietzsche, 1967). *Affirmation* conceptualizes all the positive feelings that are engendered by actions that we deem to be worth doing. All the properties of *technological immersion learning* can engender positive emotions, as was illustrated by many of the participant comments presented throughout this chapter. The potential for multiple sources of such positive feedback from a technological activity is a key feature of *TILT*.

Affirmation is the abstraction of a number of substantive codes that were present to varying degrees in all the interviews. *Accomplishment, Caring, Competition, Defining moments, Fascination, Pleasure, Reward, Recognition,* and *Success* were all low-level codes that were subsumed under the higher category of *Affirmation*. Emotional reinforcement was a feature of all these substantive codes and was considered a defining characteristic of *Affirmation*. In a sense, affirmations due to positive feedback are interpreted as positive self-affirmation, as emotions are involved in the interpretation. The following comments of the participants as to why they do what they do speak to the positive impetus engendered by their actions:

- “All the hours of experimenting and exploring fulfill something within me. I really do enjoy exploring new ideas and learning something new. The act of discovery is a real thrill!”
- "I am just so happy when I learn something new. If I had feathers, I could fly!"
- "I love building kits. That is how I learned what resistors are, what capacitors are. I learned that this part of the PCB board was a circuit and what that part will do and that it was connected to this next stage and the next stage. You could look at the diagram, the schematic, and you can see where the part is and say “Aha! D29 is the diode that I just installed. R3 is this one over here, up near the corner. I began to understand how direct current flows, because it follows all the little traces and they split off and go other places. That to me was just exciting!"
- “I made a code practice oscillator from a pair of germanium transistors in an astable multivibrator circuit and had taught myself to send code with a hand key. Hearing that clear audio tone coming from a collection of parts built on a terminal strip on a pine board was a huge rush for me and probably a defining moment in my life.”
- "When I heard my call sign coming back from the station on the other side of the Earth, sounding like it had traveled a million miles, it made it all worthwhile. All the work of building the antennas, all the scrapes, scratches and bruises, and the slap in the face by a briar was all okay, because I worked a new one on 160-meters. It was all worthwhile and I would do it again. We do all this, because we love it."

At times, *Affirmation* can come about in a tangible form that is the result of an action. Often the tangible form is a physical artifact, such as an award, a QSL card, or a physical object constructed by the doer. The following comments are example incidents of the idea that physical artifacts can provide affirmations and be a persistent reminder of a technological experience:

- “The A1-Operator award was a great surprise. It is an award that you can earn only by consistently being a good operator and you have to be nominated for the award. You can’t ask to be nominated, because that violates the code of ethics. You can only earn it over time and just be surprised when you receive the certificate in the mail from the ARRL. It was a landmark event for me.”
- “A QSL card is a souvenir from making a DX contact. It is a tangible result of a personal accomplishment. My QSL cards are only important to me, but I get a lot of satisfaction from them.”
- “I am constantly experimenting with antennas. All my antennas are homebrew and I get a lot of satisfaction from how well my station works. That tower in the back yard is a monument to amateur radio, but of course so is the room that is my office, lab, and ham shack. It’s a man cave!”

Pleasure and satisfaction are emotional responses to actions and experience. Physical artifacts that result from a technological activity can engender emotional responses that can be personally affirming and serve as a persistent reminder of the events and experience that went into the creation of the artifact. There were many incidents of this idea present in the data, but one particular seemingly unrelated incident stands out as a relevant example. During a site visit, the participant pointed to a wooden gun rack on the wall and said that he had made it as a project in a high school wood working class. He was still proud of it, even after forty years. The incident was reminiscent of an adage in the lore of Industrial Arts educators that what is important is not what the boy does to the wood, but what the wood does to the boy. Physical artifacts that can be persistent reminders of significant experiences and personal accomplishment are well represented as one of the products of technological activities.

Technological immersion within the amateur radio fraternity

One of the most difficult and daunting aspects of developing the theory of technological immersion learning was to account for the enormous range of the data. A successful theory derived from the experiences of the amateur radio community must account for a culture that is both highly diverse and highly variable, from participants whose engagement in the hobby range from essentially nil to those with a lifelong passion that is often terminated only by death. All seven properties of *TILT* have an engagement dimension that is variable along a continuum, all seven properties are interrelated, and all provide positive affirmative feedback to the participant as to the value of an action. This idea accounts for a wide range of experience and behaviors seen in the data and leads to a diversity of experience among the practitioners. Radio amateurs tend to be passionate about their technical pastime, with a degree of autonomy and curiosity that were common characteristics among the group. Most of the participants developed an interest in technical activities very early in life and had opportunities to pursue their budding interests. The substantive codes from the study reveal a number of characteristics that seemed to be common among the group, a fraternity whose members share a sense of *Identity*, *Belonging*, and *Social Connection*, all of which were prominent categories in the analysis. *Altruism* was also a notably strong characteristic among radio amateurs, with *Public Service* and *Mentoring* frequently encountered codes. Likewise, the pursuit of a pastime is a matter of *Personal Volition*—an act of will and often clustered with the *Caring, Curiosity, Engagement,* and *Empowerment* substantive codes throughout the study.

The complexity of technological activities in general and of amateur radio in particular naturally tends to produce stratification of experience that is a result of the volition of the practitioners. A study of a large number of observations over time suggests a number of specialized cases that are a vignette of the nature of being a radio amateur, as are discussed below.

Case 1: Burn-thru. There are individuals who have an initial interest in radio that was sufficient to motivate them to study the materials, pass the exams, and receive that first rite of passage affirmation of receiving their license and unique call sign. For all too many people, the process stops there and they never become further engaged in the technical culture of radio. They may never make their first radio contact or establish any personal connections within the social network. They may never actively experiment with technology or experience the adventure and challenge of the technical hobby. They never experience the multiple affirmations of positive feedback from engagement in *technological immersion learning* and, for these individuals, the causal loop of *Immersion* never becomes regenerative and interest is lost. These individuals eventually burn through their license period and when it expires, they may not renew their license. There are some disturbing suggestions that these individuals may be representative of a large fraction of new licensees and an incalculable loss to the hobby.

Case 2: Explorers. Radio amateurs tend to be autodidactic by nature and flourish from exploration afforded by *Immersion* in a technical culture. These individuals have learned to teach themselves and for them amateur radio can become a learning vehicle par excellence. These individuals are at the far end of the engagement continuum and pursue in a wide variety of activities, each with the potential for providing affirmation and contributing toward the development of self and self-esteem. Doing radio contains elements of adventure and speaks to the part of the human spirit that hungers to explore through the near miraculous extension of human abilities afforded by technology. Doing radio entails experimenting, with discoveries to be made, problems to be solved, challenges to be met, and an enormous amount of learning that is inherent in the experience. There is also the rich social element of radio that provides for the fraternity of like-minded souls and the altruistic opportunities for mentoring and for public service. It is a regenerative process and provides affirmation to the individual and rich opportunities for multidimensional learning, and feeding of the ongoing process of personal development and self-actualization.

Case 3: Islands. Not every individual becomes actively engaged in exploring the many possible diversions afforded by *technological immersion learning* in a community of practice. In the case of radio amateurs, radio is a diverse and complex field, with many subspecialties that capture and engage practitioners over a sustained period. For many, the affirmation provided by some specialties is sufficient to keep practitioners content in doing what they are doing, which may describe a sizable portion of the radio amateur population. The social element of using VHF FM on the 2-meter band for local communications and gathering around the barbecue at Field Day is sufficient for many and they may never engage in any other element of the culture. Similarly, the social element also explains the ad hoc groups who operate on the 75-meter band, frequent the same radio networks, and repeat the same contacts every day. The fraternity of the group is a powerful affirmation. There are also those individuals who live for the challenge of new DX contacts, operating on new bands, utilizing new emission modes, confronting new challenges, etc. There are also the experimenters who may only occasionally get on the air, but spend much of their time figuratively breathing pure oxygen in the pursuit of pushing the state of the art. There are also the contesters, who challenge themselves to develop their stations and operating skills to a very high level of proficiency. Altruism is also alive and well in amateur radio for individuals whose major activities are devoted to public service and to the hobby by helping others. *Technological Immersion Learning* is active within all of these specialties and can produce sustained engagement and learning for island practitioners, who may not venture beyond the comfortable confines of the local horizon.

Case 4: Island hopping. One of the distinctive hallmarks of *technological immersion learning* is its integrative character that encourages metaphorical island hopping. Every unique island discipline has its own specialized body of knowledge and distinctive subculture, with opportunities to explore and to learn, with the multiple affirmations of *Immersion* fully active for the practitioners. Still, island disciplines are subsets within a larger community of practice, with a social network that provides the ways and means for the sharing of knowledge and experience. Island disciplines are not truly isolated and share in the greater technical culture and stewardship of the domain. Ideas are shared, experiences are related, and aspirations may be born to explore a new budding interest that lies just over the island horizon. The social network of a technical culture can share the stories and create opportunities, but lighting the fire within is something that can only result from an act of personal volition. To achieve a budding ambition is an act of self-actualization: engaging in the exploration of a new interest, to be empowered from the experience and with multiple affirmations from the doing. Such feedback can be sufficiently strong to encourage more island hopping and further development in new areas of interest. Along the way is adventure and learning opportunities that touch so many bodies of knowledge: science, technology, engineering, mathematics, language, manual skill, art, geography, nature, and the human element of sharing in a community of kindred souls along the way.

Summary

This chapter has presented the *Technological Immersion Learning Theory,* a grounded theory derived from the experiences of an egalitarian social group that is devoted to experimentation and learning through technology. *TILT* conceptualizes a basic social process of *technological immersion learning* as a multi-stage learning process that occurs for people who are immersed in a technical culture that is devoted to hands-on minds-on interest-driven technological activities that provide multiple sources of feedback that promote affirmation and continued engagement in diverse learning opportunities in a persistent cycle of regeneration.

Chapter 5: Discussion

In accordance with grounded theory practice, this chapter situates a discussion of the study's findings in the context of the related bodies of literature (Christiansen, 2008; Glaser, 1992, 2001, 2002; Stern & Poor, 2011). One of the consequences of emergent research is that outcomes can be conceptually quite different from existing literature, a result that complicates literature review and restricts the scope of the comparison, due to some degree of incommensurability. The literature review was a comparison of concepts generated by the new theory with similar concepts identified in the literature of multiple fields. The comparison resulted in a broad synthesis of literature, with example works cited as representative of the larger field. In this chapter, the *Technological Immersion Learning Theory* (*TILT*) is discussed in relation to the literature in order to situate the study outcome within the body of prior research and assess its place within the main body of knowledge (Christiansen, 2011).

Contributions to knowledge

Grounded theory research offers a range of possible outcomes with respect to existing knowledge. Grounded theories can offer new insights on old problems, validate or challenge existing knowledge claims, or open new areas for study. All of these outcomes were found to be present in the study and are discussed in this chapter. The most important contributions to knowledge of this study relate to the following general areas:

- Learning theory
- Motivation theory
- Social network theory
- Praxis
- Methodology

Contributions to learning theory. This study offers a unique contribution involving technological activities as a basis for learning and skill development. The concept of technological immersion learning and its properties of *Adventuring*, *Affirmation*, *Doing technology*, *Experimenting*, *Overcoming Challenge*, *Self-teaching*, and *Social Networking*, transcend existing theories by illuminating the complex and amplifying nature of technological activities as a basis of learning and skill development.

Technological immersion learning is a new theoretical construct that was synthesized from the experiences of self-determined individuals who are absorbed in a culture of experimenting and learning through technological activities. The amateur radio fraternity at the focus of this study possesses a unique technical culture that highly regards knowledge, experience, skill, and achievement in a wide range of activities (Haring, 2007). Participants are constantly challenged to improve their own knowledge and skills in diverse aspects of the art, challenges that are facilitated by immersion in an interactive environment rich in shared experience and knowledge. The grounded theory method allowed their activities to be rendered as a densely integrated conceptual theory that is transcendent of people, place, and time. The resulting technological immersion theory of learning has implications for fields well removed from the theory's origins.

The new immersion learning theory finds similarity in kind with other instances of immersion learning activities in the literature. The first usage of the term immersion learning apparently originated in Quebec, Canada in the 1960s in a French as a second language initiative (Johnson & Swain, 1997). The term was adopted in the field of bilingual language studies to refer to the practice of learning a second language in public school through a class that is taught entirely or partly in the second language, i.e. total or partial immersion (Cohen, 1976; Cummins, 2008). Immersion approaches have been adopted in a number of disciplines, e.g., in business education (Antil & Kydd, 2008), in business management (Leavitt, 1991), in virtual reality computer simulations (Pimentel & Texeira, 1995), in 3D computer gaming (Brown & Cairns, 2004; Nacke & Lindle, 2008), in science education (Schunn, Millar, Lauffer, & SCALE Immersion Design Team, 2005), and in technology education (Mahalik, Doppelt, & Schuun, 2008). The grounded theory of technological immersion learning supports the general concept of immersion learning in complex interactive environments and contributes technological and engineering dimensions to the discourse.

The study findings contribute to a sparse field of technological learning theories and offers new constructs that highlight the nature of technological activities as a nexus of learning. Previous studies by Hill & Smith (1998) found that an exemplary project-based Technology Education classroom in Canada exhibited all the essential qualities of authentic learning (Bransford, et al., 1999) environments, later posited as a Theory of Authentic Learning for the field (Hill & Smith, 2005). The findings of the present study offer a parallel perspective in the form of an organic grounded theory that speaks to the unique nature of hands-on technological activities for promoting regenerative learning. The two theories differ in scope, with the Hill & Smith theory tailored to the classroom environment and *TILT* as an abstract grounded theory that is not bound to a particular context, but both provide useful theoretical frameworks for teaching and learning.

The study lends independent support to another empirically derived learning theory: the Dreyfus model of skill acquisition (S. E. Dreyfus & Dreyfus, 1980). The Dreyfus model was developed in the training of Air Force pilots, arguably an intensive technological activity that might itself be an example of immersion learning. The Dreyfus model ranks skill acquisition in five stages that were similar to those found during analysis of the empirical data of the present study. *TILT* illuminates a process by which expertise can progress from novice to expert as an amplified positive feedback loop. Each model illuminates aspects of the other and together they provide a more complete understanding of the development of expertise.

The finding of *Self-teaching* as a major attribute of technological immersion learning contributes to the discourse on informal and self-directed learning that has been ongoing for nearly a century, e.g. (Bouchard, 1993; Candy, 1991; Deci & Ryan, 1981; Gibbons, 1980; Knowles, 1971; Long, 1989). Self-teaching extends the concept of self-directed learning beyond the initial learning process to include the study of a domain of knowledge in order to gain desired knowledge, experience, and skill and to improve proficiency and performance in particular aspects of interest. *Self-teaching* encompasses a wide range of learning behaviors, including the autodidactic what, how, and when to learn, the mental and physical elements of training, and the experiential elements that can be learned in no other way. The study contributes an empirical grounded theory to the little charted field of autodidactism (Solomon, 2003).

Contributions to motivation theory. The focus of the study upon understanding the motives and concerns of individuals who are truly passionate about what they do contributes to the discourse on intrinsic motivation. Self-Determination Theory (Deci & Ryan, 1985) distinguished intrinsic motivation as “a natural wellspring of learning and achievement” that “can result in high-quality learning and creativity” (Ryan & Deci, 2000; Ryan & Stiller, 1991). The study findings support and extend the concept of intrinsic motivation with a distinctive empirical model that explains how multiple affirmations in regenerative feedback provide a mechanism for sustained engagement in technological activities.

The progressive development of interest in a subject is implicit in the multiple stages of *TIL* and, as such, contributes to the general discourse on interest theory (Hidi & Renninger, 2006). The multistage progression of *Induction*, *Immersion*, and *Maturation* in a continuum of regenerative techno-social development fostered by *TILT* is supportive of the 4-stage model of interest development posited by Hidi and Renninger (2006). *TILT* also augments the 4-stage interest model with the notion that interest development in a techno-social immersion context can be understood in terms of a regenerative feedback, which suggests an opportunity for further research in the field of interest theory.

Other constructs under the broad umbrella of motivation theory that were supported by the study findings include *Engagement*, *Empowerment*, and *Self-actualization*. These constructs were evidenced in the study data and, as discussed below, illuminate the deeper psychological basis of *TILT* and contribute a techno-social perspective to the discourse on these constructs as drivers of human behavior.

Engagement. The study findings contribute a techno-social perspective to the discourse on engagement. Engagement is a strong underlying property of *TIL* that embodies the state of active personal involvement and absorption in tasks undertaken for their positive physical, mental, and emotional attributes for the doer. As such, *TILT* lends support to the Kearsley and Shneiderman (1998) engagement theory of learning, in which pupils learn through collaboration in project-based activities that have an a meaningful and realistic focus. With respect to engagement in the workplace, *TILT* offers a conceptual synthesis that sustains Marcum’s (2016) assertion of engagement occurring, “when people undertake tasks related to their competence, learn continuously, immerse themselves and persist, because of the value they attribute to the work”. *TILT* extends the O’Brien and Toms (2008) rendering of engagement among computer users as, "a quality of user experience characterized by attributes of challenge, positive affect, endurability, aesthetic and sensory appeal, attention, feedback, variety/novelty, interactivity, and perceived use control”, all of which are aspects of *TILT* as a learning theory of human-technology interaction. The engagement literature broadly relates to the workplace, school, politics, and civic involvement, without consensus across disciplines. A common thread is engagement as a state actively undertaken by the individual, which is in striking contrast to a state brought about by motivation by an external actor, who utilizes rewards or coercion to entice others to achieve the motivator’s goal (Marcum, 2016).

Empowerment. The emergence of empowerment as a construct grounded in the study data adds an example of the construct that is in counterpoint to the dominant rhetoric of social activism in the empowerment literature. The lines of discourse on empowerment descend from Friere

(1970), who advocated empowering the masses through education. Indeed, much of the literature on empowerment relates to empowering the poor, the marginalized, and the dispossessed. However, empowerment is a complex construct and multiple definitions abound in diverse fields and contexts (Perkins & Zimmerman, 1995). For example, Rappaport (1981, 1984) defined empowerment as a construct that joins individual strengths and competencies, natural helping systems, and proactive behaviors to social policy and social change. Most conceptions of empowerment emphasize social process, interventions, and outcomes. In this study, empowerment was operationally defined as a process of gaining the ability to make something happen. The study findings present an empirically derived basis of empowerment, not in terms of social activism, but in terms of personal agency, volition, and power in the service of the basic social process of technological immersion learning.

Self-actualization. The study findings likewise expand the discourse on immersion activities beyond motivation theory and feedback into self-actualization, a concept coined by Goldstein and defined as “the tendency to actualize, as much as possible, individual capacities” (Goldstein, 1939, p. 46). Maslow popularized the construct in terms of “the desire for self-fulfillment” (Maslow, 1970, p. 383) on the esteem level of his hierarchy of human needs. Self-actualization emerged as an integrating concept late in the study, a fourth theoretical construct with the concept and its operational definition grounded in empirical data. The regenerative nature of technological immersion learning through multidimensional feedback is augmented by the self-reinforcing nature of self-actualization, as conceived by Maslow (1943, 1954, 1970), whereby a satisfied need for self-actualization motivates the desire to seek further self-actualization. Thus, the impetus for engagement in technological immersion activities can be understood in terms of the combined effect of two mutually reinforcing amplified causal loops. This effect is encompassed under the umbrella of multiple affirmation, a distinctive characteristics of *TILT* and one of the contributions of the field of motivation theory.

Flow theory. Among the serendipitous results of this study were findings unearthed in the complex interactions among the major variables in the data. The interactions of *Challenge* and *Skill level* illuminated developmental transitions in the data and uncovered a range of possible psychological and physiological stress responses for the subjects of the study, e.g. Figures 12 & 13. The upshot is that *TILT* accounts for a range of user stress responses that vary from boredom, to relaxation, to anxiety, to fear, as well as the optimal experience of flow (Csikszentmihalyi, 1990). The results of this study contribute an empirical example of how such responses can arise in connection with technological activities. In the literature, the overall range of stress reactions was summarized by Yerkes and Dodson (1908) and flow was characterized by Csikszentmihalyi (1990) as a state of deep absorption in an activity that is intrinsically enjoyable. Flow theory is based upon the symbiotic relationship of challenges and the skills necessary to meet the challenges (Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003). According to flow theory, flow occurs when skills and challenges are balanced, i.e. skills neither overmatched nor under-utilized. In addition, concentration, interest, and enjoyment of an activity must be experienced simultaneously in order for flow to occur (Csikszentmihalyi, 1997).

The flow experience was encountered in the course of this study, often as a personal experience while absorbed in the depths of doing grounded theory analysis. The flow criteria of simultaneous concentration, interest, and enjoyment (Csikszentmihalyi, 1997) were clearly present at those times, albeit only recognized in post flow reflection. Several probable instances of flow were observed among the study participants, while they were engaged with group activities. During the interviews, some participants reported becoming absorbed in an activity and being quite oblivious to the passage of time. These data were coded as *Time Dilation* in the analysis, but were later recognized as a manifestation of flow.

Flow experiences are intrinsically enjoyable and inspire individuals to replicate the experiences (Shernoff, et al., 2003) and, from the perspective of the individual, the flow state is a self-justifying experience and an end in itself (Nakamura & Csikszentmihalyi, 2009). One of the contributions of this study is understanding of the impetus to repeat flow experiences as arising in terms of an amplified causal loop driven by positive feedback, where flow experience provide personal affirmation as to the worthiness of doing the activity.

Contributions to social network theory. This research utilized Glaser's classic grounded theory method to study an egalitarian community of practice that has long been noted as a hotbed of technical innovation and altruistic public service (DeSoto, 1936; IARU, 2009; ITU, 2012). The multiple technical and social dimensions identified and abstracted in the formulation of *TILT* contribute to the consilience of the social nature of learning and contribute a techno-social dialectical perspective to the discourse on learning and social network theory.

The study findings support Lave and Wenger's (1991) concept of a community of practice as groups of people who share a common interest or passion for something they do and learn to do better as they interact regularly. The study findings also corroborate the notion that membership in a community of practice shares in a collective identity and a community competence relative to the domain of interest (Wenger, 1998). As a basis for learning, Bandura (1977) noted that people learn from each other by observation, imitation, and modeling and Lave and Wenger (1991) further argued that learning is situated, usually unintentional, and is embedded in activity, context, and culture. The social elements found in the study support of the social nature of learning and the importance of social interaction and collaboration, but the social elements were also found to exist in a dialectical relationship with all the other elements of technological immersion learning. Dialectics is an uncommon tradition in Western thought, but is possibly the most appropriate frame of reference for the study of human development (Glassman, 2000, p. 2; Roth & Lee, 2007). The techno-social-cultural-historical elements of *TILT* are interrelated, dynamic, and inherently embody inner contradictions, which contribute to the changing and the evolving nature of technological immersion learning. The alignment of *TILT* with the dialectic tradition and cultural-historical activity theory (Vygotsky, 1986) adds a heuristic technological perspective to the discourse on learning and social network theory.

Contributions to praxis. Although this research focused on a particular cultural group, the resulting grounded theory of technological immersion learning is abstract of people, place, and time. As such, *TILT* can potentially be relevant and useful to understand and inform praxis in a number of fields. Communities of practice devoted to particular domains of interest that have legions of passionate devotees may find little interest and nothing to gain from an academic theory that purports to explain the basis of their passions. However, where there is real interest as to the deeper motivations of how people come to be passionate about what they do, it may well be that *TILT* could be of value. Before treading into that sensitive area, I make a cautionary reference to the teachings of Lao-tse in the Tao Te Ching: "If I keep from imposing on people, they become themselves" (Rogers, 1980, p. 42). One of the tacit preconditions of *TILT* is the existence of space for autonomy and self-determination. These qualities cannot be commanded, but they are qualities that can be nurtured in environments that are conductive to igniting the passion to learn. The following discussion of *TILT* in relation to praxis begins with the origin in the radio amateur community and proceeds to education practice in several fields, with closing comments on contributions to informal education.

Amateur radio practice. The study outcome offers a substantive theory that may be useful in understanding the mechanisms that drive persistence in the complex hobby. Although there is over a century of literature devoted to the activity, social research involving the group has been sparse. The study contributes to the academic research that has included historical studies (Bartlett, 2007; DeSoto, 1936; Elser, 1981), sociological inquiry (Bowers, 1934; Haring, 2002, 2007; Harmer, 2001), and survey research (Hampton, 1959; McMahon, 1974; Smith, 1975). There is a range of literature devoted to the educational influences of the activity with respect to self-directed learning (Redding, 1997), engineering education (Anderson, 1991; Batchelder, Whites, & Gasper, 2004), Industrial Education (Kostenbauder, 1976; Tester, 1977), and activities in the science classroom (Knezek & Jones, 1990; Koser, 1975) and in middle school (Hollenbeck, 1997). Amateur radio aboard manned space missions has been maintained for two decades with NASA's Shuttle Amateur Radio Experiment (SAREX) (NASA, 1983) and the Amateur Radio on the International Space Station (ARISS) programs, with notable positive effects on student achievement (Palazzolo, 2006). Martin and Martin (2006) included amateur radio in a collection of 21st century best practices in Technology Education. This grounded theory research and the precursor pilot study (Coleman, 2009) contribute to the methodological diversity of research involving the amateur radio community. For radio amateurs themselves, *TILT* offers a lens for understanding the nature of what is for many a passionate life-long hobby that also has an uncertain future. Current anecdotal evidence suggests that the attrition rate among newly licensed beginners in the hobby is very high, a worrisome trend for the long-term viability of the group. From the *TILT* perspective, many newcomers enter the *Induction* phase, but never begin active *Immersion* activity. Without positive feedback and affirmation, the original interest may not persist and eventually flicker out, to the ultimate loss to the hobby. *TILT* provides a lens for understanding the fascinations of the complex hobby and offers insights on nurturing the next generation of radio amateurs.

Technology Education practice. The outcome of this study speaks to the inherent value of technological activities as a basis for inspiring learning. Technological immersion learning is supportive of the basic tenets of the field of technology education, where technological literacy (Dugger, 2001) is advocated as an element of a well-rounded education. Although the field tends to draw a distinction between technology *education* and technical *training*, the former relating to the development of lifelong human capability and the latter being geared to vocational task skills (Seemann, 2003), the true strength of the subject may lie in its real-world connections (Lewis, 1999). The notion that technology education ought to lead to multiple ends remains an essential element of Technology Education (Lewis, 2004), a position supported by the study outcomes. *TILT* makes no distinctions as to intent and supports pragmatic technological immersion learning, with the essential elements of active hands-on engagement in absorbing real-world activities. Active hands-on engagement is a hallmark of technological learning activities, the efficacy of which is well founded in the literature. For example, the results of the 2011 NAEP found that students whose teachers reported their classes doing hands-on projects almost every day scored higher on average than students whose teachers reported less frequent projects in class (National Center for Education Statistics, 2012, p. 10). *TILT* supports active learning through hands-on minds-on technological activities in a community of practice as a basic model for learning through technology.

The study presents a distinctive educational model that broadens the pedagogical umbrella encompassing problem solving, design, problem posing (Lewis, Petrina, & Hill, 1998), the technological method (Savage & Sterry, 1990), problem-based and project-based learning (both PBL), and situated learning (Lave & Wenger, 1991). The dialectical nature of *TILT* and the feedback mechanisms interconnecting its technical and social properties comprise an organic techno-social learning environment where regenerative learning can take place. Because technological immersion learning is inherently dialectical, all the constituent elements come into play and share an integrative relationship that contributes to a holistic worldview. Humans attempt to understand the world through activity (Leont'ev, 1978; Vygotsky, 1978), with the specific activity of concern in this research the process of technological immersion learning. Bound up in activity is that every one of its constituent components is culturally and historically contingent (Roth, 2012). The individual components cannot be isolated without consideration of all the supporting conditions. Activity is situated in a complex milieu that produces a dense web of experience that is unique to the individual and ever evolving. Individuals continually mold their fragments of experience into an organic whole (Glassman, 2000; Pepper, 1942) that is continually revised as contradictions inevitably arise in the process. Dialectical relationships are dynamic and embody their own inherent inner contradictions (Roth & Lee, 2007; Roth, Radford, & LaCroix, 2012). Contradictions are discordant with expectations—challenges, gaps, surprising events, or conflicting conditions that disturb the organic whole. Contradictions drive transformation and must be transcended to bring about a new organic whole (Pepper, 1942). Technological immersion learning is particularly well equipped for resolving contradictions, as *Overcoming challenge*, *Experimenting*, *Problem solving*, and *Designing* are major attributes of *TILT*. All of the above elements are nonlinear and challenge the prescriptive linear frameworks often posited for design and problem solving. The holistic nature of *TIL* is congenial to pragmatism and abductive inference, findings that are supportive of discovery, problem framing (Roth, 1995) and problem posing (Lewis, et al., 1998). The study outcomes support the Lave and Wenger (1991) contention that learning is situated, usually unintentional, and embedded in activity, context, and culture. The study findings further speak for the inherent worthiness of technological activities as a basis for transdisciplinary learning.

The study findings support the general concept of *immersion units* (Schunn, et al., 2005) as a classroom immersion activity in a school setting, where students do real science and design activities, interact with each other, analyze data, and present results. This concept parallels technological immersion learning, as both concepts support absorption in a real-life situation involving experimenting and learning through technological activities in situations that have real actions, outcomes, and consequences. Scope, time, and control are major contrasts between the two immersion concepts, as immersion units are pragmatically tailored to the time and space constraints of the classroom. Technological immersion learning imposes no constraints on scope, space, or time and the study results extend the concept of immersion learning with a regenerative learning process through technological activities.

Among the aims of education is to find ways to present course materials in such a manner that students not only gain knowledge, but also develop life-long self-directed learning and problem solving abilities. The outcomes of this study support that general aim, with a grounded theory that originated from within a community of passionate self-directed learners. Although *TILT* originated from outside the classroom, it seems likely that the theory may be amenable to transplant, given due care in preserving space for user autonomy and social interaction. To that end, the MUSIC model and MUSIC Inventory proposed by Jones (2009, 2015) are apropos, as they were developed for the express purpose of preparing motivating classroom interventions. All five elements of the MUSIC model: *EMpowerment*, *Usefulness*, *Success*, *Interest*, and *Caring* were found in the study and mirrored by codes and memos on *Empowerment*, *Utility*, *Affirmation*, *Fascination*, and *Caring*. Although *TILT* was empirically grounded in activities outside the classroom, there is no reason to believe that technological immersion learning is a figurative hothouse orchid that thrives only in an exotic environment. With due attention to MUSIC, it seems likely that *TILT* can present a supportive model for rich multidimensional learning through the study of technology.

Informal learning practice. The study findings offer corroborating evidence for the benefits of learning activities outside the traditional school setting. There is a growing recognition that out of school learning is beneficial for children and young adults (Resnick, 1987), an assertion that is well evidenced in the study data. The nature of formal and informal learning differ strikingly in character, with the emphasis of traditional schooling upon individual performance and evaluation, whereas learning outside the classroom tends to be social in nature and shared within group activities. The differences in *type* of learning is striking as well, with schooling favoring general knowledge and abstract concepts, whereas outside activities are situational and of intrinsic interest. *Relevance for living* is a major departure between the two scenes of learning. Graduates and employers alike lament that there is little of what students learn in school and university that is useful to their work and life (Roth & Van Eijck, 2010). However, learning transcends the artificial boundaries of the classroom and the tacit assumptions that abstract concepts actually matter with what happens in real life. Likewise, Roth and Van Eijck (2010, p. 1033) found theoretical frameworks unhelpful in their previous learning research and found it better to think of learning in terms of “heterogeneous, fluid engagement in ongoing but continually changing collective practices.” The dialectical nature of technological immersion learning supports the Roth and Van Eijck findings and accounts for the complex and evolving nature of social learning. The study evidences the value of informal learning activities and presents a grounded theory of learning for technological immersion learning environments.

Contributions to classic grounded theory methodology. This study contributed to the discourse on classic grounded theory with respect to methodology and to the research outcomes. This study utilized the full spectrum of classic grounded theory procedures, with adherence to the canons of constant comparison, theoretical sampling, and theoretical saturation. The focus was entirely upon the concerns and experiences of those being studied, with minimal preconception or assumptions of relevance. The result was a set of empirically grounded concepts and abstract theoretical propositions that work to explain a latent pattern of social behavior that fits the field of study, is relevant to the people being studied, works to explain the manner in which they act on their concerns, and is readily modifiable as new data becomes available. The result was a parsimonious set of empirically grounded concepts and theoretical constructs that yield a dense integrated theory with explanatory and predictive power that is abstract of people, place, and time.

The study results challenge the canons of typical qualitative research in that the goal was not accurate description or profuse detail, but transcending abstraction and conceptualization. The study also challenged reliance on computer software for coding and analyzing qualitative data in grounded theory analysis. Theorizing relies heavily on memoing and preconscious processing for abductive creation of new ideas, a process easily subsumed by over reliance on software.

The study results also contribute to CGT discourse by adding two examples that are uncommon in the grounded theory literature. Appendix A of this thesis offers an example of how a novice researcher came to grounded theory research only after a systematic process of pragmatic evaluation that ultimately identified classic grounded theory as the emergent methodology best suited to the research problem and to the researcher. As of this writing, this may be a unique contribution to the literature. Chapter 3 offers a detailed example of the analytical process of coding, conceptual emergence from empirical indicators, theoretical sampling, theoretical coding, and theoretical saturation to arrive at a substantive grounded theory. These two examples chronicle the path of a novice minus-mentoring in classic grounded theory research, presented in the hope of helping others who may be interested in the methodology.

Finally, this study offers American Pragmatism as a harmonizing influence for classic grounded theory research. As a philosophy of action, pragmatism collapses dichotomies and effectively repudiates the epistemological discourse that has engulfed qualitative research for decades. As explained in Appendix A, the confusion and frustration of deciphering the rhetorical quagmire that has surrounded qualitative research since Kuhn (1970) effectively evaporated with the adoption of American Pragmatism as a scientific method.

Summary of Contributions

Table 4 summarizes the contributions of this thesis with respect to theory, practice, and method. The table outlines areas that were supported by the study findings, areas to which new understanding was added, aspects that were challenged by the findings, and new contributions to knowledge resulting from this grounded theory study.

Table 4
Contributions to theory, praxis, and method

Adapted from Holton (2006)

Contributions	***Supported***	***Added***	***Challenged***	***New***
Learning theory	Immersion learning theories	Concept of technological immersion learning	Behaviorist stimulus-response theories	Grounded theory of technological immersion learning
	Authentic Learning, Hill & Smith (1998,2005)	Example of empirical grounding		Regenerative learning
	Dreyfus model, Dreyfus & Dreyfus (1980)	Understanding of skill development as regenerative learning		
	Self-directed Learning, e.g. Knowles (1971), Gibbons (1980), Long (1989)	Self-teaching as an attribute of *TILT*		
Motivation theory	Motivation and self-determination theory; Deci & Ryan (1985); Ryan & Stiller (1991)	Role of positive and negative feedback in learning through technology	Power asymmetry of external motivation	Grounded theory of technological immersion learnng
	Interest theory, Hidi & Renninger (2006)	Regenerative nature of interest development		
	Engagement theory, Kearsley & Shneiderman (1998)	*TILT* as conceptual synthesis	Coercion as motivation	
	Empowerment, Friere (1970); Rappaport (1981); Zimmerman (1990)	Empirical grounding of empowerment in *TIL*		
	Self-actualization concept, Goldstein (1939) and Maslow (1943)	Concept of multidimensional affirmation		Mutually reinforcing multiple feedback loops
	Flow theory Csikszentmihalyi (1990)	Flow experience as an amplified causal loop		Flow experience in technological activities

Adapted from Holton (2006)

Contributions	***Supported***	***Added***	**Challenged**	***New***
Social network theory	Communities of practice Wenger & Lave (1991); Wenger (1998)	Empirical support from GT research		Technological immersion learning theory
	Cultural-Historical Activity Theory Vygotsky & Leont'ev (1978)	Dialectics and CHAT in technological immersion learning theory	Reductionist perspectives	
Praxis	Amateur radio studies; Haring (2007); Harmer (2001); Redding (1997); Elser (1981); Tester (1977); Smith (1975)	Grounded theory research; islands of experience; island hopping; burn-thru, explorers		Technological immersion learning theory
	Technology education; STEM education	Technology as nexus of STEM	Hegemonic primacy of science and math in STEM	*TIL* as pragmatic inquiry
	Problem/Project Based Learning	Inherent pedagogical value of technological activities	Linear models of design and problem solving	
	MUSIC model of academic motivation (Jones, 2009, 2015)	Empirical support from GT research		
	Informal learning, (Resnick, 1987)	Transdisciplinary learning		
Method	Use of the full complement of CGT procedures to generate empirically grounded theory	Examples of concept emergence from indicators; progression of theoretical coding	Use of preconceived theoretical frameworks in GT research	Phenomenological narrative of GT novice minus-mentoring in CGT.
		American Pragmatism as a supporting perspective for CGT	Reliance on CAQDAS	Classic grounded theory as a flow experience.

Credibility of the theory

Classic grounded theory research is specifically devoted to the generation of conceptual theory. In contrast to more traditional research methods that use data in the service of hypothesis testing or accurate description, grounded theory utilizes a rigorous and systematic analytical process that generates an integrated set of conceptual hypotheses derived from empirical data (Glaser, 1998; Glaser & Holton, 2004). The sampling procedures of grounded theory research methodically aggregates incidents in data as conceptual indicators, in a manner somewhat similar to the aggregation of people in survey research (Glaser, 1998, p. 31). The procedures employed in grounded theory incorporate verification procedures to constantly ground developing concepts in data and continual conceptual modifications as new data arise (Glaser, 1998). The resulting grounded theory remains close to the data and accounts for much of the variation in behavior on the scene in as few categories and properties as possible. The end result is a parsimonious theory that is abstract of people, place and time that accounts for a pattern of behavior in the research (Glaser, 1992).

The complexity and multivariate nature of social phenomenon can result in complex and multivariate conceptual hypotheses that may not be amenable to isolation or reduction for verification by traditional verification procedures (Holton, 2006, p. 225). Thus, the credibility of the theory must be ascertained by other means. To that end, Glaser advocated fit, workability, relevance, and modifiability as hallmarks of credible GT research (Glaser, 1998; Glaser & Holton, 2004). The evaluation of a grounded theory is based on the theory's fit, workability, relevance, and constant modifiability with respect to reflecting the patterns of social behavior in the area being studied, particularly with regard to behavior related to the resolving of a main concern (Glaser, 1992, 1998).

The criterion of *fit* relates to the validity of the developed concepts with respect to the behavior being studied, i.e. the fidelity of concepts with respect to observed behavior. The study was conducted with rigorous adherence to classic grounded theory procedures, with all codes and concepts carefully developed from empirical data. The naming of all the concepts was done to closely fit and reflect the essence of the data and thus raise the level of abstraction.

The criterion of *work* refers to the ability of a grounded theory to interpret and explain the behavior in a substantive area and predict the course of future behavior. The rigorous adherence to CGT procedures and complete insistence on the emergence paradigm allowed *Experimenting* and *Self-teaching* to emerge as a main concern. The *Induction*, *Immersion*, and *Maturation* stages of the basic social process reflect the progression of the main concern, with the properties of *Adventuring, Affirmation, Doing Technology, Experimenting, Overcoming Challenge, Self-teaching,* and *Social Networking* densely evidenced in empirical data. Likewise, the amplifying causal loop theoretical structure of the theory works to explain the action on the scene and allows understanding of unexpected phenomenon, e.g. the example of the islands of experience that was described in Chapter 4. The theory works at the conceptual level in accounting for experiences in the research area, as well allowing for application of the theory in other fields.

The *relevance* of the theory refers to the emergence of a main concern from the experiences of those in the research area and the degree to which that main concern is reflected in the data supporting its significance. The main concern of experimenting and self-teaching was well evidenced in data and reflected in the emergent process of technological immersion learning, indicating a high degree of relevance to the action on the scene. Relevance was achieved by allowing the core problem and processes to emerge from the participant's accounts. All the concepts emerged from the analysis of data and continually compared for relevance to the experiences of those being studied.

Modifiability is an important criterion for a grounded theory. Modifiability is fundamental to the grounded theory method, as the concepts developed during analysis are continually modified in response to new data. Likewise, the completed grounded theory retains the characteristic of being modifiable to account for new data as it emerges. This continuing openness to being modified is a powerful feature of grounded theory. As conceptual level theory, grounded theory is an abstraction of the particulars from a substantive area, which means that the theory can be constantly modified as new data grounded in changing conditions generates new properties and dimensions to be integrated into the theory. The resultant theory stays alive and relevant through its ready modifiability (Holton, 2006, p. 227).

This study presents a theory of technological immersion learning that reflects the experiences of an egalitarian cultural group who are passionately engaged in the pursuit of their chosen technological activity. The theory works well to conceptualize how the group goes about doing what they do, but the theory is also abstract of people, place, and time and has a range of applicability beyond its origins. It is entirely feasible that the theory could be modified with new concepts, properties, or dimensions as new situations develop or as new data arise. The point of modifiability as a characteristic of grounded theory is that the theory remains alive and responsive to new situations that develop and culture evolves over time.

Limitations

The purpose of this research was to develop a substantive theory derived from an exemplary group of technologically sophisticated individuals, i.e. the amateur radio enthusiasts. The aim of the research was to discover what was going on in the field and the theory of technological immersion learning met that intent. The theory is an excellent fit for the social world in which it is grounded (Holton, 2006, p. 228), but no doubt could be refined through additional effort. Every grounded theory retains its dynamic nature and can be readily modified, enhanced, or extended through further theoretical sampling to identify new concepts, properties and dimensions that extend the conceptual scope and general implications of the theory (Glaser, 1998; Holton, 2006).

The primary limitations of this study rest with the lone researcher working in isolation without the benefits of a research team and constrained by time, finance, and experience. However, the inherent natural pacing (Glaser, 1996) of classic grounded theory was congenial to the study coexisting within a full-time engineering career and busy family life. The delayed action response of preconscious processing resulted in the analysis bubbling up as it needed to and the study steadily progressed amid the complexities of modern life. Time constraints significantly prolonged the study, but were not felt to have negatively impacted the development of the theory and may have actually aided the development by assuring ample time for theoretical saturation to occur. Despite these constraints, rigorous adherence to the tenets and procedures of classic grounded theory produced a parsimonious conceptual theory that transcends the original data and offers general implications with scope and depth beyond substantive field of origin.

Implications for future research

This study contributes to future research by suggesting potential areas for study and offers commentary with respect to methodology. A grounded theory is fundamentally an integrated set of hypotheses grounded in data, but transcends the origin to produce a conceptual theory of a substantive area. A grounded theory is abstract of people, place, and time and offers implications for praxis in other fields, as well as the potential for further development and modification or verification.

Potential areas for future research. Technological immersion learning speaks to the value of technological activities as a nexus of learning and personal development. Although the theory was derived from an exemplary group noted as a hotbed of technological innovation and altruism, the phenomenon of social groups devoted to particular technological activities would seem to be commonplace. For example, newcomers entering an area involving new technology may encounter a unique vocabulary, new concepts, materials, processes, techniques, skills, activities, both oral and written history, and a complex social network devoted to the practice. The foregoing is the *Induction* stage of *TILT*. Should the newcomer actively engage in technological activities that involve hands-on experimenting, self-teaching, and problem solving in the face of challenges, then technological immersion learning might well become an active process.

The situation outlined above encompasses quite a wide range of activities and suggests that *TILT* may be relevant in other venues that have nothing at all to do with the origins of the theory. During the development of the theory, several areas of interest appeared to relate well to *TIL* and suggest additional research opportunities. Amateur astronomy was a notable area, particularly the amateur telescope makers. The Maker movement in general appears to be involved in a form of technological immersion learning, as does flying private aircraft, and metal and wood shop work in general. I was also quite astonished to discover, quite by accident, that there is a subculture devoted to homemade turkey calls and *TILT* works quite well for understanding the experiences of those enthusiasts. The essential components are active hands-on engagement in technological activities that involve experimenting and self-teaching, and dynamic responses to meeting emerging challenges through problem solving skills. Whether theory provides a way of understanding activity in a substantive area is dependent upon the observer to determine the degree to which the theory fits, works, and is relevant for understanding the action on the scene. Modifying the theory in response to new data is also possible, as new concepts or dimensions emerge from a research situation.

Methodological considerations for future research. Ideally, research methods should suit the problem being studied, the questions being asked, and the answers that are being sought. All methodologies have their place in research, but where theory generation is the primary aim, I am in a position to comment on the experience of doing classic grounded theory research. I chose to structure this thesis in the spirit of a phenomenological narrative in order to capture the process and travails of coming to terms with a demanding, but highly rewarding methodology. The full set of classic grounded theory procedures went into this study, with the result being a dense conceptual theory that could not be foreseen at the outset. The methodology is powerful, but quite demanding of the researcher.

The importance of mentoring by accomplished grounded theorists cannot be overstated. In my case, local mentoring was not an option when I began the study, but the encyclopedic works of Glaser and that of the Grounded Theory Institute guided me on the path to learning Glaser's classic grounded theory. Workshops and seminars are now readily available through the Institute and highly recommended in the interest of shortening the learning curve and connecting novice researchers to the community of classic grounded theory researchers.

In situations where the emergence paradigm of Glaser's CGT is not appropriate, the choice of other versions of grounded theory can be justified (Christiansen, 2008). For instance, in cases where it is desirable to generate a theory about a specific behavior or process, it may be appropriate to review the literature and pre-frame the research in terms of an existing theory. In such cases, the Corbin-Strauss GT may be appropriate, or in stances where collaboration is desired, then Charmaz's constructivist GT can be used to advantage. Of course, where theory generation is not a research goal, the full range of research methodologies is available to meet research aims.

Epilogue

This study began as a survey of the intractable problems of public education in America, with particular note of the disturbing trends of high-stakes testing and unintended consequence of narrowing instruction to those subjects covered by standardized tests. Rather than studying the pathology of education in America, this grounded theory study of a contrasting example was undertaken as an *analysis of good* in the hopes of learning something from an exemplary case that could be useful in informing educational practice. The emergent *Technological Immersion Learning Theory* offers an empirical example of the potential of technological activities for creating highly interconnected techno-social environments that promote wide range transdisciplinary learning. Technology is the great integrator of human experience and transcends the artificial boundaries of academic disciplines. Rather than being just the 'T' in STEM, technology enables science, is the *raison d´être* for engineering, and, as Yasukawa (1998) pointed out, mathematics can itself be considered as a technology. Beyond the STEM disciplines, technology is intertwined with virtually every aspect of the human experience, spanning the gulf between the sciences and the humanities. In effect, the study of technology offers integrative general education for the modern technological world. *TILT* highlights the potential of rich and engaging learning environments for inspiration and learning.

In doing this classic grounded study, I have endeavored to make the research process as open and transparent as possible, with all due care in demarcating the significant events that ultimately led to the grounded theory of technological immersion learning. Still, understanding the merits of grounded theory research is found only in the usefulness of the resulting theory. Glaser and Strauss (1967) stated that the hallmarks of a successful grounded theory are that it *fits* the data of the substantive situation; it *works* to explain the action on the scene, and is *relevant* to the concerns of those involved. A grounded theory is also *modifiable* as new evidence is found in the continuation of the constant comparative method Glaser (1998). These criteria make sense for evaluating a grounded theory from the inside out by one who is close to the data. However, Juliet Corbin (2009), in a recent refinement of Straussian grounded theory, presented a more pragmatic and universal perspective on accessing the findings of grounded theory research:

> “Findings have a way of speaking for themselves. Findings either resonate, offer new insights, explore phenomena in depth, add to a knowledge base, and make you stand up and listen or they don’t.” (Corbin, 2009, p. 52).

Corbin’s insightful perspective captures the essence of grounded theory research and, speaking from the inside out as the researcher, I find that *TILT* is congenial to Corbin’s criteria. However, the “stand up and listen” criteria is something that only the reader can do for themselves. As researcher, I have found the theory to be helpful for understanding the techno-social world of radio amateurs, just as it should, but I also have found the theory to be a way of understanding my own life experiences in ways that have nothing at all to do with amateur radio. The theory has a range of applicability outside the context of its origins (Glaser, 1978, 1992, 1998; Glaser & Strauss, 1967), just as predicted, but where the theory may be applicable cannot be predicted with certainty. Only the reader can recognize whether the theory is useful in another context and provides understanding and useful insights.

The end result of this grounded theory research was the emergence of a *Technological Immersion Learning Theory* that illuminates the merits of technological activities as a nexus for learning. The idea that technological activities have exceptional value as a learning vehicle has long been the touchstone of a number of closely related fields that trace their lineage from the Manual Training movement after the American Civil War. In the long evolution from Manual Training, to Industrial Arts Education, then to Technology Education, and most recently as Technology and Engineering Education and Integrative STEM Education, the intrinsic value of technological activities as an element of general education has been a closely held tenet fundamental to the study of technology. However, that distinctive tenet had not been reflected in the literature of the field, which was markedly deficient in foundational research. That deficiency was the genesis of this dissertation. The *Theory of Technological Immersion Learning* provides at least a tentative suggestion that the basic tenet of the field may be valid. Further research is needed, as *TILT* did not originate from within the classroom, but from a study of an exemplary case of technology enthusiasts long noted for their technical and public service. The example presented by the radio amateurs hints at a connection between the study of technology and lifelong learning and development. This research is presented in the hopes of inspiring further study and development of effective learning environments for the modern technological world.

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26 January 2017

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Appendix A: Critical Path Methodology and Epistemology

Classic grounded theory is an uncommon and demanding methodology that was uniquely suited to this research project. Unfortunately, grounded theory research in general is also elusive and misunderstood by many (O'Reilly, Paper, & Marx, 2012), since the term *grounded theory* has become a nebulous label that is applied to a range of methods that have very different aims, principles, and procedures. The ground breaking method of Glaser and Strauss (1967) has been remodeled into multiple strains of the method, conflated with qualitative data analysis (QDA), and jargonized (Glaser, 2009) to the point that the term *grounded theory* is now thoroughly ambiguous. Charmaz (2006) observed that researchers have claimed grounded theory in cases that do not resemble even the most liberal definition of the method. Hood (2007) has likewise pointed out that much research purported as grounded theory actually utilizes a General Inductive Qualitative Model (GIQM) and few actual grounded theory studies properly use the "Troublesome Trinity" of constant comparison, theoretical sampling, and theoretical saturation. In the face of such confusion, this chapter presents the background necessary to explicate the methodological and epistemological choices made for the present study and to effectively lay bare the foundations of the research (Greckhamer & Koro-Ljungberg, 2005). The landscape of grounded theory is explored in this chapter, along with a discussion of the nature of theory generation by abductive inference. Classic grounded theory as scientific method is discussed, followed by a discussion of the epistemology of research and a reflection of the development of the researcher throughout the study. The intent of this phenomenological account is to render the study as transparent as possible, with full disclosure and candor in all its aspects.

Deconstructing grounded theory

Grounded theory is a research methodology that was developed for the express purpose of generating inductive theory from empirical data. The product of the collaboration of sociologists Barney Glaser and Anselm Strauss in their work with dying patients in the 1960's, the method is derived from the complementary backgrounds of its creators. Glaser's study of quantitative and qualitative mathematics under Lazerfeld at Columbia University, *explication de text* at the Sorbonne in Paris, and studying theory generation with Merton provided the quantitative core of grounded theory. Teaming with Strauss, who was trained in qualitative methods at the University of Chicago and studied symbolic interactionism under Blumer provided the opportunity to adapt the techniques to qualitative data. Although often classified as a qualitative method, grounded theory is actually a general method that can use both qualitative and quantitative data to produce conceptual theory (Glaser, 1998; Glaser & Holton, 2004; Glaser & Strauss, 1967; Strauss & Corbin, 1994).

Roots of grounded theory. The roots of grounded theory reside in the 1950's in the work of Paul F. Lazarsfeld on the methodology of quantitative studies and linkage of research results to theory. Lazarsfeld's initial emphasis was on correcting existing theories with reliable data, with later shifts to linking theory with research design, and eventually to theorizing directly from the data. The latter idea is the precursor to grounded theory, but remained undeveloped and in testing mode until Glaser and Strauss in the 1960's. Lazarsfeld developed many effective procedures for extracting hidden patterns in quantitative data, including many which are key to quantitative grounded theory today, but it was elaborational analysis and latent structure analysis that were expanded by Glaser and Strauss for use with qualitative data to produce abstract conceptualizations of categorical variables. The constant comparative method evolved in connection with the analysis of categorical variables and their properties to conceptualize latent patterns in qualitative data (Glaser, 2008; Lazarsfeld, 1993). The core process of grounded theory is the constant comparative method, which remains the essential common element in all the variants of grounded theory methodology

Variations in method. After the seminal collaboration of Glaser and Strauss in the 1960's, grounded theory bifurcated and evolved along different paths that stemmed from differing conceptualizations of the method by its two founders. Glaser continued to develop the original method that descended from Lazerfeld and Glaser at Columbia, while Strauss and Corbin developed a version of the method with different procedures and closely tied to the qualitative traditions of the Chicago school and the social theory of *symbolic interactionism*. The emphasis on symbolic interractionism is especially strong in Strauss' version of the method and into the variants of the method that were subsequently developed by his students, i.e., Charmaz and Clarke. Charmaz (2006) proposed a constructivist grounded theory method tied to the theoretical perspective of social constructivism and (Clarke, 2005) has put forth a method tied to post-modernist theoretical perspectives and situational and discourse analysis. These three differing conceptualizations of grounded theory by Strauss, Charmaz, and Clarke apparently favor the *a priori* attachment of particular theoretical perspectives and utilize procedures that differ significantly from that of the classic grounded theory method developed by Glaser.

Feminist grounded theory is a fifth variant of the method that emerged in the nursing profession, a field that has long used grounded theory in knowledge development relevant to practice. Feminist grounded theory was developed in the nursing field to ensure that women's voices were heard amid the androcentric bias in the research community (Wuest, 1995). Wuest (1995) overlayed feminist perspective upon grounded theory, without apparent preference for either the Glaserian or Straussian variants of the method. The emphasis of feminist grounded theory is that a perspective can be applied to research method as a sensitizing agent, without necessarily being a methodology in and of itself. Reinharz (1992, p. 241) affirms that feminist theory is itself not a research method, but is a perspective that can be applied to a traditional disciplinary method such that the demands of both the discipline and feminist scholarship are met. This distinction of perspective and method is useful and cautionary, as theoretical perspectives can be blinders as much as sensitizers and it is entirely up to the researcher to discern the difference.

These five variants of grounded theory are each suited to producing particular kinds of knowledge and each has its own ideology. There is no cookbook approach and, as with any research, the researcher has the responsibility to select the most appropriate methods for the goals of the research and to learn what is necessary to apply those methods correctly. This simple statement is not so simple for would-be grounded theory researchers working in isolation from expert training and mentoring. The literature claiming grounded theory is discordant from the variations of the method and with widespread claims for the use of grounded theory methods that actually have been applied only in part or claimed in name only. Making sense of the Gordian knot that is the literature of grounded theory is a formidable task for anyone aspiring to learn grounded theory methods and particularly so for aspiring researchers working in isolation.

Minus-mentoring in grounded theory. Grounded theory research is a difficult and complex undertaking that demands much of the researcher. The decision to engage in grounded theory must also be followed by the equally weighty decision as to which school of grounded theory is best suited to the inquiry and to the researcher. Neither decision is trivial. Grounded theory has a long and steep learning curve that can only be negotiated by actually doing a grounded theory research project, ideally with mentoring by an accomplished grounded theorist. The need for mentoring should not be underestimated and Stern (1994) cautioned on the difficulties of *minus-mentoring*, with the metaphor that, "it may be possible to learn brain surgery from a book, but it is far from usual. And brain surgery is easier!" (p. 219). Stern also cautioned against the hazards of inadequate mentoring by individuals who have never actually done grounded theory, a situation that may unwittingly contribute to the generational erosion of grounded theory (Stern, 1994, p. 216). For many would-be grounded theory researchers, minus mentoring may be the only viable option, as it was for this researcher. The onus is on the researcher to perform due diligence and make an informed decision as to which grounded theory method that best suited to the research and to the researcher.

The complexity of learning grounded theory from literature that is fragmented into multiple strains of the method and entangled with the rhetoric of epistemology, philosophy, and the discourse of power was daunting and frustrating for this researcher. Coming to grips with grounded theory studies that produced no theory, defaulted to thick description, imposed *a priori* frameworks upon the research and included arbitrary requirements, such as a minimum sample size or demanding that a theory be presentable graphically, and even claiming grounded theory in the name of hypothesis testing was torturous and genuinely perplexing. Faced with pervasive confusion in the literature and the paucity of helpful exemplars, I decided to revert to the original sources and do a pragmatic determination as to which GT method was best suited to both the research the researcher.

My initial study of grounded theory (GT) was the Strauss and Corbin (1990) text, *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*, which was purportedly oriented toward making GT accessible for beginners. The text seemed reasonably clear and I felt I understood the basic process, so I began experimenting with the method by using a qualitative data set from some earlier work. I began open coding of the extant text and gradually developed several score open codes, which were then grouped into similar categories in the initial stage of axial coding, a hallmark of Straussian grounded theory. It was when I began to apply the reflective coding matrix that I ran into difficulties with the Straussian coding paradigm. The reflective coding matrix and conditional coding guide are tools used to systematically explore the properties and dimensions of various categories. These tools purportedly give structured guidance to newcomers, by a methodical turn-over-every-stone approach in the hunt for properties and dimensions that *could* be in the data. I found the structure to be restrictive and cumbersome and after a while I could perceive an element of risk of coding for what *should be* in the data, rather than for what was *actually* in the data. I had read of the emergence versus forcing controversy between the originators of grounded theory and now had a personal appreciation of the issues.

It was at this point that I read the original sources, *Discovery of Grounded Theory* (Glaser & Strauss, 1967) and the follow-up *Theoretical Sensitivity* by Glaser (1978). As with the previous study of Straussian GT, my old data set gave me a pragmatic way of exploring classic grounded theory. Gradually, I discovered that the emergence paradigm of Glaserian GT was well suited to my research problem and to my personal sensibilities. I was sufficiently encouraged by classic grounded theory that I conducted a mixed methods pilot study (Coleman, 2009) to test the alignment of method, research, and researcher as preparation for my doctoral research. The alignment was quite good indeed and continued reading of many of the later works of Glaser (1995a, 1995b, 1998, 2001, 2005a, 2008) was convincing that classic grounded theory was a consistent and rigorous methodology that was an excellent fit for my doctoral research and my dispositions as a researcher.

In parallel with the study of classic grounded theory outlined above, I also studied the two postmodern variants of grounded theory proposed by Charmaz (1994, 2000, 2006) and Clarke (2005) and found that they did not align particularly well with my requirements. Although philosophical debates on recognized research designs and their theoretical underpinnings can exercise a formative influence upon researchers (Crotty, 1998, p. 14), for this researcher the purported epistemological distinctions of these postmodern variants of GT seemed more rhetorical than useful. Further, several technical aspects of the Charmaz and Clarke variants of GT conflicted with the fundamental mission of theory generation. For example, one of the principles of constructivist grounded theory is that the data be *co-constructed* in partnership between participants and researcher (Charmaz, 1994, 2000, 2006). This view is problematic on several fronts, one being what does one do with an extant data set? Another is the problem of collaboration when collaboration is not advisable. Collaboration makes sense for action research or where accurate description is a research goal, but theory generation often seeks to conceptualize the tacit knowledge and behaviors that are below the conscious level of the participants. To attempt collaboration with participants who have no appreciation for tacit knowledge or of conceptual theory generation would seem inadvisable. Similarly, Clarke's application of situational diagrams and discourse analysis to show the complexity of a situation is a toolset that seemed ill suited to a novice grounded theory researcher and contrary to theory generation in general. The goal of theory building is not to capture complexity and accurate description, but instead seeks simplicity through conceptualizations that transcend and abstract large swatches of complex behavior and makes it comprehensible. I have studied postmodernism and social constructivism and understand the precepts, but I ultimately concluded that neither of the postmodern variants of grounded theory was suited for my study, leaving Glaserian classic grounded theory as the emergent methodology of choice for my research

A dissection of theory and scientific method

The product of this doctoral research is a theory, a word that often conjures up grand associations such as Einstein's theory of relativity, Newton's theory of gravity, Darwin's theory of evolution, the Big Bang theory of modern astrophysics, or perhaps the theory of quantum electrodynamics, QED. These are formal scientific theories that have great explanatory power, comprehensively dovetail with existing knowledge, and explain and reasonably predict the behavior of the natural world. On the opposite end of the continuum of meanings is a more casual usage of the word 'theory' that is tentative and hypothetical, such as "The grass is wet, so it must have rained today." Both usages help us to understand the natural world and explain observed phenomena, but one derives from scientific method and is durable over time, while the other is a conjectural untested hypothesis that may persist only until proven false. A more precise definition of theory is in order to better understand the nature of theory.

The nature of theory. Keppel, Saufley, and Tokunaga (1992) characterized theory as a set of propositions which summarize, organize, and explain a variety of known facts and provides a logical framework for the generation of new tests and ideas on a topic. This definition is consistent with the grand formal theories of the natural sciences, as well as the more modest middle range theories that comprise the vast middle ground on the continuum of theory. Among the more effective theories across the continuum of theories are the grounded theories that are derived from empirical data and effectively conceptualize and explain the phenomena in a particular substantive area. Theories are a way of understanding empirical experience and help to develop a working understanding of reality and life.

Theory is central to the research enterprise. Deductive methods test theory by evaluating the testable predictions of a theory. Deductive methods dominate both the natural and social sciences, whereby the researcher studies a phenomenon of interest and poses a specific research question relating to an existing theory that may be able to answer the research question. The researcher poses a testable hypothesis based upon the theory, collects data in order to test the hypothesis, and performs various statistical analyses upon the data in an attempt to falsify the hypothesis. The result of a successful deductive study is a statement of statistical significance that the hypothesis was not disproved—not that the hypothesis was true, but just that it was not proven false and thus the study adds a bit more evidence that the hypothesis may actually be true. The entire deductive process requires that the researcher enter the study with *a priori* theoretical assumptions and make a prediction as to what will happen in the end—all before the first piece of data is gathered. Deductive methods test hypotheses that are derived from theory, but do not *create* theory. The creation of theory requires a different methodology.

In situations where existing theory is inadequate to explain a particular phenomenon, inductive methods are used to develop new theoretical perspectives. In contrast to deductive research wherein the researcher proceeds from the general and narrows to the specific, i.e. from theory to data, inductive methods invert the procedure, begin with the specific, and move to the general, i.e. from specific observational data to generalizations that constitute a new theory that accounts for the observed phenomena. Thus, the results follow from the data, rather than data being used in the service of testing a theory. The inductive process is the essence of the physical sciences, where observations of nature drive the development and refinement of theory. In the social sciences, grounded theory is purported to be an inductive methodology that begins with observations of the social phenomena, identifies latent patterns that are implicit in the data, and ultimately produces a conceptual theory that accounts for the observations. An important question relating to theory that is often unasked or goes unanswered is a fundamental one: how does a new theory come about? What are the mechanisms by which new ideas arise to become new theory? These epistemological questions are at the heart of understanding inductive methodologies and the creation of new ideas. To that end, an epistemology of scientific inquiry that was developed by Charles Sanders Peirce, the founder of American Pragmatism, provides a useful model for understanding the creation of new knowledge, a subject entirely relevant to doing grounded theory research.

Abductive inference and the creation of new ideas. The mechanisms by which new ideas arise are a bit mysterious and deeply intrinsic to the machinations of the creative human mind. To a great degree, creativity appears to be nonlinear and non-algorithmic, with much in keeping with the *Gestalt* model of discovery (Magnani, 2002). Creating something new, such as a hypothesis or concept, sometimes happens instantaneously, as with the blinding flash of insight of the Zen experience of *satori*. Other times the process may be more overtly comparative, as the sense-making engine of the human mind processes our perceptions and seeks order and understanding to the point of constructing mental structures and models to order and explain what we perceive. Charles Sanders Peirce called this creative process *abduction* and described it as the "first stage" of scientific inquiries (Peirce, 1978d, pp. 320-321). Understanding the nature of abductive inference is one of the fundamental problems in human cognition and indeed has been called the fundamental problem of contemporary epistemology (Hintikka, 1998).

Peirce initially introduced the concept of abduction into the study of logic in the late 19th century to mean the selection of a hypothesis to explain an observation, but later elaborated the concept to mean the creation of a new idea or hypothesis to explain an unexpected or surprising new fact. Peirce also referred to this concept as retroductive reasoning (Peirce, 1978a, pp. 30-31), described as a type of backward inference that proceeds from the consequent to the antecedent. Such backward reasoning is not a valid form of inference from the standpoint of formal logic, but rather one that provides a tentative hypothesis that something may be true from the pragmatic standards of plausibility and human imagination. Peirce argued that abduction is a distinct form of inference that can be stated as a definite logical form: "The surprising fact, C, is observed; But if A were true, C would be a matter of course, Hence, there is reason to suspect that A is true" (Peirce, 1978c, p. 117).

Perspective on the role of abductive reasoning in theory generation may be found Peirce's model of scientific inquiry, which describes a cycle of inquiry that consists of three phases of thought: abduction, deduction, and induction (Peirce, 1978b, pp. 273-507). Each type of inference has a distinct role in this epistemology, with the cycle beginning with an unexpected or unexplained phenomenon, observation, or anomalous fact that does not fit with current understanding. The dissonance of expectation versus fact initiates a search for a hypothesis or conceptualization that would best account for the unexpected fact. The formation of a tentative hypothesis is the role of abductive inference, which can draw upon all resources of human memory, experience, and imagination to formulate a plausible hypothesis, a hunch or guess which explains the unexpected fact and fits with other existing knowledge. New ideas and conceptualizations arise from abduction and Peirce emphasized that, of the three ways of knowing, it is only abduction that creates any new knowledge (Peirce, 1978b, pp. 496-497). Abductive reasoning produces tentative hypotheses that may explain new facts and promotes those hypotheses best considered to be pursuit worthy and testable by experiment using the deductive and inductive modes of thought (McKaughan, 2008). The plausibility of a hypothesis is determined by testing its ability to explain and predict what is happening in a particular situation, beginning by deducing the necessary consequences of the hypothesis. By deduction, the properties and consequences of the hypothesis can be determined, i.e. "given that A and B are true, then C must be true." Induction can then be used to test the predictions of the hypothesis against empirical reality. The term *test* in this case is not used in the narrow sense of quantitative testing, but in the broader sense of the coherence of all that is known, i.e. the axioms, hypotheses, predictions, and observations support the observed reality. Thus it is possible to evaluate the plausibility of the hypothesis and either accept it, reject it, or subject it to modification. The sequence is summarized below.

1. Abduction: Formulate a tentative hypothesis that may explain an unexpected new fact or anomaly, with no consideration of validity or probability, only that the hypothesis is worthy of consideration.

2. Deduction: Given the hypothesis, deduce the testable consequences of the hypothesis, i.e. given that if A and B are true, then C must also be true.

3. Induction: Test the coherence of the predictions of the tentative hypothesis against observations of empirical reality. The prediction C is observed to be true, therefore the hypothesis *may* be true. Note that induction allows that the conclusion may be false, even if all the givens are true.

The result of induction can be that a new idea works for the current context, that an old idea works in a new context, or that an old idea continues to work in an old context. Induction tests extant mental constructs and models for fit and coherence with empirical experience.

The above sequence is Peirce's logic of science and it provides a useful epistemology that clarifies the creation of new ideas and the role of abduction in the cycle of scientific inquiry. New ideas may originate with a flash of abductive insight, but such ideas only become accepted and useful when they are shown to fit with experience. Deduction can be used to advantage to work out relationships of a new idea with extant knowledge, but it is the inductive correlation with experiential reality that is the core of the sense-making engine of humans—and of the grounded theory method.

Grounded Theory as scientific method. Grounded theory has been widely characterized as an inductive methodology, with the constant comparative method noted in all the variants of the method, e.g. Annelles, (1996), Charmaz, (2000), Christiansen, (2008), Clarke (2005), Cooney, (2011), Corbin & Strauss, (1990), Dey, (1999), Dick, (2005), Glaser (1965, 1978, 1992), Glaser & Strauss (1967), Haig, (1995), Locke, (2001), Simmons, (2013), Stern, (1994), Stern & Poor, (2011), Strauss & Corbin, (1990), and Wuest, (1995). Although Glaser and Strauss promoted the inductive nature of grounded theory and elaborated at length on the mechanics of the constant comparative method (Glaser & Strauss, 1967), the cognitive mechanism by which new ideas arise was effectively submerged in the metaphor of emergence. Peirce's concept of abductive inference lifts the veil on emergence and provides the means for understanding how new ideas arise in grounded theory research. Likewise, Peirce's epistemology of science provides a useful model for understanding the deeper essence of the constant comparative method and how abduction, deduction, and induction operate together in the creation of new knowledge.

Glaser and Strauss (1967) did not mention abductive inference in their seminal development of the grounded theory method, although Strauss did reference Peirce in a later work (Strauss, 1987, p. 12) and noted the role of abduction in research operations at least once (Charmaz, 2014). After languishing for decades after Peirce, the scholarship of abduction has blossomed into a major topic of inquiry in social research, e.g. Strauss (1987), Shank (1987, 1998), Kapitan (1992), Haig (1995), Hintikka (1998), Nesher (2001), Magnani (2002), Richardson & Kramer (2006), Bryant (2009), Campos (2009), Reichertz (2010), Wirth (2010), and Timmermans & Tavory (2012). One upshot of this abductive turn (Bryant, 2009) in social research is a de facto response to the thirty years of torturous epistemological debate that has surrounded grounded theory in the postmodern era since Kuhn (1970). Abductive inference, Peirce's epistemology of science, and American Pragmatism illuminate some less than obvious aspects of grounded theory that were unelaborated in the mechanics of the method and obscured by metaphor and the dense grounded theory lexicon.

Both Glaser and Strauss classified grounded theory as a *general method* of scientific inquiry that produces a set of conceptual hypotheses that are systematically generated from data and integrated into an inductive theory for understanding social phenomena (Glaser, 1978, 1992; Glaser & Holton, 2004; Glaser & Strauss, 1967; Strauss & Corbin, 1994). Rather than being strictly a qualitative method, grounded theory works with any data (Glaser, 1998; Glaser & Holton, 2004), although qualitative data remains far and away the most popular among researchers. The well-known Glaserism of *All Is Data* (Glaser, 1998, pg. 8) finds a metaphorical doppelganger in Peirce's logic of science, which allows that the full range of human faculties, knowledge, experience, intuition, and imagination can spark a creative insight that can then be examined by deduction and tested by induction against all that is known (Peirce, 1978b). Peirce's epistemology is quite compatible with grounded theory and provides useful insight on the creation of new ideas. Grounded theory procedures provide a rigorous and methodical analytic environment where abduction, deduction, and induction operate together in the service of conceptualization. Surprising facts can make new connections in the *all is data* gestalt and inspire insight and ideas that can be analytically compared with data. Induction cannot create new ideas, but rather correlates and tests ideas against empirical reality. The *raison d´être* of grounded theory is conceptualization (Glaser, 1965, 1978, 1992, 1994, 1995a, 1995b, 1996, 1998, 2001, 2002, 2005a, 2005b, 2007, 2008, 2009; Glaser & Holton, 2004, 2007; Glaser & Strauss, 1967). The test by induction is to determine if new concepts work in a particular context, if old concepts work in a new context, or if old concepts continue to work in the original contexts and are still useful. Grounded theory concepts are not mere conjecture, but are rigorously developed abstractions that are deeply grounded in the data and continually tested by induction for relevance and fidelity to the phenomenon under study.

The grounded theory method provides the procedural tools for theory development, but the *theoretical sensitivity* of the researcher is a personal element that is critical to success. Theoretical sensitivity was introduced as a concept by Glaser and Strauss (1967) in their seminal work and initially characterized as the ability to have conceptual ideas and make something of them, later elaborated as the essential ability of the researcher to generate concepts from data and to relate them through theoretical models (Glaser, 1978, 1998; Glaser & Holton, 2004). The development of a researcher's theoretical sensitivity and the ability to theorize are among the most difficult challenges of learning and doing grounded theory. Here again, the ideas of Peirce provide a useful perspective, since the ability to connect knowledge in new ways entails abductive inference—a creative act that produces new hypotheses in response to unexpected evidence (Peirce, 1978b). The researcher's theoretical sensitivity and the concept of *all is data* are intertwined with the capacity for abductive reasoning. Abduction does not happen in a vacuum, but is the product of researcher's entire repertoire of knowledge and experience made manifest through intuition, creativity, and logic. Strauss and Corbin (1998) elaborated on the elements of theoretical sensitivity and noted personal experience, professional experience, personal knowledge of the literature, and analytic rigor as being important elements. The development of theoretical sensitivity is an important concern that is addressed by wide reading in other fields, a tactic recommended by Glaser (1978), Glaser & Strauss (1967), Stern & Poor (2011), and Strauss & Corbin (1990) for promoting the development of theoretical sensitivity.

The genesis of the present study itself actually has a decidedly Peircian air about it. The notion of unexpected or surprising facts was how this study began, with a surprising event on a Florida beach and a subsequent search for understanding of the nature of the highly accomplished amateur science and technology enthusiasts. The inspiration to use the grounded theory methodology to resolve the research problem was itself an abductive insight that occurred after most of the usual research methodologies were evaluated and rejected as inadequate to the task. While the thread of logic sketched earlier in the thesis outlines the methodological choices made for this study, the verification of the efficacy of grounded theory as the method was the result of an inductive process that took place over several years and was cinched by the mixed-methods pilot study (Coleman, 2009) that was the precursor of the present study. Those experiences, along with the epistemological thought that went into the conceptualization of this study, all indicated a high order of compatibility between the empirical observations of the group and the potential for theoretical synthesis promoted by the classic grounded theory method.

Classical American Pragmatism as a theoretical perspective

In this postmodern postpositivist era of research, (Creswell, 1998; Lincoln & Guba, 1985) researchers are now obliged to consider and acknowledge the theoretical perspectives employed in their research. The following is intended meet that obligation, but in writing these reflections I have also tried to be mindful of Becker's admonition that a lot of time is wasted with *a priori* metaphysics of research that has little or nothing to do with what researchers actually do (Becker, 1996). Equally apropos is Glaser's observation that, "Epistemological discussions are of no potential help to the actual doing of research. Rather, they can easily have the negative effects of sowing doubt in the emergence of categories and causing premature judgments of relevance" (Glaser, 2005b, pp. 1-2). Becker and Glaser comments were helpful for this researcher, as was Peirce's pragmatist maxim of clarifying ideas by reduction to their practical consequences (Peirce, 1978c, p. 258). With those admonitions in mind, the following reflections are intended to clarify the nature of classical pragmatism as a theoretical framework employed in this grounded theory research.

Pragmatism is a viable alternative to positivist and anti-positivist schools of thought in the research enterprise. In particular, pragmatism dissolves the dichotomy between positivist and anti-positivist thought and shares some concerns from both perspectives, while objecting to postmodern relativist and idealist positions (Goldkuhl, 2004). Pragmatism collapses most dualities and dichotomies and eschews unproductive philosophical debate. Of the many forms of pragmatism that evolved in the past century, the classical American pragmatism of Peirce, James, and Dewey was most helpful as a theoretical framework for grounding this grounded theory study.

Classical American pragmatism is a practical problem-solving philosophy that places experience as the central concern in experimentally resolving problematic situations. The intellectual foundations of pragmatism are somewhat obscure, but traceable through Peirce to a diverse group of thinkers at an informal Metaphysical Club at Cambridge in about 1870 (Wiener, 1946). Charles Sanders Peirce first annunciated the principles of pragmatism in a series of articles in Popular Science Monthly (Peirce, 1877, 1878a, 1878b, 1878c, 1878d, 1878e) and went on to systematically develop a philosophy of science with a formal logic of inquiry at its core (Shields, 1998). The writings of Peirce went largely unnoticed until William James popularized pragmatism as a philosophy (James, 1897, 1907, 1909) and promoted the idea of concepts and theories as instruments or tools for inquiry and understanding. For James, theories were "instruments, not answers to enigmas" (James, 1907). John Dewey subsequently built on the foundations of Peirce, furthered the development of instrumentalist theory of knowledge, and applied it to a range of social and cultural problems. Dewey described pragmatism in general as the systematic exploration of "the logic and ethics of scientific inquiry" (Dewey, 1929, p. 10) and explicitly labeled his naturalistic pragmatism as instrumentalism (Dewey, 1925).

Classical American pragmatism is a deep and complex philosophy that is difficult to summarize and easy to misinterpret (Shields, 2008). However, understanding the basic tenets of pragmatism is aided by a simple and useful framework developed by philosopher and psychiatrist David H. Brendel (2006), who classified the tenets of pragmatism by the 4-Ps: *practical, pluralistic, participatory,* and *provisional* (Shields, 2008). The 4-P's are not mutually exclusive categories, but serve to broadly conceptualize the tenets of classical pragmatism. Brendel's 4-P framework is used to structure the following brief outline of pragmatic inquiry.

Practical. Classical pragmatism is a problem solving theory of inquiry that embraces the practical "world of concrete experience...multitudinous beyond imagination, tangled, muddy, painful, and perplexed" (James, 1907, p. 21). Pragmatism emphasizes experimental inquiry in the pursuit of resolving a *problematic situation.* The focus of pragmatic inquiry is on the problematic situation and most of the tenets of pragmatism make little sense outside of that context (Shields, 1998). Peirce maintained that productive inquiry must be grounded in practical reality and that pragmatism itself was "nothing else than the logic of abduction" (Turrisi, 1987, p. 282). The *pragmatist maxim* was an essential rule for clarifying ideas for both Peirce and James and often considered to be the core of classical pragmatism. Peirce's canonical statement of the pragmatist principle in *How to Make our Ideas Clear* was:

> Consider what effects, which might conceivably have practical bearing, we conceive the object of our conception to have. Then, our conception of those effects is the whole of our conception of the object (Peirce, 1878c).

The pragmatist maxim allows ideas and hypotheses to be evaluated by reduction to their practical consequences with respect to the problematic situation. Hypotheses, ideas, and questions with no practical consequences are considered void. Likewise, the instrumentalist use of concepts and theory as tools for problem solving dispenses with rhetoric and arguments that reduce to distinctions without differences and distinctions with no practical consequences as unproductive and null.

Pluralistic. One of the strengths of classical pragmatism is that it approaches practical inquiry from a pluralistic transdisciplinary perspective. The complexity and diversity of human experience is inherent in the fabric of the problematic situation and pragmatic scientific inquiry benefits from the diversity. James (1907) used the metaphor of a hotel corridor to illustrate the pluralistic nature of pragmatism. Pragmatism resides in the midst of theories like a hotel corridor. All the rooms, i.e. theories, open into the corridor and all the rooms can be entered. The pragmatist owns the problem and the hotel corridor and can freely move from room to room, selecting and testing theories for their usefulness in resolving the problem. Multiple realities and views are entirely allowable, with all subject to reduction to their practical consequences, their value solely related to how they work in practice (Shields, 1993).

James and Dewey developed classical pragmatism as a comprehensive philosophy that embraces all five branches of philosophy, with metaphysics, epistemology, logic, ethics, and aesthetics (Shields, 1993). Positivist inquiry relying on measurement and verification methods focuses only on epistemology and logic, with no consideration of metaphysics, ethics, or aesthetics as valid domains of knowledge. In contrast, pragmatism places literature and the arts on the same footing as scientific inquiry (Rorty, 1982, p. 31). The pluralistic nature of pragmatic inquiry restores a measure of balance to Western thought that is disproportionately dominated by science and technology by making a space for ethics and aesthetics. For this researcher, pragmatism's accommodation of ethics and morality also makes space for the ancient concept of *phronesis*, a concept descended from the Greeks, but never incorporated into Western thought. Aristotle wrote of the intellectual virtues of *phronesis*, *episteme,* and *technē* in *The Nicomachean Ethics* and extolled *phronesis* as the most important of the three. The etymology of the words is instructive, as the latter words, *episteme* and *technē*, are recognizable as the root words of the modern terms epistemology and technology, whereas *phronesis* is not the root of any modern word, nor is there as modern equivalent for it. *Phronesis* is related to ethics and prudence, but with a specific deeper meaning. *Phronesis* is a practical wisdom that, according to Aristotle, is of a "true state, reasoned, and capable of action with regard to things that are good or bad for man" (Aristotle, trans. 1976; Flyvbjerg, 1993, 2007). *Phronesis* is an ethical study of values that considers the ramifications of what we do in the world—not just the "*can we?"* but also the "*should we?"*, both important pragmatic ethical and moral concerns for the modern world.

Participatory. The concept of the "community of inquiry" is a fundamental notion in the philosophy of classical pragmatism (Shields, 1999). Scientific inquiry is fundamentally a social enterprise and indeed, "what distinguishes it from all other methods of inquiry is its coöperative or public character" (Buchler, 1955, p. x). Peirce originally conceived of pragmatism as a philosophy of science with a formal logic of inquiry at its core. James (1907) and Dewey (1938) subsequently built upon Peirce's original inquiry model and applied pragmatism to a wide range of social problems. Dewey and Addams emphasized the community aspect of inquiry and democratic ideals for resolving social problems (Addams, 1930; Dewey, 1916, 1927). Those individuals who are directly involved in a problematic situation are best placed to understand and understand the problems—not just the experts. As Dewey noted, a shoemaker may know how to repair a shoe, but only the wearer knows where it pinches (Dewey, 1927, p. 207).

The participatory nature of pragmatism can be illustrated by the Buddhist parable of the blind men and the elephant. Shields (1999, 2004, 2008) used the parable to demonstrate the three principles of a community of inquiry: the problematic situation, scientific attitude, and participatory democracy. The story begins with three blind men separately encountering an elephant for the first time, each facing the problematic situation of figuring out the nature of the new object. Each man's perception of the elephant as a tree (leg), wall (side), or rope (trunk) is incorrect, with the insight of the proverb implying that the three blind men were unable to go beyond their limited perceptions. However, three blind pragmatists using the ideas of Dewey would return to engage and explore the empirical reality and communicate with each other as they touch, feel, smell, taste, listen, measure, compare, contrast, hypothesize, conceptualize, argue, and experiment in a pragmatic egalitarian community of inquiry to understand the problematic situation of elephant. Over time, the pragmatists would learn a great deal about the new space-time object called elephant, developing and refining their conceptualizations that are grounded in empirical experience. Our perceptions may be limited and complete understanding may be impossible, but collaboratively combining the diversity of human experiences in a process of scientific inquiry is a chance of progressively better knowing the elephant.

Provisional. Finally, the provisional and fallible nature of knowledge is a central feature of classical pragmatism. Peirce described this aspect of the scientific method as *Fallibilism*, which holds that "people cannot attain absolute certainty concerning questions of fact." (Peirce, 1959, p. 59). Dewey, James, and Peirce emphasized the value of the process of scientific inquiry as a means for finding provisional truths in problematic situations. Knowledge is always provisional and open to doubt and criticism—and to evolution. Pragmatism is modeled on Darwin's theory of evolution and, like natural selection, the development of understanding and knowledge through pragmatic scientific inquiry is an evolutionary process that adapts thought and actions over time to a changing milieu.

Classical pragmatism is a harmonizing perspective for conducting classic grounded theory research. Whereas the goal of classical pragmatism is the resolution of a problematic situation through scientific inquiry, the goal of grounded theory is conceptualize and understand a problematic situation by means of a theory derived from empirical experience. The hallmarks of rigorous grounded theory research is that the theory *fits* diverse empirical data, *works* to explain the action on the scene, is *relevant* to situation, and is *modifiable* as new evidence is found (Glaser, 1998). These quality factors support the *practical*, *pluralistic*, and *provisional* aspects of Brendel's 4-P's (2006). The *participatory* aspect of pragmatic inquiry was also sustained in this research project, which was conducted within an egalitarian technological cultural group that is a distributed community of practice. Conceptualizing the actions, interactions, and pragmatic problem solving activities of the group was one of the goals of this grounded theory research and one of the attractions of classical pragmatism as a theoretical perspective.

Development of the researcher - A personal reflection

> "A human being should be able to change a diaper, plan an invasion, butcher a hog, conn a ship, design a building, write a sonnet, balance accounts, build a wall, set a bone, comfort the dying, take orders, give orders, cooperate, act alone, solve equations, analyze a new problem, pitch manure, program a computer, cook a tasty meal, fight efficiently, die gallantly. Specialization is for insects." Robert A. Heinlein

I have two reasons for writing the following personal reflections, one giving a nod to the postmodernist stance that the background of the researcher is not irrelevant to the research enterprise (Golinski, 2005), and the other to candidly acknowledge the trepidations and tribulations that come from electing to follow my own lead and do something new in the field. Doing grounded theory is a complex and difficult undertaking that demands much of the researcher and entails a certain element of risk. In contrast to conventional deductive and descriptive research methods, inductive research places a premium on the abilities of the researcher to discern patterns in the data and conceptualize higher-level understanding, i.e. the ability to theorize. None of my research classes had prepared me to conduct inductive research, which placed the onus entirely on me to prepare accordingly. That preparation required about two years of study to finally arrive at the point that I felt that I was ready to undertake the project. The mantra of classic grounded theory may be *trust to emergence*, but at the same time there are no guarantees that emergence will actually occur. Emergent categories are not an automatic result, but depend critically upon the theoretical sensitivity of the researcher to have abductive insights and conceptualize abstract relationships that are relevant, fit the data, and work to explain the action in the research situation.

The prospect of taking on a grounded theory study as a doctoral project and failing as a theorist was a daunting concern for this researcher. A leap of faith was required and there was real risk, but both could be assuaged to a fair extent by conscientious preparation. In my case, I learned grounded theory from thousands of pages of its primary sources and did my own pragmatic evaluation of the various GT approaches methods to select the best-fit method for my project and my predilections as a researcher. I was serious about theoretical sensitivity and followed the recommendations of Glaser (1978), Glaser & Strauss (1967), Stern & Poor (2011), and Strauss & Corbin (1990) and read widely in many unrelated fields to gain exposure to ideas outside my home discipline and research area. Extensive reading in unrelated fields can counter parochial perspectives that may have taken root from years of narrow graduate study and promote broader horizons, new ideas, and richer interconnections that could be useful background for supporting theory generation. Wide reading was natural a natural fit, as I had been reading on both sides of the academic divide long before my doctoral program. I was especially influenced by the works of Jacob Brownowski (1974), Carl Sagan (1980), Mortimer Alder (1986, 1992), E. O. Wilson (1998), and George Bugliarello (2000, 2003) and credit those scholars with my humanist awakening. From wide reading, I became aware that academic boundaries are purely arbitrary and that disciplines can become metaphorical closed worlds (Edwards, 1996) that are self-referential and bound by their own limited rhetoric. Ortega y Gasset (1932) coined the colorful expression *barbarism of specialization*, which captures the effect of such narrow education quite well. Particularly useful for me in redressing my own barbarism was wide reading from the field of Science and Technology Studies (STS), where I became familiar with the philosophical discourse at the intersection of science, technology, and the humanities. I came to grips with postmodernism and social constructivism in the STS literature, which was to be helpful in pondering the epistemological debates that have dominated the literature of qualitative research in general and grounded theory in particular for three decades. Although philosophical debates on recognized research designs and their theoretical underpinnings may exercise a formative influence upon researchers (Crotty, 1998, p. 14), to me much of the postmodern debate surrounding epistemology seemed more rhetorical than useful and offered little practical guidance on conducting real research. While struggling with the philosophical debates in the research community, I happened to revisit the writings of John Dewey, followed by that of Charles Sanders Peirce and William James—the three founders of American Pragmatism. After so much time in the rhetorical quagmire, finding classic pragmatism was, for me, akin to digging up the Rosetta stone or finding Ariadne's thread in the dark postmodern labyrinth. It took some time to sort out classical pragmatism from other more recent variants, such as Rorty's neopragmatism, but with classical pragmatism most of the confusion of decades of postmodern debates in qualitative research effectively evaporated.

My own personal belief system is that there really is a cosmos that likely has existed long before humans arose to contemplate it and will likely continue to exist long after humans and the planet Earth are reduced to dust and gas and returned to the interstellar void in the dark between the stars. That ontological realism is supported by an epistemology that is adaptable to empirical experience. There are aspects of empirical reality that I would term to be *deterministic*, e.g. aspects of the natural world that are observable, understandable, and predictable. I use the term *deterministic* in the technical sense to refer to systems that have a predictable and reliable response to external inputs, e.g. Input A will always and predictably elicit Output B from a deterministic system, regardless of whether or not there is a human present to observe and interpret the output. The spectacular successes of the natural sciences, technology, and engineering in amassing cumulative knowledge of the cosmos are reliable indicators of something that can reasonably be described as some form of objective reality that is amenable to study. The case is quite different for the social sciences in that human behavior is thoroughly *nondeterministic*, e.g. Input A may not reliably elicit Output B, but could elicit other outputs that can change over time, or a human may simply say, "What do you mean by Input A"?
The nondeterministic nature of humans is problematic for applying hypothetico-deductive methods in social research, which Flyvbjerg (2007) noted has having been remarkably unsuccessful in finding universal norms that can apply across human thought. The larger problem may be that there may not actually be any rational universal norms that can apply across human thought (Bourdieu, 1977; H. L. Dreyfus, 1982; Flyvbjerg, 2007), or as Michel Foucault (1972) noted, "Nothing is fundamental." If Foucault is correct, then traditional positivist social research that looks for determinism in a nondeterministic social world is severely constrained in the types of problems that are amenable to study.

Our brains are sense-making engines that have evolved with logical and heuristic power that have driven the ascent of man (Bronowski, 1974) and enabled us to survive as a species. Science and mathematics are among our best inventions that have extended our ways of knowing and the range of our grasp beyond ourselves through technology. But, the scientific method that we were taught in elementary school, usually with a simplistic diagram showing steps of experimentation, is not one method, but is a general term for disciplined systematic inquiry that utilizes the sense-making resources of our brains to discover something new. The scientific method applies to all research paradigms: rationalistic and empirical, quantitative and qualitative, deductive, inductive,

and abductive, with the mind of the researcher as the most important element. I have come to the realization that, epistemologically speaking, there is little difference between quantitative and qualitative research. What differences there are lie in the questions that are asked and the answers that are sought.
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