A Case Study on How Workers in a Fast-paced Environment Go Through the Knowledge Life Cycle When Dealing with Critical Incidents

Julaine Melissa Fowlin

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

Katherine Cennamo, Chair

Jennifer Brill

John Burton

Barbara Lockee

25 March 2014

Blacksburg, Virginia

Keywords: knowledge management, knowledge life cycle, organizational learning, instructional design and technology, human performance technology, fast-paced

A Case Study on How Workers in a Fast-paced Environment Go Through the Knowledge Life Cycle When Dealing with Critical Incidents

Julaine M. Fowlin

Abstract

21st century work environments are becoming more dynamic; they are fast-paced and require critical incidents to be dealt with in a shorter time frame. At the same time, in order for organizations to survive knowledge management (KM) systems need to be in place that allow organizations to learn from these incidents and use the knowledge gained to solve new problems. The knowledge life cycle consists of three phases: create, preserve, and disseminate. The knowledge life cycle also involves the transformation of knowledge from tacit to explicit, which is important to shift knowledge from the individual level to the organizational level; this represents a very important objective of KM.

KM is not a domain on its own but intersects with other areas such as organizational learning, performance support, and communities of practice. Learning and performance support are among the concerns of practitioners in the sister fields of instructional design and technology (IDT) and human performance technology (HPT). Yet still, there are not many studies that examine KM through the lens of these professions. There is a need for knowledge to be accessible and for structures to be put in place to facilitate the knowledge life cycle.

The purpose of this study was to explore how workers in a fast-paced environment go through the knowledge life cycle when dealing with critical incidents, and the factors that acted as driving and restraining forces. A single instrumental case study research design was used to study employees of a walk-in computer software help desk. The HPT model along with

principles and procedures of critical incident technique were used to create a framework for data collection, which included interviews, a focus group session, and examination of extant data.

Findings revealed that workers went through the knowledge life cycle by making internal and external connections and both organizational and individual factors impacted the flow of knowledge. A disconnection between available tools and work processes posed the greatest barrier to going through all the knowledge life cycle process.

Dedication

To My Son, Josiah

Thanks for being such a "trooper" during this process. May this be a testimony to you that you should always follow your dreams, and never give up when confronted with challenges.

To My Parents, Ian and Sybil Fowlin

I am the product of your nurturing and support. You instilled in Davine, and I that we should have high aspirations and work toward them. I remember as early as basic school, whenever we struggled with a concept, you creatively found alternative means to foster our understanding. This built fortitude, without which this journey would not have been accomplished. Mom, unfortunately you are not with us to share in this experience, I miss you. Dad, you are the best dad anyone could ask for! You remain a source of strength for me, your phone calls, prayers, and constant reminder that there is a light at the end of the tunnel kept me through this journey. You are a lifelong learner with a great zeal for knowledge. You may not have a PhD, but your intellectual contributions to society have been excellent. This degree is as much yours as it is mine!

To My Aunt, Marlene Forrester

You issued the mandate that you were done at the master's level, so I, being of the younger generation should get the PhD. Mission accomplished! Auntie Mar, thanks for picking up the batton that mom left and being a mother to me, and a grandmother to Josiah. I would not have been able to finish this degree in a timely manner without your love and support.

Acknowledgements

While putting this study together I felt like a novice chef who had an idea of the flavors she wanted for a five-course meal, but no recipes for creating the dishes, so whenever someone asked me what my study was about, I would start by saying, "I'm cooking up a study." Bon appétit, the dissertation meal is ready, and I am indebted to several people for the lovely outcome!

First, I would like to thank God for what my father calls "divine intervention" and "divine favor." Thanks for putting just the right people in my life at just the right time when I needed them. Thank you for presenting me with the wonderful opportunity to see the completion of the dissertation meal. To Thee I give thanks!

Thanks to Dr. Cennamo, the head chef, for enduring all the test samples, and thanks for making the recipes better. Dr. Cennamo, you acknowledged my challenges and provided both academic and emotional support. You knew just the right words of encouragement and books to recommend. I am grateful for your caring "pep talks", when the "overwhelm" bug struck. I am much stronger because of your push. You provided me with opportunities to give several drafts and gave incremental deadlines, which contributed to my progress. You read each draft in detail and made it your policy to always give positive feedback before outlining the areas that needed to be worked on. I hope to emulate you someday.

To the other members of my committee, thank you for challenging, and channeling my curiosity through your questions and valuable suggestions. Dr. Brill, thank you for sharing your expertise and inspirational experiences of successfully applying instructional design in organizational settings; for your guidance with putting together the various recipes for the dissertation meal, and for your very timely words of encouragement. Dr. Burton, thanks for

whetting my appetite with all the possible flavors of the field of instructional design, which later informed my study, and for your cheerful and motivating spirit throughout this process. Dr. Lockee, thanks for pointing me in the right direction in terms of the ingredients that I definitely needed to include, for always checking on my progress when you saw me, and for your reassuring smile that the dissertation meal will be pleasing to the palate. Dr. Potter, you are not a member of my committee, but I want to thank you for the guidance you provided with my prospectus in the Research in Instructional Technology Course, which helped immensely.

Stabilizers: I would like to thank my mentors who stabilized me throughout this process. Dr. Glenda Scales, Dr. Catherine Amelink, and Mr. Carlton Samuels, I am eternally grateful for the tremendous personal and professional development that you afforded me, all of which contributed to my successfully completion. Dr. Scales, my "mother hen", you are a true advocate for students. I came to you with my ideas and you provided me with a kitchen to cook in and ingredients. This dissertation meal would not have existed without your help. Dr. Amelink, you are such a great mentor. You supported me throughout this entire process by sharing your own experience as a doctoral student, reading my drafts and giving valuable feedback, and allowing flexibility in my work schedule so that I could meet my very pressing deadlines. Mr. Samuels, it was through working with you that my passion for instructional design was ignited. Thanks for your continued mentorship, for always responding to my questions, for hearing my ideas, and for your suggestions.

P.E.O. (Philanthropic Educational Organization) Sisterhood. I would like to thank the PEO, especially chapters AH, AU, and BP in Blacksburg, VA. Thank you for your scholarship, help with transporting Josiah to and from daycare when I didn't have a car, the encouraging emails and cards, the goodie bags, and the gatherings where I got refreshed and renewed energy

to continue. Special acknowledgment and thanks to sisters Diane Wilson and Loretta Walker for taking Josiah and I under their wings.

Synchronicity Rescuers: I would like thank my "synchronicity rescuers" that is, the people who unknotted my thinking at a critical stage by happenstance. Dr. Brand, you came to my rescue when I needed your insights the most. Thanks for your input and genuine interest in my well-being. Michelline, meeting you was definitely synchronicity. Thanks for sharing your resources, strategies, and knowledge. You just gave me all the information I needed at just the right time. I know you are right behind me and I am cheering for you! Dr. Salisbury, thanks for taking time from your very busy schedule to bless the dissertation meal. You gave me the last dose of inspiration I needed to present the meal!

Idea Generators: In my quest for ideas for my dissertation meal, I sought advice from several other chefs, who dedicated their time to talk with me and provide feedback. Thanks to Dr. Creamer, Dr. Van-Aken, Dr. Larson, Dr. Nelson, and Dr. Blake for spending the time to share your experiences with me, for suggesting resources, and for providing me with a schema for breaking down my ideas.

Dissertation Writing Group: Special thanks to the members of my dissertation writing group, Jenny and Joyce, whom I connected with very well. Our meetings at Starbucks were a form of energizer for me as we shared our experiences and provided support for each other. Thanks for all your help and I will be on stand-by to return the favor. I am cheering you both on as you progress toward this milestone as well.

Coworkers: I would like to thank The College of Engineering Dean's Suite for being such wonderful and supportive coworkers. Dale, it was your ingenious and thoughtful idea that allowed the entire GA's to be in the same space. Thanks for accommodating me and for all your

valuable help with my study. Lisa, thanks for hiring me in the first place, and for being so caring and authentic. Ryan, thanks for all your help with my study, and for tolerating all the dissertation conversations in the office. Jeff, thanks for being so welcoming to all my unannounced visits to your office for assistance, and for your support with my study. My fellow graduate assistants, Tina, Ashley, and David having you all in the same space has been a blessing, thanks for the support and sharing of ideas, Dale indeed crafted the perfect community of practice. I know you are all right behind me,and I am cheering you on as well!

Friends and Family: I am very grateful to both the maternal and paternal sides of my family for their love and support to Josiah and I in so many different ways, which contributed to my successful completion. I would like to express gratitude to all my friends and colleagues who have been sources of strength, comic relief, baby sitters, and professional development motivators, especially: my 'old' friends, Shanique, Latoy, Bartlett, Dennesha, Manisha, and Cynthia; my 'newly' acquired friends since moving to Blacksburg, Damion L, Titilola, Wendy, Abbie, Joyann, Liselle, Josh, Cathy, Leslie, Anahita, and Deepali. Thanks also to the African families who embraced Josiah and I in their families and helped in many ways to push me through, Drs. Malapile, Mukuni, Nkhata, Nygoyi, and Sanga.

I would especially like to thank Sy, for being there constantly for Josiah and I even when he had his own PhD struggles to bear. Sy, thanks for being my rock!

Software Help Desk (SHD): Finally, I would like to thank the technicians and leadership team of SHD for giving me the privilege to use their organization as the case for this study. Throughout my study you were all very corporative and provided a very pleasant research experience.

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction to the Study

Deep reliance on classroom training as the predominant means of gaining knowledge and achieving mastery has long been criticized by many (Brown, Collins, & Duguid, 1989; Collins, Brown, & Holum, 1991; Mincer, 1962). Mincer (1962) asserts that "it is important to be reminded that formal school instruction is neither an exclusive nor a sufficient method of training the labor force" (p. 50). Therefore, completing a certification or graduating from a school marks just the beginning of the learning process, what Mincer (1962) calls the preparatory stage. The learning process or training process continues as the knowledge acquired in school must be applied in organizations that have very specific contexts and ways of doing things. Spitzer (1984) provides over thirty reasons for the failure of formal training and among those more than half of them relate to the need for authenticity, practice and follow up. Some examples of the related failures are, insufficient opportunities to apply new skills at work, training is not applicable to job, training takes place in a classroom with no reference to the performance context, no job aids to scaffold learning from training to job, and no follow up with learners after they leave training.

According to Swanson (1999), the Training Within Industry (TWI) project during World War II is one of the most influential initiatives on training today as it represents one of the pivotal moments in history where training had to be done in a new way. With many employees joining the war effort TWI was used as an emergency plan to quickly develop competence in the remaining labor force and marked the turning point for many training and human resource development fields (Ruona, 2001). TWI was not only focused on training, but also used tools that were called "job instruction, job relations, and job methods" (Swanson 1999, p.3). However,

after World War II, the lack of competition resulted in minimal emphasis on training initiatives and the TWI project ended. By the 1970's, global competition resulted in renewed interest in training and performance improvement initiatives.

The above citations from the early and mid-20th century show the extent that the literature on training has long advocated for training that is meaningful and situated in authentic settings as well as instructional (formal or informal) aids that facilitate just in time learning. The conditions of today are even more complex and dynamic than when the TWI project was launched. These complex environments are often fast-paced and require problem solving to take place in a shorter time frame, in order to keep up with high demand for service (Dalkir, 2011). The knowledge creation that takes place in contemporary working environments occurs in various forms and is used for multiple purposes; as a result there is a need for a different approach to workplace learning, other than formal training (Fuller, Unwin, Felstead, Jewson, & Kakavelakis, 2007; Illeris, 2011; Rosenberg, 2012; Salisbury, 2008).

Therefore, though the workplace is not a space designed with formal learning as its main objective, individuals constantly learn new things while doing their jobs. This knowledge, when used in the organization, results in organizational learning (Argyris & Schön, 1996). Argyris and Schön (1996) explain that

> Organizational learning occurs when individuals within an organization experience a problematic situation and inquire into it on the organization's behalf….In order to become organizational the learning that results from organizational inquiry must become embedded in the images of organizational held in its members' minds and or/ epistemological artifacts (the maps, memories, and programs) embedded in the organizational environment (p.16).

According to Argyris and Schön (1996), organizations are seen as "holding environments for knowledge" and organizations "directly represent knowledge" (p.12-13). As "holding environments for knowledge," knowledge may be stored in the heads of organizational members, but will be lost if they leave. Other holding environments include documents that preserve lessons learned and steps taken to solve problems; documents that represent the identity of an organization, such as policies and mission statements; and tangible objects within an organization that trigger and guide certain kinds of behaviors. Organizations directly represent knowledge by virtue of the fact that knowledge is embedded in the daily routines of the organization. This knowledge is often difficulty to articulate by members, but can be unearth through qualitative inquiry by outsiders. The knowledge that evolves from organizational learning is thought to be essential in maintaining the unique value of an organization as it cannot be exchanged or traded and is difficult to duplicate (Nonaka, Toyama, & Bysoière, 2001). There is a high need for knowledge to be accessible, and for structures to be put in place to facilitate the flow of knowledge, especially in fast-paced and dynamic environments; this essentially is what knowledge management (KM) is about.

KM, Instructional Design and Technology, and Human Performance Technology

KM is multifaceted and "encompasses different aspects of an organization: people, culture, process, structure, leadership, technology, and measurement" (Haney, 2006, p. 619). KM is therefore, not a domain on its own but intersects with other areas such as organizational learning, performance support, and communities of practice (Alavi & Denford, 2011; Cowley-Durst et al., 2001; Dalkir, 2011; DiBella & Nevis, 1998; Haney, 2006; Schwen, Kalman, Hara, & Kisling, 1998). Learning and performance support are among the concerns of practitioners in the

sister fields of instructional design and technology (IDT) and human performance technology (HPT). Yet still, there are not many studies that examine KM through the lens of these professions (Nworie & Dwyer, 2004). IDT and HPT adopt a systemic and systematic approach that is integral to any KM initiative as "exploiting knowledge and improving performance will happen only if the whole system is understood and managed" (Massey, Montoya-Weiss, & O'Driscoll, 2005, p. 39). Researchers that have examined KM through the lens of IDT found it necessary to develop new instructional design models (Gunawardena, Layne, & Frechette, 2012; Plass & Salisbury, 2002). Plass and Salisbury (2002) created a Living-Systems Design (LSD) model designed to develop a KM system that was flexible and catered to changes in organizational needs and requirements. Gunawardena et al. (2012) developed an instructional design model called WisCom (Wisdom Communities) to better meet the demands and needs of 'knowledge-based society'. WisCom has its roots in social constructivism, among many other theories, and is designed to be used to scaffold the process of forming cohorts online who work collaboratively. Similarly, researchers who conducted studies in HPT found the need to adapt existing frameworks to study knowledge within performance systems (Massey et al., 2005; Yoon, Song, & Lim, 2009). These findings suggest that the traditional approaches of HPT and IDT may not be adequate for studying and supporting KM in contemporary organizations.

Need for the Study and Related Research

Nguyen and Hanzel (2007) allude to a very important expectation of instructional designers in stating that "anyone involved in the delivery of training knows that business conditions often require training interventions to be delivered in ways that are not ideally structured or timed" (p. 8). IDT and HPT practitioners are therefore required to provide support that is not traditional and involves tasks not typically performed in the past (Reiser, 2001). In

addition, in order to be effective, instructional designers are required to have an understanding of some of these environments to be able to address their needs effectively.

Fast-paced job settings that deal with critical incidents is one of these environments. Many of the work environments in the 21st century are evolving to match the aforementioned description and there is a need for a greater understanding of such settings (Chadha, 2012). These environments can be found in a wide range of disciplines from security (Chadha, 2012) to health care (Andrus, 2005) to information technology (González, Giachetti, & Ramirez, 2005), just to name a few. These environments often require instructional interventions that are atypical of formal training and that involve managing the knowledge flow within the organization.

The literature surrounding KM is largely fragmented and is divided between studies that primarily examine features of a KM information technology infrastructure and those that study people, organizational and process factors (Schwen et al., 1998). Many of the previous studies that examined knowledge within the context of a fast-paced environment where knowledge changes focused primarily on big companies/institutions and investigated how various technology systems can help address the flow of knowledge among employees (González et al., 2005; Halverson, Erickson, & Ackerman, 2004; Kang, Yoshida, Motoda, & Compton, 1997; Kriegsman & Barletta, 1993). Most of the studies do acknowledge that the flow of knowledge involves both the people and the processes and advocate that the natural environment be studied before any technology intervention is recommended or implemented (González et al., 2005; Halverson et al., 2004; Kang et al., 1997; Kriegsman & Barletta, 1993; Nunes, Annansingh, Eaglestone, & Wakefield, 2006). Some of the studies (Göker & Roth-Berghofer, 1999; Kang et al., 1997; Kriegsman & Barletta, 1993) have pointed out that it is best to organize knowledge

based on troubleshooting incidents or cases and they base this on the premise that all knowledge can not be captured and people think in terms of whole experiences and not just isolated pieces.

Though many studies have been done in KM, because of the contextual nature there remains a need for more empirical studies that capture contextual patterns especially in the fields of IDT and HPT; as "while IT capabilities allow firms to access, embed, and transfer knowledge, the real challenge concerns the complex interplay between content, context, and the knowledge workers who pull the process pieces together" (Massey et al., 2005, p. 53). There is also a tendency of findings from KM studies to be presented as a panacea often leaving managers to stumble in applying principles to their practice due to lack of differentiating elements; viewing knowledge as a life cycle provides a framework for examining the various facets of KM and caters to context (Birkinshaw & Sheehan, 2002).

IDT and HPT practitioners possess the general tools, knowledge, and skills to contribute to the KM literature. However, KM is a relatively new area to these fields and there is a need for more studies that offer insights with regards to knowledge flow among workers in different contexts that are representative of 21st century work environments (Cowley-Durst et al., 2001) . An understanding of the knowledge life cycle in various environments and industries will enable executives and HPT/IDT practitioners to make more informed decisions regarding the knowledge needs of the organization and the tools and strategies for managing it (Birkinshaw & Sheehan, 2002)

Purpose and Benefits of the Study

The purpose of this case study was to examine how workers in a fast-paced environment go through the knowledge life cycle when dealing with critical incidents and the factors that acted as driving and restraining forces. According to Richey, Klein, and Tracey (2011), the ID

knowledge base consists of knowledge related to six content domains: learners and learning processes; learning and performance contexts; content structure and sequence; instructional and non-instructional strategies; media and delivery systems; and designers and design processes. They state that "in addition to serving as a definition of the ID field itself; one can view the various taxonomy elements…as variables to be addressed in research and theory construction" (p.182).

This study is an overlap between the learning and performance context, and the instructional and non-instructional strategies domains. Under the domain of learning and performance context, the study examines knowledge flow in a specific context as well as the factors that impact it. Richey, Klein, and Tracey (2011) assert that "instructional designers must become adept at attending to those contextual factors that have proven to have the most impact on both learning and performance" (p. 172). Under the instructional and non-instructional strategies, the study focuses on KM, which is considered a non-instructional intervention (Fox & Klein, 2003). In general there is a need for more studies that examine non-instructional interventions as well as more studies in the work place setting (Richey et al., 2011). The results of a content analysis of articles (1997-2000) published in Performance Improvement Quarterly (PIQ) done by Klein (2002) supports this view and he states that, "rigorous studies on interventions such as performance support systems, job aids, KM, motivation, and incentive systems is required to inform the field" (p. 105). Conn and Gitonga (2004) in their replication of Klein's (2002) study examined three (Educational Technology Research and Development, Tech Trends, and Quarterly Review of Distance Education) journal publications by AECT covering a range from 1999 – 2003. Conn and Gitonga (2004, p. 19) found that very few articles were on workplace

learning and most of the ones identified were not empirical research; they assert that the following are needed:

- More empirical research studies on topics related to workplace learning and performance.
- More studies based in government, military, healthcare and higher education settings.
- More research on these [electronic performance support systems, KM initiatives, workplace communities of practice, job aids or workforce development] and other interventions such as incentives, workplace and workflow redesign and organizational development is needed.

This study is related to several of the areas mentioned above where there is a need for more empirical research and will add to the IDT and HPT knowledge base by providing greater insights of the KM patterns among workers in fast-paced organizations when dealing with critical incidents, and the influence of contextual factors. The findings from this study may be used to inform IDT and HPT solutions for similar environments, recognizing that as instructional designers our responsibility transcends beyond designing formal or direct instructions (Hoadley & Van Haneghan, 2011). With regards to formal training, the study may inform formal training focused on how to effectively manage knowledge, as opposed to training in the content area itself, since the content knowledge is constantly changing. Although knowledge is highly context specific and we can't have a "one size fits all approach", we can build our knowledge base through thorough analysis of how knowledge flows in various contexts.

Research Questions

1. How do workers in a fast-paced environment go through the knowledge life cycle processes (create, preserve, and disseminate) when dealing with critical incidents?
2. What are the factors that act as driving and restraining forces with regards to going through the knowledge life cycle when dealing with critical incidents?

The succeeding sections include: Chapter 2 which provides a review of the literature surrounding the knowledge life cycle in organizations and how knowledge should be studied in the work place setting; Chapter 3 which provides an outline of the research design and procedural steps taken to plan, implement and analyze the various facets of this study; Chapter 4 which presents the results and Chapter 5 the interpretation of findings, conclusion and recommendations for future studies.

Chapter 2: Literature Review

The objective of this chapter is to give an overview of the literature surrounding the concepts of this study. The concepts of knowledge and the knowledge life cycle are examined as well as the theoretical underpinnings with emphasis on the Theory of Organizational Knowledge Creation by Nonaka and colleagues (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka, Toyama, et al., 2001). The success factors in managing the knowledge life cycle are discussed. In addition, a crucial foundation to this study is the literature surrounding how knowledge should be studied in organizations, so the chapter ends with examining the relationship between IDT and HPT approaches and how these relate to the study of knowledge surrounding critical incidents. The literature on how knowledge should be studied provides a precursor to discussing the methodologies used in this study in Chapter 3.

Definitions of Knowledge

Many definitions of knowledge exist and they all emphasize that though there is a relationship between information and knowledge the two terms are not synonymous and thus should not be used interchangeably. The word 'value' seems to be one shared aspect among the definitions that distinguishes knowledge from information. Kerssens-Van Drongelen, De Weerd-Nederhof, and Fisscher (1996) define knowledge as "information internalized by means of research, study or experience that has value for the organization" (p.213). Davenport, De Long, and Beers (1998) give a more detailed definition that defines knowledge as "information combined with experience, context, interpretation, and reflection; a high value form of information that is ready to apply decisions and actions" (p.43). Nonaka, Reinmöller, and Toyama (2001) view information as meaningless as it is without a context, purpose, or established value. Knowledge on the other hand is "meaningful; it is relational and context-

specific, for it is continuously created in and justified in a changing environment…Hence knowledge can be defined as a meaningful set of information that constitutes a justified true belief and/or an embodied technical skill" (p. 828). Justified truth in this definition adopts a pragmatic view of knowledge which emphasizes organizational context rather than a positivist absolute view of universal truth (Nonaka & Von Krogh, 2009).

Knowledge Life Cycle

According to Fahey and Prusak (1998), it is important to view knowledge as a flow rather than a stock item or an object that exists on its own. Knowledge as flow indicates that it changes and is embedded in the day to day activities of the organization. Knowledge flow involves individuals and often connects a community of workers; "it is inseparable from the individuals who develop, transmit and leverage it" (Fahey & Prusak, 1998, p. 266). In tandem with thinking of knowledge as a flow several authors (Birkinshaw & Sheehan, 2002; Dalkir, 2011; Haney, 2006; Mertins, Heisig, & Vorbeck, 2001; Salisbury, 2008) have posited that knowledge be viewed as a life cycle. The complexities of the models vary, but they all start with a 'create' phase and provide a way to break down how knowledge flows through an organization. Viewing knowledge as a life cycle allows for a more detailed understanding of the dynamics. In addition, the emphasis on the different phases of the knowledge life cycle may vary depending on the organization (Birkinshaw & Sheehan, 2002). The discussion that follows will examine three representations of knowledge as a life cycle.

Haney's model. First, Haney (2006) proposes that knowledge be viewed as a life cycle with seven (7) phases (see Figure 1).

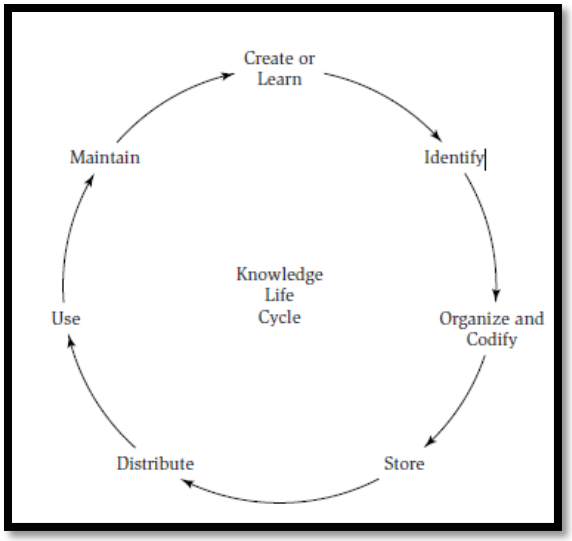


Figure 1. Haney (2006) knowledge life cycle.

1. Create or learn, and (2) identify: these first two phases initiate the start of the knowledge life cycle through acquisition; as acquisition usually occurs through "creating, learning, or purchasing" (Haney, 2006, p. 626). Before or after acquisition there is also a process of identifying what is important and useful to the organization.
3. Organize and Codify: after knowledge acquisition occurs and the importance is identified, knowledge is then organized in a meaningful way that is directly applicable to the context, while "codification converts the contents into a format that can be stored, maintained, and accessed in organizational repositories" (Haney, 2006, p. 626).
4. Store: knowledge can be stored in various ways; however, most often it involves using information/computer technology. Knowledge must be stored in a secured and easily accessible format and location.
5. Distribute: distribution may occur in a manner that either pushes the knowledge to users (example sent in an email or presented in a meeting) or pulls the user to the knowledge (made available and individuals access as needed).

6. Use: knowledge is integrated and applied to supporting, delivering, and or developing products and services.
7. Maintain: knowledge is "updated, changed, added to, deleted, or replaced" (Haney, 2006, p. 627). Maintaining also involves monitoring usage of knowledge and training/coaching/supporting users.

Brikinshaw and Sheehan's model. Second, Birkinshaw and Sheehan (2002) represents knowledge as a life cycle in the form of a S-curve (see Figure 2) where knowledge cycles through four stages, "creation, mobilization, diffusion and commodization" (p.76). Time is an added variable in this model of the knowledge life cycle based on the notion that as knowledge progresses through the various stages of the life cycle there is an increase in the number of people that have access to it.

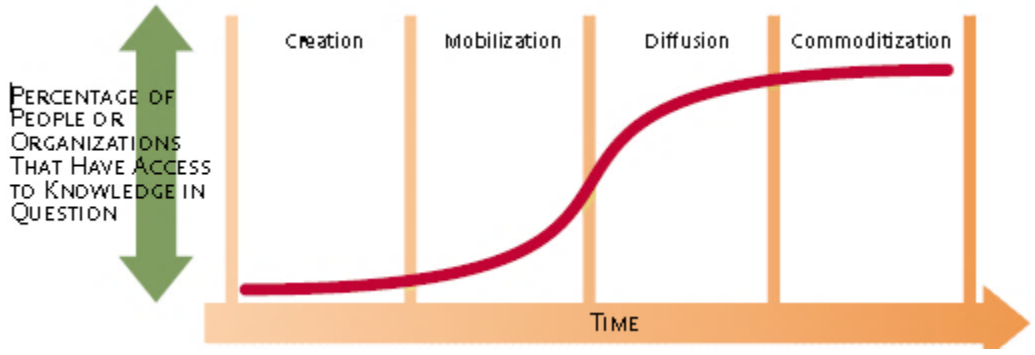


Figure 2. Birkinshaw and Sheehnan (2002) knowledge life cycle.

Birkinshaw and Sheehnan's knowledge life cycle evolved from five years of research in large organizations and as such reflects certain dynamics that may not be evident in smaller organizations, they also use the word 'idea' to represent knowledge.

1. Creation is where an idea is conceived and the knowledge is in the individual's head. At this stage it can be considered as abstract insight gained through experience and experimenting. If the idea transcends the individual in a way that can be validated and acquires an interested audience it will proceed to the next phase. However some ideas do not mature to the next phase due to lack of interest among other bottle necks. In this sense the creation phase can be compared to exploring a topic for a dissertation, where the student usually has many ideas but some may fall through.
2. Mobilization is where the idea moves from the individual's head and takes on a more concrete form that can be shared with others and tested. Similar to Haney's organize and codify stage, knowledge sharing is the hallmark of this phase and this is usually done within a community that the individual trusts. In keeping with the dissertation example, mobilization would be akin to presenting the idea to one's committee in the form of a proposal and then progresses to the development and implementation of a research study.
3. Diffusion is where, if the idea survives the mobilization phase, it becomes fully developed and is now publicly available for others to learn and even replicate. For example, the publishable work that evolves from a dissertation.
4. Commodization is where the idea gets so interwoven in the discipline that is becomes common knowledge. For example in education things like Bloom's taxonomy or Gagne's instructional events have evolved to this stage.

According to Birkinshaw and Sheehan (2002), the speed of the flow of knowledge varies in different contexts. They identify three factors that can increase the rate of knowledge flow: competition stealing information, information leakage, and intentional documentation and sharing. Intentionally sharing is recommended in cases where it is not very feasible to secure the

knowledge. Two factors that decrease the rate of knowledge flow are intellectual property rights, like having a patent, and the extent that the knowledge is hard to imitate.

Salisbury's model. Third, Salisbury (2008) presents a more simplistic view of knowledge as a life cycle which consist of three phases, create, preserve, and disseminate (see Figure 3). Some of the phases are similar to Haney's life cycle however, Salisbury views knowledge as being conceived out of problem solving. The emphasis on problem solving in Salisbury's (2008) model makes it suitable for this study as the study seeks to examine the flow of knowledge that evolves from critical incidents.

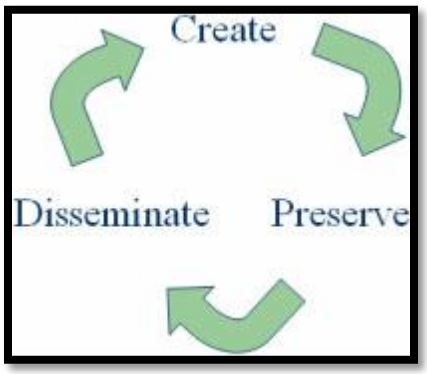


Figure 3. Salisbury (2008) knowledge life cycle.

1. Creation occurs when new or unique problems are solved holistically or a subset of a bigger problem; this encompasses Haney's create or learn and identify phases.
2. Preservation involves documenting the nature of the problem and how it was resolved; this is similar to the organize and codify, and the store phases of Haney's knowledge life cycle.
3. Dissemination and application involves knowledge sharing among employees as well as stakeholders that were affected, and is similar to the distribute phase of Haney's knowledge life cycle. In the next iteration of the ongoing knowledge life cycle, the disseminated

information will help in creating new knowledge when it is used to solve future problems and as of such the organization's problem solving competence will also improve.

Types of Knowledge

Throughout the knowledge life cycle, knowledge takes on different forms and functions. There are many classifications of knowledge and equally as many debates about the way knowledge should be classified (De Jong & Ferguson-Hessler, 1996; Gourlay, 2006; Robin & Hong, 2011; Wilson, 2002). Brown and Duguid (2001) assert that the views of knowledge are divided into leaky (knowledge as something that can be stolen) and sticky (knowledge as something that can be transferred or that flows within an organization). Some classifications are more elaborate than others and thus range from simple two dimensions like declarative and procedural stemming from the work of Anderson (1983) or tacit to explicit from the work of Polanyi (1967) to more elaborate matrices that further distinguishes types of knowledge based on factors such as level (basic or elaborate) and generality (general or domain specific), among others (De Jong & Ferguson-Hessler, 1996). However, explicit and tacit are among the most widely used classifications of knowledge especially in organizational and management research (Gourlay, 2006; Rosenberg, 2012) with the definition of tacit being most debatable (Brown & Duguid, 2001; Gourlay, 2006; Robin & Hong, 2011; Wilson, 2002).

Explicit and tacit knowledge. Explicit knowledge can be articulated and documented, which makes it easy to share. It is the knowledge that is used in formal training, found in books and manuals (Nonaka, 1994; Nonaka & Takeuchi, 1995; Rosenberg, 2012; Smith, 2001). Polanyi (1967) captures the intricacies of tacit knowledge in his very popular quote, "we can know more than we can tell" (p.4). Thus, tacit knowledge is often referred to as the knowledge in

people's heads. It comprises intuition and is often considered common sense to those who have it.

Tacit knowledge is often not verbalized, but plays an integral role in how people problem solve and devise solutions; it is therefore best seen in their actions. However, through articulation tacit knowledge can be shared (Jasimuddin, Klein, & Connell, 2005; Nonaka & Takeuchi, 1995; Stenmark, 2000). Tacit knowledge is best developed and shared in informal ways, often on the job through individual work experiences, interacting with coworkers, coaching and so forth (Smith, 2001). Tacit knowledge may be categorized along two dimensions: technical and cognitive (Nonaka & Takeuchi, 1995). The technical dimension refers to the knowledge that guides the decisions and actions of experts and the individual is often unable to explain the principles that govern the behavior. Nonaka and Takeuchi (1995, p. 8) use the phrases "know how" and "hard-to-pin-down" to describe the technical dimension. The cognitive dimension refers to our epistemologies, perceptions and innate patterns of thinking. "The cognitive dimension of tacit knowledge reflects our image of reality (what is) and our vision for the future (what out to be)" (p.8). The division of tacit knowledge as technical and cognitive seems similar to Polanyi's (1967) reference of knowing as both practical and theoretical with both elements always together, "both the "wissen" and "können" of the Germans, or the "knowing what" and the "knowing how"…" (p.7).

Some have argued that what Polanyi meant when he proposed the term tacit knowledge was that tacit knowledge can never be articulated as it is hidden (Gourlay, 2006; Hildreth & Kimble, 2002; Robin & Hong, 2011; Wilson, 2002). Thus,Wilson (2002) postulates that when 'taken for granted' knowledge is expressed, it is implicit knowledge and not tacit knowledge. He further states that Nonaka and Takeuchi (1995) are responsible for the confusion and they

should have used the term implicit instead of tacit in their framework. However, for the purposes of this research the expanded version of tacit knowledge as explained above will be adopted. In addition, though there are distinctions between tacit and explicit knowledge this study accepts the view that they are inseparable and "mutually complementary entities" that interact through social processes (Nonaka & Takeuchi, 1995, p. 61). There is also a call to see knowledge more as dimensions rather than separate types as they are interdependent (Alavi & Leidner, 2001; Brown & Duguid, 2001). Knowledge therefore can take different forms that embody both tacit and explicit elements (Nonaka & Von Krogh, 2009)

Knowledge Management

The transformation of knowledge from tacit to explicit is important as it shifts ownership from the individual to organization and thus benefits the entire community (Peroune, 2007); this represents a very important objective of KM. To this end "knowledge management is the process of controlling or directing the creation, identification, organization, storage and dissemination, and maintenance of knowledge in order to support strategic goals" (Haney, 2006, p. 620). Rosenberg (2012, p. 159) provides a similar but more encapsulating definition of KM that is "Knowledge management is the creation, archiving and sharing of valued information, expertise and insight within and across communities of people and organizations with similar interest and needs…." Mertins et al. (2001,p. 3) further add a more holistic definition that includes methods, tools and instruments stating that, "knowledge management describes all methods, instruments, and tools that in a holistic approach contribute to the promotion of the core knowledge processes-to generate knowledge, to store knowledge to distribute knowledge and to apply knowledge…"

The creation of KM environments and systems that encourage the natural interplay and flow of tacit and explicit knowledge is still a challenge for many organizations, but is important to maintain competitive advantage. Howell, Williams, and Lindsay (2003) also assert that in order for an organization to remain competive it has to be prepared to facilitate lifelong learning, also referred to as continuing professional education (Farmer, Buckmaster, & LeGrand, 1992). Any organization can acquire technology, however the competence\knowledge of the workforce is what will make the organization competitive (Morell et al., 2013; Murray, 2006; Rosenberg, 2012; Smith, 2001). With stringent economic conditions organizations are therefore looking for cost effective ways to meet their learning needs (Backus, Keegan, Gluck, & Gulick, 2010). One way of dealing with this is to focus on managing the knowledge life cycle and providing environments that facilitate the flow of knowledge (Birkinshaw & Sheehan, 2002; Haney, 2006; Salisbury, 2008).

Evolution of the Field of Organizational Knowledge

The study of organizational knowledge is not a new discipline, but prior to the 21st century most of the discussion resided within the field of economics, influenced by the classic works (works that existed before organizational knowledge was formalized) of economists such as Edith Penrose and Fredrick Hayek and philosophers such as Michael Polanyi (Easterby-Smith & Lyles, 2011). Penrose (1959), as cited by Easterby-Smith and Lyles (2011), focused on team work and the importance of organizational members' knowledge to a firm's economic processes. She posited that organizations need to deviate from their routines sometimes and allow for experimentation, as well as the success of a team is based on their experiences of working together rather than just a collection of their individual experiences. Her views foreshadowed social constructionist theory. Hayek (1945), as cited by Easterby-Smith and Lyles (2011),

focused on the contextual nature of knowledge and found it problematic to use knowledge created in one circumstance to make a generalized decision for the entire organization. His views preceded situated cognition and also influenced the use of qualitative methodology for the study of organizational learning and KM. Polanyi (1967), on the other hand is primarily known for his distinction between tacit and explicit knowledge.

Easterby-Smith and Lyles (2011) further classifies the remaining influences on organizational knowledge as foundational works, which they define as, "some of the first writings that set the agenda for subsequent work" and popularizing works, which they define as, " works which have acted as the most visible watersheds in the development of the field" (p.9). The work of Nelson and Winter (1982) as cited by Easterby-Smith and Lyles (2011) is considered one of the major foundational works for organizational knowledge and emphasizes the value of tacit knowledge to organizational competence. The major popularizing work emanates from the work of Nonaka and colleagues in the Theory of Organizational Knowledge Creation (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka, Toyama, et al., 2001) which will be discussed in detail below.

Nonaka and Takeuchi (1995) work is not without criticism however. They have been assigned the culprits for the perceived tacit explicit fallacy and others have drawn on the lack of generalizability due to the fact that the theory was developed based on studies in Japan (Glisby & Holden, 2003; Gourlay, 2006). Nonaka and colleagues have responded to the criticisms (Nonaka & Von Krogh, 2009; Von Krogh, Nonaka, & Rechsteiner, 2012). Nonetheless, the debates surrounding this theory are inevitable and expose the challenges of examining organizational learning and presenting frameworks that are both pragmatic and empirically grounded. Like theories in all disciplines none is universal and each serves their purpose. The Theory of

Organizational Knowledge Creation (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka, Toyama, et al., 2001) focuses on all levels of the knowledge life cycle and how to manage them (Nonaka & Von Krogh, 2009) and as such provides a framework for this study.

Theory of Organizational Knowledge Creation

After reviewing the existing theories of the late 20th century Nonaka and Takeuchi (1995) concluded that the major existing economic, management and organization theories lacked a perspective on how knowledge is created in organizations. Even though all the existing theories saw knowledge as important, there was a tendency to view knowledge as passive and as an object that can be collected, stored, and used later. This was the impetus for the development of the Theory of Organizational Knowledge Creation. The Theory of Organizational Knowledge Creation's epistemology is based on the interaction between tacit and explicit knowledge and the premise that organizational knowledge creation is derived through the interrelationship between tacit and explicit. The ontology of the Theory of Organizational Knowledge Creation emphasizes that knowledge creation occurs at varying levels within an organization, such as, individual, group, and organizational. Nonaka and Takeuchi (1995) posit that a knowledge creating spiral evolves when tacit and explicit knowledge interacts at different ontological levels. They refer to the knowledge conversion processes as the "engine" of the knowledge creation process, as they are based on individual experiences and capture the assimilation of individual knowledge to organizational knowledge (p. 57).

The knowledge conversion model. According to Nonaka and colleagues (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka, Toyama, et al., 2001) knowledge is created through the interaction between explicit and tacit knowledge which may occur in four knowledge conversion processes; today the model is known as SECI (Socialization, Externalization, Combination, and

Internalization). The SECI model illustrates the interplay between explicit and tacit knowledge in the knowledge creation process as well as how personal knowledge gets transformed to organizational knowledge. That is, from tacit knowledge to tacit knowledge (Socialization), from tacit knowledge to explicit knowledge (Externalization), from explicit knowledge to explicit knowledge (Combination), and from explicit knowledge to tacit knowledge (Internalization). The creation of new knowledge and transfer of knowledge are two processes that often occur together; in other words, by sharing knowledge, new knowledge is created. Nonaka and Takeuchi (1995) argue that the existing organizational theories of the late 20th century examined socialization, combination and internalization, but lacked focus on internalization. Thus to some extent one may say the SECI model embodies existing theories such as: theories of group processes and organizational culture, related to socialization; information processing, related to combination; and internalization related to organizational learning(Nonaka & Takeuchi, 1995) . Figure 4 shows a visual representation of all the four modes of knowledge conversion and their processes.

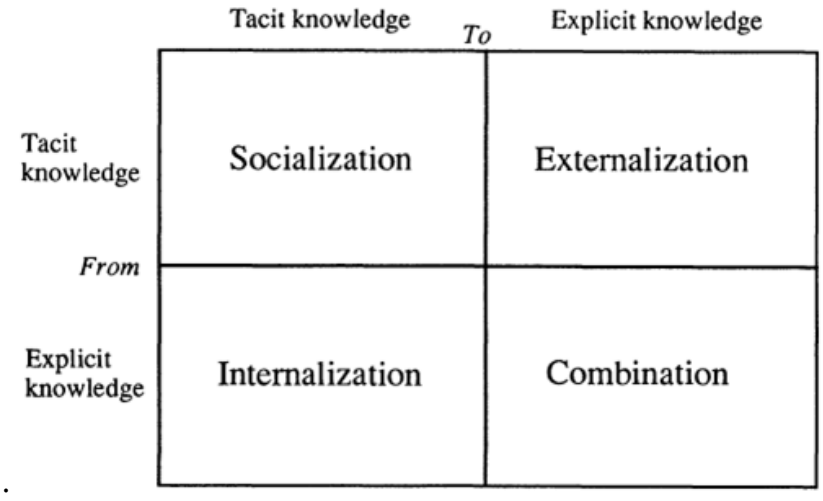


Figure 4. Nonaka (1994) four modes of knowledge conversion.

- Socialization (tacit to tacit) involves the sharing of tacit knowledge through interaction with others and this can occur by observing the individuals, modeling them, and applying skills learned. Tacit knowledge can be transferred formally or informally. In order for tacit knowledge to be transferred there has to be some form of shared experience. Without shared experiences the knowledge is abstract and not meaningful; thus the process is called socialization. One outcome of the socialization process is a shared schema among individuals as well as shared technical skills. The outcome of socialization is "sympathized knowledge" (Nonaka & Takeuchi, 1995, p. 71). Socialization can be difficult to manage but environments can be created to foster socialization among workers. The physical environment can be designed to have informal meeting/conversation areas as well as a culture of love, care and trust (Nonaka, Toyama, et al., 2001).
- Externalization (tacit to explicit) involves concretizing knowledge in a form that can be shared with others. Externalization is considered to be crucial to knowledge creation as new explicit knowledge is derived from tacit knowledge. "When tacit knowledge is made explicit, knowledge becomes crystallized, at which point it can be shared by others and can be made the basis of new knowledge"(Nonaka, Toyama, et al., 2001, p. 495). One way of doing this is by using metaphors to make concepts less abstract; " through metaphors people put together what they know in new ways and begin to express what they know but cannot yet say"(Nonaka & Takeuchi, 1995, p. 13). For example, metaphors are used a lot with prototyping to create a product concept. The outcome of externalization is referred to as "conceptual knowledge" (p. 71).

- Combination (explicit to explicit) involves combining knowledge from different people using social processes, such as: blogs, wiki's, meetings, and email exchanges. This is often done through synthesizing existing information by sorting, adding and re-conceptualizing. In this case knowledge becomes a more "systematic whole" (Tee & Lee, 2013, p. 314) and can be shared with others even in different contexts. In practice this process is like the iterative process of writing a paper with several drafts, that is, first the explicit knowledge is collected from various sources internal and/or external to the organization and these are combined to form new explicit knowledge, secondly, this is then distributed to members of the organization, Thirdly, they in turn provide feedback that informs changes to make the knowledge more practical for use within the organization (Nonaka, Toyama, et al., 2001). The outcome of combination is 'systemic knowledge' (Nonaka & Takeuchi, 1995).
- Internalization (explicit to tacit) is similar to the traditional model of learning and "is the process of embodying knowledge through practice, action and reflection" (Tee & Lee, 2013, p. 314). Internalization is not restricted to face-to-face experiences but can occur virtually through simulations or experiments. Documenting explicit knowledge is helpful for internalization as it makes concrete what the individual experienced and thus builds on their tacit knowledge. Documentation also allows others to vicariously experience the experiences of others. The outcome of internalization is "operational knowledge" (Nonaka & Takeuchi, 1995, p. 71). Through internalized knowledge the existing tacit knowledge of members of the organization may be expanded, refined, or re-conceptualized. This newly acquired body of tacit knowledge is then shared through socialization and this triggers a new knowledge creation spiral, where knowledge

> accumulated at the individual level is processed and amplified at the organizational level through the four modes of knowledge conversion and through movement up the various ontological levels or knowledge entities (Nonaka, Reinmöller, et al., 2001; Nonaka, Toyama, et al., 2001)

The use of the term "conversion" in the model has attracted debate and most recently Tsoukas (2011), building on assertions in his previous articles, proposed a phenomenological view purporting that knowledge cannot be converted from tacit to explicit knowledge, but it's more about articulation. Tsoukas (2011) argues against the view that explicit and tacit knowledge occurs along a continuum; instead he views them as two sides of the same coin. Nonaka and colleagues responded to the debates and provided evidence that supports viewing knowledge on a continuum and seeing it as conversion (Nonaka & Von Krogh, 2009). Nonetheless, the debates seem more rooted in semantics than deep theoretical differences since one common thread between the Nonaka and colleagues and their critics is that tacit and explicit knowledge are not separate or mutually exclusive.

Knowledge spiral. Knowledge creation is not a linear process nor is it restricted to any one ontological level; in fact it transcends organizational boundaries and often includes interactions with the external environment. The environment often receives the output of knowledge created within the organization as well as provides information that triggers knowledge creation within the organization. Thus knowledge creation is a continuous dynamic spiral through the four modes of knowledge conversion. The elevation and movement of knowledge from various ontological levels is referred to as "cross leveling" of knowledge (Nonaka & Takeuchi, 1995, p. 88). They assert that the spiral usually starts with socialization through interaction and this builds a field where organizational members can share experiences

and schema. Then through dialogue externalization mode is activated where members express tacit knowledge. Then combination mode is activated by connecting previous and newly formed explicit knowledge. Then all the newly formed knowledge is applied and integrated in practice and "learning by doing" triggers internalization (p.71). As noted earlier, each knowledge conversion mode produces a different content of knowledge and these interact together as well. The process by which consumer wants are translated into the development of a new product is cited as a good example of the socialization and externalization conversion modes and illustrates how sympathized knowledge becomes explicit conceptual knowledge. Figure 5 illustrates the knowledge conversion modes with the contents of knowledge and the knowledge spiral.

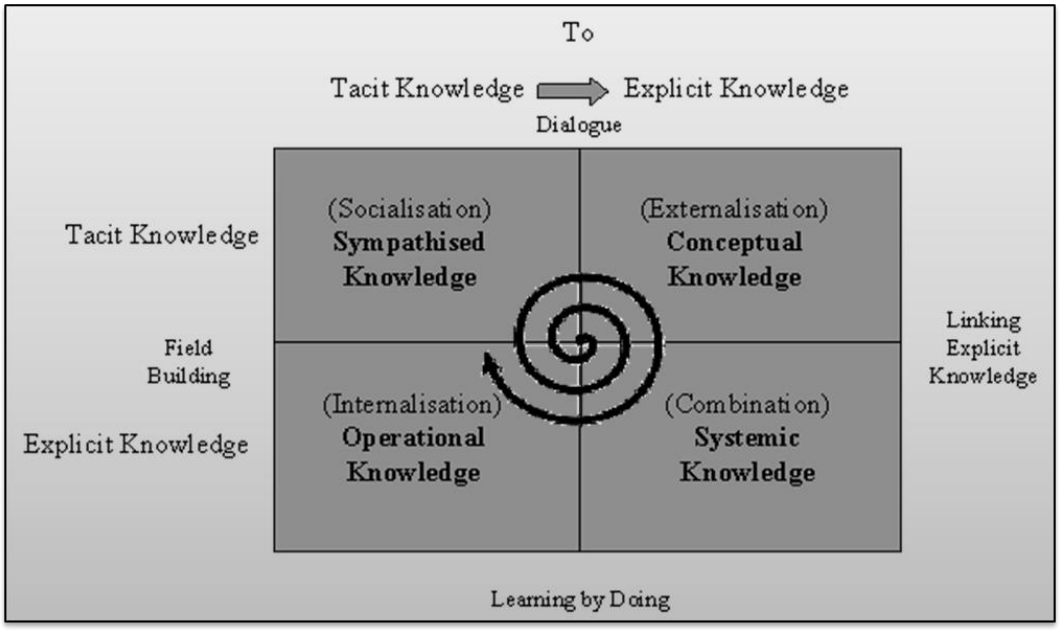


Figure 5. Nonaka and Takeuchi (1995) knowledge spiral with knowledge conversion modes and knowledge contents. Adapted from: http://www.iscn.at/select_newspaper/installation/sweden_fig2.gif.

Tripartite layered model of knowledge creation. The SECI model is now part of a tripartite layered model of knowledge creation (see Figure 6) where all the elements must

interact to form a spiral of knowledge creation (Nonaka, Toyama, et al., 2001; Nonaka, Toyama, & Konno, 2000). The other components of the model are "(b) ba, platforms for knowledge creation; and (c) knowledge assets, or the inputs, outputs and moderator of the knowledge-creation process" (Nonaka, Toyama, et al., 2001, p. 493).

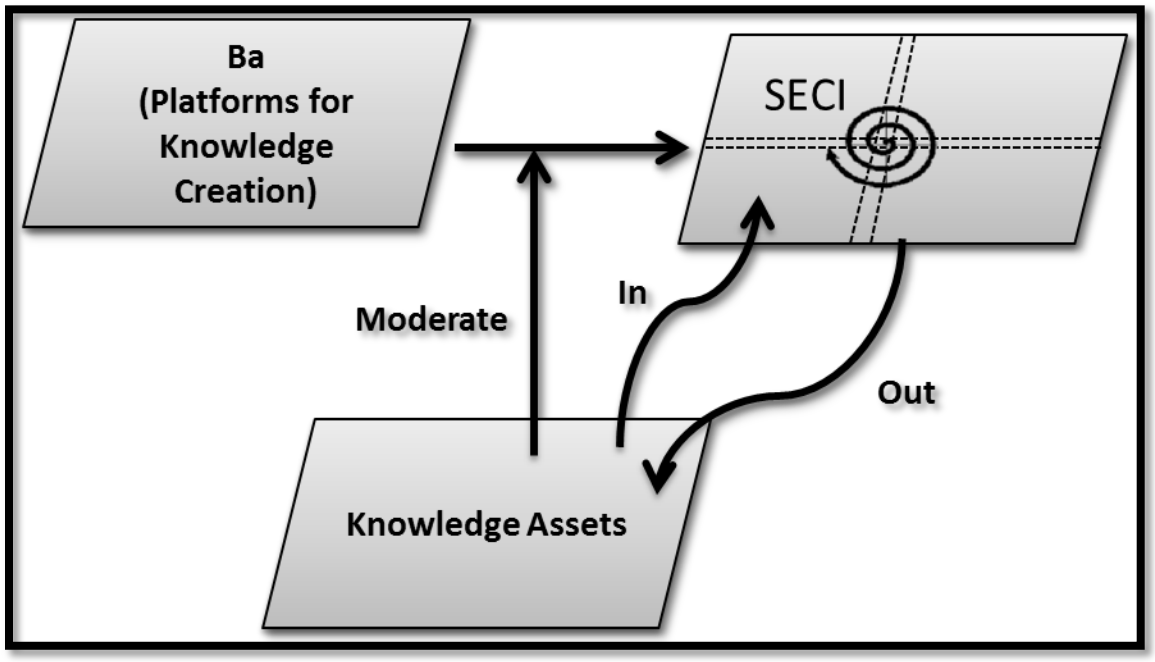


Figure 6. Tripartite layered model of knowledge creation. Adapted from Nonaka, Toyama et al. (2001).

Ba. According to Nonaka and colleagues (Nonaka & Konno, 1998; Nonaka, et al., 2001; Ikujiro Nonaka, Ryoko Toyama, & Noboru Konno, 2000), ba is a Japanese concept that basically means "place" in English and evolved out of the work of Japanese philosopher Kitaro Nishida and was later expanded by Shimizu. However, in the context of the tripartite model ba is defined as, " a context in which knowledge is shared, created, and utilized, in recognition of the fact that knowledge needs context in order to exist" (Nonaka, Toyama, et al., 2001, p. 499). Ba is crucial to the knowledge creation process and emphasize the importance of teams in creating shared context and it is through interaction in this shared context that new knowledge

emerges and knowledge moves from the individual to the organization (Ikujirō Nonaka & Hirotaka Takeuchi, 1995). Ba refers to place in the most generic sense and is not limited to a physical space, but includes virtual and mental space, as well as a combination. The defining feature of a ba is that interaction occurs in the space and through that interaction, significance and meaning are derived from the information that is shared and knowledge is created (Nonaka et al., 2000).

Nonaka, Toyama, et al. (2001) assert that ba may be similar to concept of community of practice where the work place and learning are tied together through practice and interaction in various trajectories (Brown & Duguid, 1991; Lave & Wenger, 1991; Wenger, 1998) but they outline that ba is fundamentally different in the following ways:

- A community of practice is designed for members to learn the knowledge that is integrated in the community while ba is focused on new knowledge creation.
- A community of practice has fairly stable boundaries (discipline, task, culture, history). The boundaries of a ba are more dynamic and flexible; participants can change them easily. "It is created, it functions, and then disappears, all as needed" (p. 499).
- In a community of practice there are several trajectories and through time spent in the community, members move up the trajectories to become full participants. Membership is not fixed in ba and members relate to the ba rather than belong to the ba.

There are four (4) kinds of ba and each is related to each of the knowledge conversion modes of the SECI model. Each ba provides the platform for a different kind of knowledge creation and, by extension, the knowledge creating spiral, however they are not exclusive (Nonaka & Konno, 1998; Ikujiro Nonaka et al., 2000). Each ba is defined based on two primary "dimensions of interaction": type and means. That is, whether the interaction takes place within the individual or

collectively and whether the interaction is by means of face-to-face or vicariously through virtual means like books, web conferencing etc. (Ikujiro Nonaka et al., 2000, p. 16).

Originating ba. The originating ba is associated with the socialization knowledge conversion phase, thus it involves the sharing of tacit knowledge and marks the beginning of the knowledge creation process. It is characterized by individual and face-to-face interactions (Nonaka et al., 2000). Tacit knowledge is transferred to tacit knowledge through the sharing of "feelings, emotions, experiences, and mental models" (Ikujiro Nonaka et al., 2000, p. 16). Individual barriers are broken down as individuals sympathize or empathize with each other; this may explain why the knowledge that emerges from socialization is called 'sympathetic knowledge'(Nonaka & Takeuchi, 1995) . As members participate in the originating ba they develop trust among each other; the level of commitment and concern increases as well and this forms the foundation for knowledge conversion.

Dialoguing ba. The dialoguing ba is associated with the externalization knowledge conversion phase thus tacit knowledge is made explicit and it is characterized by collective and face-to-face interactions. The skill of making abstract concepts and ideas more concrete is crucial to the success of this ba, usually done through metaphors and analogies (Nonaka & Konno, 1998) . Through dialogue, common terminologies and schema evolve as individuals share their mental models and skills and in the process self-reflect on their own thinking. The dialoguing ba is more structured than the originated ba in that individuals with complementary knowledge and skills need to be selected.

Systemizing ba. The systemizing ba is associated with the combination knowledge conversion phase thus explicit knowledge is made explicit and it is characterized by collective and virtual interactions (Ikujiro Nonaka et al., 2000). The systemizing ba usually involves

utilizing the collaborative affordances of information technology such as combining information in a database or content management system or exchanging ideas in a discussion forum or a wiki (Nonaka & Konno, 1998)

Exercising ba. The exercising ba is associated with the internalization knowledge conversion phase thus explicit knowledge is made tacit and it is characterized by individual and virtual interactions (Nonaka et al., 2000). The exercising ba can be compared to actual physical exercising where the body's muscles get stretched and the more it is done the better one gets. Similarly, in the exercising ba, through context specific job training and self-reflection, the individual undergoes continuous learning and improvement. The constant participation in the work experience inculcates certain patterns and ways of processing information which are reinforced through explicit means like manuals, training guides, etc. Eventually the knowledge becomes internalized and individuals develop automaticity in what they do.

Knowledge assets. In addition to the ba the tripartite model also acknowledges the role of knowledge assets. Nonaka, Toyama, et al. (2001) define knowledge assets as the "inputs and outputs of the knowledge-creation process" (p.501). Knowledge assets are unique to the organization and are integral to the value system and culture; through the SECI conversion process which is facilitated through ba, organizations are constantly creating new knowledge assets from existing ones. Knowledge assets cannot be managed like stocks and therefore require a system that takes into account their contextual and dynamic nature. There are four types of knowledge assets: experiential, conceptual, systemic, and routine.

Experiential knowledge asset. An experiential knowledge asset is tacit in nature and is developed through the process of socialization. It is created through the shared authentic experiences of organizational members and stakeholders. Experiential knowledge is engrained in

the culture of the organization, making it difficult to pattern and distinguishes one organization from another. Therefore "[organizations] must build their own knowledge assets through their own experience in their own context" (p.501). An essential characteristic of experiential knowledge is that it is human-centered; thus it involves a range of emotions, feelings and non-verbal expressions, such as trust, security, gestures, passion, enthusiasm, tension.

Conceptual knowledge asset. A conceptual knowledge asset is explicit in nature and is developed through externalization. It is created when experiential knowledge is articulated. Examples of conceptual knowledge include branding, product designs, logos, etc.

Systemic knowledge asset. A systemic knowledge asset is explicit in nature but more organized and comprehensive than conceptual knowledge. It is created through combination and may be viewed as 'packaged' knowledge; examples include patents, manuals, and product specifications. This kind of knowledge is easy to pass on and can be good for inter-company purposes as well as sharing outside and in some cases making a profit. The transferability of a systemic knowledge asset also makes it vulnerable to "hackers" and must be protected especially if the company's value stems from this kind of knowledge asset.

Routine knowledge asset. A routine knowledge asset is tacit in nature and represents the "taken for granted" aspects of the day to day operations of an organization. They are created through internalization; as exercises are repeated, a shared way of thinking and doing things is developed and reinforced. However, routine knowledge assets, if not managed carefully, may lead to inertia and hinder knowledge creation because the organization becomes set in its ways of doing things.

Managing the knowledge process. The three layers of SECI, ba, and knowledge asset must be managed efficiently as organizations continually expand existing knowledge assets by

cycling through SECI process in supportive platforms, ba. Nonaka, Toyama, et al. (2001) posit that the middle-up-down management model facilitates effective knowledge creation and management through fostering global interaction, while top-down and bottom-up place the knowledge creation responsibility at the individual level with little interaction. The tree structure of knowledge flow that exists in traditional hierarchy-based top-down companies does not facilitate knowledge creation globally as knowledge creation is assigned to the top managers. Basic information from the bottom is transmitted to the top and they create implementation plans to be executed by subordinates. Top managers therefore have to make sure that plans are very clear and practical (Nonaka, Toyama, et al., 2001). The bottom-up model is the extreme form of management where top managers take a "hands off" approach and leave the knowledge creation to organizational members. In this capacity top managers act as 'sponsors' and the organization is more individual focused with a high level of autonomy.

Middle-up-down management is most appropriate for knowledge creation as all members of the organization interact at different levels and knowledge creation is not left to one ontological level. The middle manager acts as 'knowledge producer' and navigates the knowledge creation process. Top managers give vision and road maps and middle managers break down vision in to concrete concepts and achievable, milestones, and goals. Knowledge creation can be chaotic with all the dialogue and individual insights so the roles of managers are like confusion traffic controllers where middle managers bridge the gap between the "what should be" frame of mind of top leaders and the "what is" frame of mind of employees (Nonaka & Takeuchi, 1995, p. 15).

Technology and KM

Though technology on it's own does not enable effective KM, when used to support organizational goals and the entire knowledge life cycle, technology has made KM more efficient and thus deserves some attention (Alavi & Denford, 2011; Cho, 2011; Hayes, 2011; Nonaka, Reinmöller, et al., 2001; Rosenberg, 2012; Salisbury, 2008). The impact of web 2.0 technologies necesitates that instructional designers consider the informal learning that the technology affords when designing KM initiatives in organizations (Rosenberg, 2012). The distinction between the terms information and knowledge transcends beyond mere definition of terms but also distinguishes various technology systems, as many have mistaken information management for KM, where information management focuses on capturing explicit data and is void of context and social relations (Nonaka, Reinmöller, et al., 2001).

Technology has facilitated the preservation and dissemination of information the challenge of creating a flexible dynamic environment that connects all the phases of the knowledge life cycle remains a challenge. The main focus of IT tends to be on combination. Organizations need more than mere capture of information in order to survive (Alavi & Denford, 2011; Hayes, 2011; Nonaka, Reinmöller, et al., 2001; Rosenberg, 2012; Salisbury, 2008). Thus, as Salisbury (2008) states:

> Effective organizations must be able to work and learn together-concurrently. The learning processes must be modeled and combined with work processes…The work processes and learning processes must live in the same space, occur at the same time and be interdependent (p.142).

Nonaka, Reinmöller, et al. (2001) divides technology into two complementary concepts: conversion support tools (CSTools) and action-reflection triggering (ART) systems. CSTools are

the tools that are used to make organizational knowledge conversion routine and systemized such as Wal-Mart's use of analytic systems to identify patterns in customers' purchases. ART systems are used to prompt employees to act and reflect such as Seven-Eleven's use of a system where employees can develop and test hypotheses easily (Nonaka, Reinmöller, et al., 2001). Hayes (2011) provides another classification of information technology tools affiliated with KM: integrative and interactive. The literature on integrative information technology addresses applications that allow for knowledge capture in retrospect where members of an organization can record things like lessons learned or problem solving steps to be retrieved later, for example, knowledge repositories. They also include systems that allow for a directory of company experts and their expertise. The literature on interactive information technology addresses applications that allow for ubiquitous interaction, for example, emails, wikis, and blogs. According to Hayes (2011) interactive technologies now encapsulates what is called E2.0 platforms, referring to technologies geared at facilitating collaboration and flow of knowledge throughout the knowledge life cycle; for example, the ability of users to tag data and the use of "pattern matching alorithms" for automatic tagging (p.85).

Critical Success Factors

Studies (Cho, 2011; Gold, Malhotra, & Segars, 2001; Haney, 2006; Nonaka & Takeuchi, 1995; Nonaka, Toyama, et al., 2001) have identified several success factors that foster an organization's effective iteration and management of the knowledge life cycle. These factors tend to span a wide range of organizational areas from people, culture, to technology. According to Haney (2006), there are seven critical success factors that must be taken into account when managing the knowledge life cycle : people, culture, technology, processes, structure, leadership, and measurement. Gold et al. (2001) proposed similar factors in the form of knowledge

capabilities. They group many of the factors mentioned by Haney (2006) under two broad categories of knowledge capabilities: Knowledge Infrastructure Capability (technology, structure, culture) and Knowledge Process Capability (acquisition, conversion, application, protection). Cho (2011) modified the KM capabilities framework proposed by Gold et al. (2001) by adding incentive under knowledge infrastructure capability (see Figure 7).

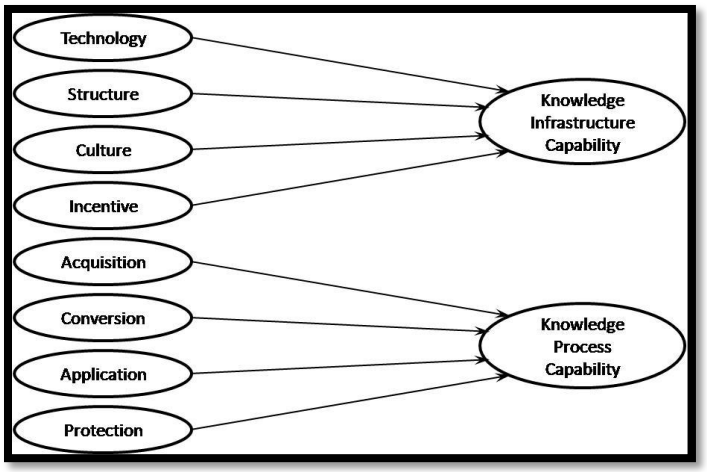


Figure 7. Cho (2011) Modified framework of KM capabilities.

Nonaka and Takeuchi (1995) refer to the success factors as enabling conditions and posit that an organization has to foster these conditions in order for knowledge to spiral effectively through the knowledge life cycle. The enabling conditions are intention, autonomy, fluctuation and creative chaos, redundancy and requisite variety. Each will be described briefly below:

- Intention: An organization's vision for and commitment to KM. Commitment is evidenced by implementation of a business/organizational strategy that enables the organization to effectively go through the stages of the knowledge life cycle. The vision also acts a yard stick in determining/justifying what knowledge is most valuable to the organization.

- Autonomy: Allowing organizational members at the individual level to exercise feasible levels of autonomy, this usually results in intrinsic motivation to create knowledge which in turn creates opportunities for the organization to grow.
- Fluctuation and creative chaos: Establishing a structure but at the same time promoting comfort with ambiguity and the unpredictable nature of external factors that influence the organization. Fluctuations results in a deviation from the organization's routines and things that are uncommon thus triggering knowledge creation through creative chaos. Creative chaos refers to an environment where members try to solve a problem through constant reflection "while in action" (p.79).
- Redundancy: Developing a shared repertoire of organizational knowledge through various activities. The knowledge transcends the basic requirements of organizational members and can be achieved through overlapping or strategic rotation of employees. An example of overlapping is where two different teams in an organization develop ideas for the same project and then debrief about the pros and cons of each approach.
- Requisite Variety: Ensuring that organizational members have a variety of expertise and also that they all have access to the same information sources or knowledge asset to build their knowledge. This will enable the organization to handle various complex problems.

Studying Knowledge in Organizational Settings

The preceding discussions focused on the literature surrounding the concepts of this study. The discussion will now move toward the literature surrounding the tools and processes for studying knowledge in an organization. To begin, the relationship between IDT and HPT will be established. After which the elements of the HPT model and critical incident technique (CIT) will be discussed as they both informed the methodology in Chapter 3.

The relationship between HPT and IDT. An examination of the history of HPT reveals that many HPT consultants started out as IDT specialists. They made the shift when many began to question the effectiveness of training on its own as a solution for achieving organizational goals. In their quest, they realized that training is not an end in itself, but it is just one of several other factors that may influence performance (Gilbert, 1987; Irlbeck, 2002; Molenda & Pershing, 2004; Robertson, 2004; Ruckdeschel, Yarter, Rivecdo, Cortes, & Cookson, 1998; G. Rummler, 2007; Tosti & Kaufman, 2007). Training is reliant on several other factors within a system in order to be effective. Therefore, one must be able to fully analyze those factors. In addition, training is said to have a short lived effect in the transfer context unless accompanied by other performance interventions. Molenda and Pershing (2004) sum up the need to examine factors other than training by stating that "training alone seldom solves performance problems. Almost all performance problems are rooted in more than one cause, and although training or instruction may be part of the solution, other interventions…are invariably required to make training payoff" (p.27). Thus, HPT is sometimes thought of as the big umbrella under which instructional technology falls. HPT is seen as a combination of IDT and non-instructional solutions to performance problems (Gilbert, 1987; Klein, 2010; Molenda & Pershing, 2004; Pershing, 2006; Rosenberg, Coscarelli, & Hutchison, 1999; Wilmoth, Prigmore, & Bray, 2002). According to Mager (1988) "In the HPT suprasystem, instructional technology is a subsystem, and HPT is a subsystem in the overall management suprasystem" (p.25).

Definitions of IDT and HPT. The relationship between IDT and HPT may be seen in their definitions. Some definitions of IDT allow one to see a clear distinction between the two fields, with IDT being focused on instructional solutions and HPT being more general to performance improvement as a whole (Gustafson & Branch, 2002; Smith & Ragan, 1999).

However, other definitions incorporate HPT into the definition of instructional design making it difficult to see a distinction (Rothwell & Kazanas, 2008). This could be due to the fact that "trainers are transitioning away from their traditional role of emphasizing instructional solutions and moving toward solutions designed to address the root causes of performance problems" (Rothwell, Hohne, & King, 2007, p. 13).

Gustafson and Branch (2002) define instructional design as, "a system of procedures for developing education and training programs in a consistent and reliable fashion" (p.17). Smith and Ragan (1999) provide a more comprehensive definition of instructional design as "the systematic and reflective process of translating principles of learning and instruction into plans for instructional materials, activities, information resources and evaluation" (p.2). Rothwell and Kazanas (2008) provide a very different definition from the previous two,

> Instructional design means more than literally creating instruction. It is associated with the broader concept of analyzing human performance problems systematically, identifying the root causes of those problems, considering various solutions to address the root causes, and implementing the solutions in ways designed to minimize the unintended consequences of corrective action. (p.3)

The International Society for Performance Improvement defines HPT on their website as:

> A systematic approach to improving productivity and competence uses a set of methods and procedures -- and a strategy for solving problems -- for realizing opportunities related to the performance of people. More specific, it is a process of selection, analysis, design, development, implementation, and evaluation of programs to most cost-effectively influence human behavior and accomplishment. It is a systematic combination of three

fundamental processes: performance analysis, cause analysis, and intervention selection, and can be applied to individuals, small groups, and large organizations. (ISPI, 2012)

In defining HPT Klein (2010) highlights the link to IDT by stating that, " human performance technology (HPT) expands the scope of instructional design and technology (IDT) by employing the systems approach to address a problem or realize an opportunity" (p.135). In addition, according to Klein and Fox (2004), in the 1990's IDT evolved to include HPT theories and practices. However, definitions after the 1990's (Gustafson & Branch, 2002; P. L. Smith & Ragan, 1999) are still referring to IDT as instructional solution focused; this indicates that the shift is not universal and there are varying views within the IDT profession. Nonetheless, it is evident that HPT is having an impact on IDT and some authors have reflected this shift by including HPT concepts in their definition of IDT (Reiser, 2001). The scenario reflected in the literature examined so far is that HPT evolved out of IDT, but now IDT is adapting to include HPT. The overlap between the definitions is not surprising as a lot of organizations, especially business and industry, are expecting instructional designers to have some HPT skills and currently in the workplace some IDT people are performing this role (Klein, 2010; Larson & Lockee, 2009; Ruckdeschel et al., 1998). Ruckdeschel et al. (1998) point out that people from other disciplines like human resources development and environmental engineering are often required to fill the capacity of HPT specialists. However, those with an IDT background seem to transition more easily to HPT than others. Rothwell et al. (2007) state that, "trainers are transitioning away from their traditional role of emphasizing instructional solutions and moving toward solutions designed to address the root causes of performance problems" (p.13).

HPT model. The HPT model (see Figure 8) is proposed by researchers (Haney, 2006; Massey et al., 2005; Schwen et al., 1998) as an effective framework to study KM practices in an

organization and has been successfully used to study knowledge flow, structure and patterns in organizations. The HPT model was initially designed by Deterline and Rosenberg and was published in 1992 by the International Society for Performance Improvement (ISPI). The model acts as a guideline for practitioners, providing them with specific things to do, illustrating feedback loops, and focusing on examining the interrelationships that exist among various organizational factors (Van Tiem, Moseley, & Dessinger, 2000). There are variations of this model and one may find differences in terminologies across authors. For example, Figure 9 is a previous representation of the HPT model taken from Van Tiem et al. (2000). When Figure 8 and 9 are compared, it is noticed that previously (Figure 9) cause analysis was separated from performance analysis, but currently they are grouped under one phase. This could be due to the fact that both performance analysis and cause analysis require the HPT practitioner to play the role of analyst (Rothwell et al., 2007). Another difference is that change management is illustrated as a revolving process in the current version. Nonetheless, the major phases remain the same and the changes reflect that HPT is indeed an evolving field. The following discussion will focus on the major processes, tools and data of each phase.

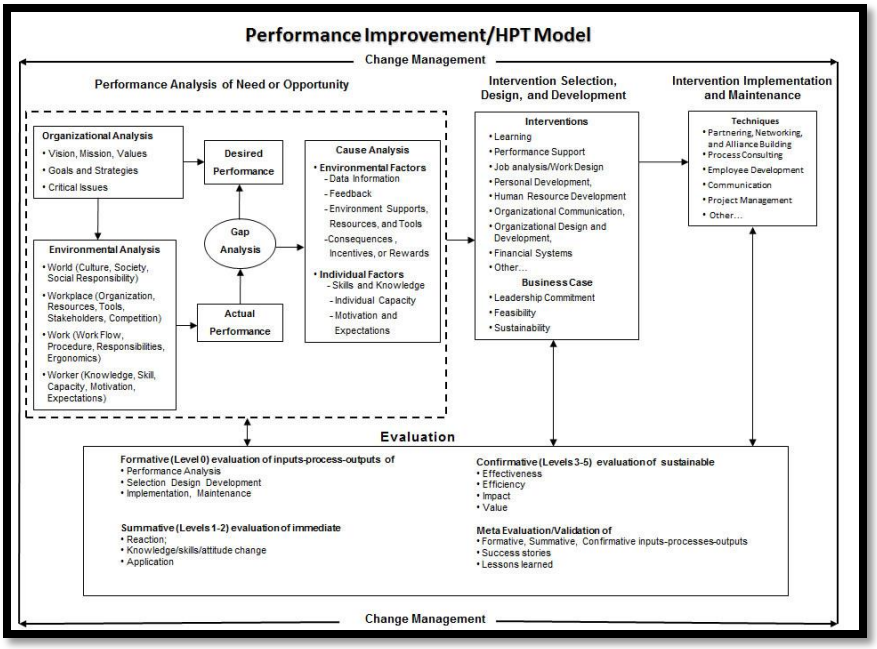


Figure 8. Current HPT model from Van Tiem et al. (2012)

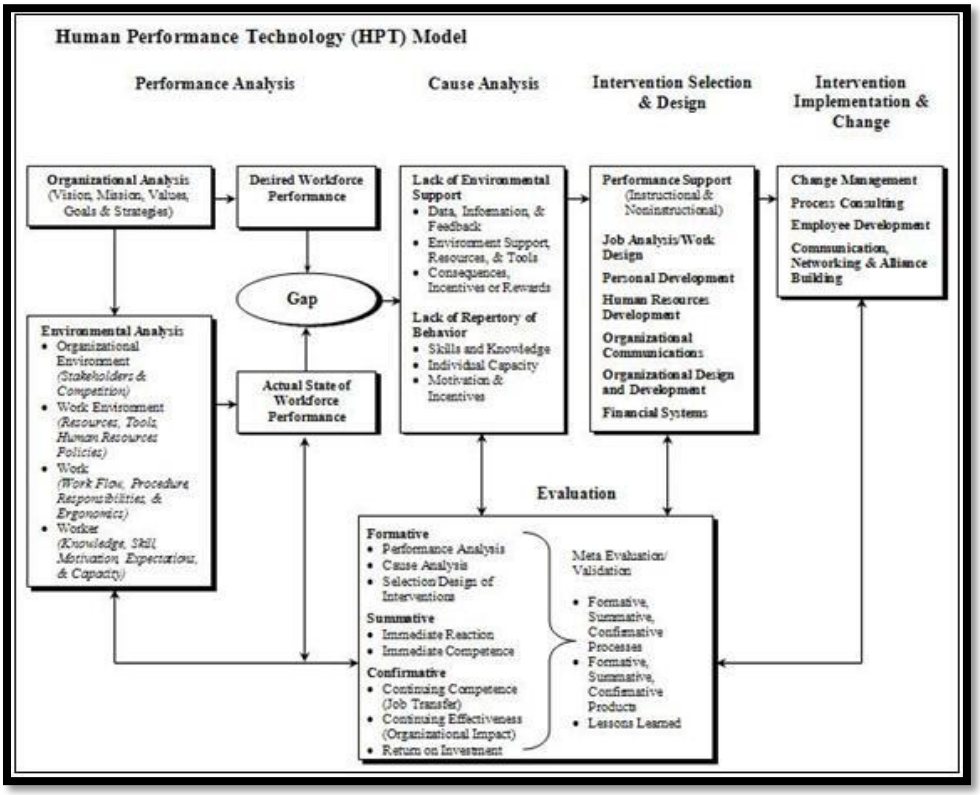


Figure 9. Previous version of the HPT model from Van Tiem et al. (2000)

Performance analysis of need or opportunity. The performance analysis of need or opportunity stage, as the current HPT model (Figure 8) illustrates, includes organizational analysis, environmental analysis, gap analysis and, cause analysis. Even though the current diagram groups all these analyses under one umbrella, on the International Society for Performance Improvement's website, they assert that HPT is "in reality, a systematic combination of three fundamental processes: performance analysis, cause analysis, and intervention selection" (ISPI, 2012). Therefore, under the performance analysis of need or opportunity phase the discussion will focus on the HPT practitioner as an analyst and performance analysis and cause analysis will be discussed separately.

HPT is empirical and relies heavily on information that is extracted from data collected. Rothwell et al. (2007) divide data sources into two categories: human and non-human. They further highlight that data may already exist (referred to as extant data) or the HPT practitioner may generate new data using tools like a survey. Rothwell et al. (2007, p. 54) provide some examples of potential human and non-human sources. Human sources include employees, supervisors, executives, clients/customers, vendors/suppliers, star performers and subject experts. Non-human sources include work records, exit interviews, help desk logs, absentee reports, performance appraisal data, financial reports, sales logs, survey data, benchmarking results and quality reports.

Performance analysis. In performance analysis, the HPT practitioner investigates the current situation in the organization. This involves learning about the organization's culture, policies, processes, and exactly what is happening. The practitioner also tries to capture the desired situation and expectations. Therefore, the performance analysis phase focuses on three primary areas: ascertaining the current performance state of the organization, the desired

performance state and the gaps between desired and actual performance (Rothwell, 2000; G. Rummler & Brache, 1995; Van Tiem et al., 2000). Environmental factors are also examined, since they impact performance as well. A performance analysis that is well done should focus on "the vision, mission, values, goals and strategies of the organization- the directions that particularly impact the desired state of performance. The internal and external environment-organization, competition, work performer-drivers that particularly affect the actual state of performance state" (Van Tiem et al., 2000, p. 23). Performance analysis is crucial to the entire HPT process. The findings of the performance analysis provide a framework for all subsequent activities. If the analysis is inaccurate "tremendous amounts of time, effort, and financial resources may be squandered on activity that does not solve the problem or achieve the goal" (Rothwell et al., 2007, p. 50).

Five primary techniques are used in performance analysis: extant data analysis, needs analysis, knowledge task analysis, procedural task analysis, and system task analysis (Rossett, 1989; Swanson, 1994; Van Tiem et al., 2000). As was previously mentioned, existing data is referred to as extant data. Extant data analysis involves examining existing organization records to find information about the current state of the organization. Examples of such documents are "sales reports, customer surveys, safety reports and quality control documentation" (Van Tiem et al., 2000, p. 24). The HPT practitioner uses qualitative and quantitative data collection instruments to gather information. These include "interviews, group processes (brainstorming, focus groups etc.), observation and surveys" (Van Tiem et al., 2000, p. 25).

Needs analysis is defined by Rossett (1989) as "the systematic effort that we make to gather opinions and ideas from a variety of sources on performance problems" (p.63). The data is collected primarily from human sources such as workers, customers, management, etc. Humans

are subjective in nature, so the data that is collected during needs analysis may not be objective. Nonetheless, it helps to get an idea of how different stakeholders view the current state of the organization and their opinions about things that need to be done for the organization to reach desired performance (Van Tiem et al., 2000).

Knowledge task analysis involves doing research on what skills and knowledge are needed for employees to perform optimally at what they do. The information is gathered from existing literature in the field as well as subject matter and performance experts (Swanson, 1994; Van Tiem et al., 2000). Van Tiem et al. (2000) describe the knowledge task analysis as "identifying and synthesizing the invisible details of optimal performance" (p.24). The information gathered during task analysis help HPT practitioners to make informed decisions about performance gaps.

Procedural task analysis can be deemed as the opposite of knowledge task analysis as it focuses on what can be observed. Swanson (1994) refers to this as, "documenting people-thing work place expertise" (p. 123). People-thing refers to the relationship that exist between the employee and the task they are expected to perform. The outcome of the performance analysis is a documentation of procedures required to perform various tasks, what Swanson (1994) refers to as,"cookbook style, step-by-step procedures" (p. 151). Van Tiem et al. (2000) postulate that one limitation of the procedural analysis is its focus on performance under normal conditions. Things are very dynamic in the global economy so investigating what is needed for abnormal conditions is very important.

Systems task analysis compensates for the limitation of procedural analysis and focuses on the expertise that is needed for optimal performance to occur when conditions are abnormal (Swanson, 1994; Van Tiem et al., 2000). Swanson (1994) state that "systems analysis can help

develop a more accurate picture and understanding of the selected system, the connections among subsystems, and the expertise required of those connections and handoffs from one expert worker to another" (p.ix).

Cause analysis. Cause analysis is a more micro examination of the organization to try and ascertain what factors are responsible for the gap between desired and actual performance. Chevalier (2003) categorizes the cause analysis into driving and restraining forces in determining the factors that affect performance. He defines,

> Driving forces are those factors that are already working to close the gap between the present and desired level of performance... Restraining forces are those factors that work against us as we try to close the gap between the present level and the desired level of performance. (p. 10)

Rothwell et al. (2007) caution HPT practitioners to be careful when determining causes. They highlight that one can easily confuse the consequence or presented problem with the root cause and this has dangerous implications. HPT divides these factors into two categories: organizational/environmental support and individual behavior. Environmental factors, as indicated in the HPT model in Figure 8, refer to information and feedback that are given to employees: the support and rewards system. In this case an organization is viewed like agriculture. The environmental factors are the soil and the people are the seed. In order for the plant to grow the soil must provide a fertile environment. Therefore, in order for an organization to flourish employees must be provided with an environment that fosters high performance. In keeping with the agriculture analogy, individual behavior is akin to the seed. The seed also needs to have some characteristics of its own to grow as well. If a dormant seed is placed in fertile soil

it won't grow. Therefore, individual behavior refers to what employees bring to the table, their knowledge, skills, attitudes, potential, values, motivation, and will power.

Intervention selection and design. According to Van Tiem et al. (2000) intervention selection and design are done after the problem has been fully analyzed, that is, what is causing the gap between desired and actual performance. This process is very similar to a doctor writing a prescription after diagnosis. Here the HPT practitioner has to do a lot of decision making to decide what interventions would best improve the problem. HPT is very systemic as previously mentioned, so interventions must aim to address the problems comprehensively and holistically. Some possible interventions include training, job aids, job redesign, personal development initiatives (coaching, mentoring, career development, informative feedback), improving organizational culture and communication, and organizational employee assessment metrics tied to a reward system.

Interventions are classified most times as either instructional or non-instructional. It is impossible for a HPT practitioner to be an expert in all interventions. However, a good HPT practitioner should have basic knowledge of both instructional and non-instructional interventions and know where to find information about others. Spitzer (1992) provides some guidelines for effectively selecting an intervention. He suggests that intervention design should be based on information derived from detailed cause analysis; interventions should be geared at the target audience and setting and should be timed well; interventions should be designed collaboratively utilizing all available resources, especially within the organization; interventions should have a sponsor who advocates for the implementation; interventions should be cost effective and requirements prioritized. Several intervention options should be explored and existing resources noted to avoid 'reinventing the wheel'; interventions should be long term and

be integrated into the organization's culture; interventions should be done in a cyclic manner ensuring that evaluation is done at each stage.

Spitzer (1992) goes on to suggest that a systems approach be adopted when designing interventions using the steps of analysis, design, development, implementation and evaluation. This systematic approach includes coordinating intervention efforts; making sure expectations are clear and agreed on; determining the requirements, components and specifications of the intervention; documenting the design and getting approval; prototype testing; and developing intervention with revisions.

Intervention implementation and change. According to Van Tiem et al. (2000) after the intervention is selected, it is time to put plans into action and monitor progress. This is where the people skills of an HPT practitioner are extremely crucial as plans have to be communicated to all stakeholders and changes have to be handled with sensitivity. Affected departments of the organization must view the implementation as a collaborative effort that will be beneficial to them. The HPT practitioner must be cognizant of and address fears and resistance to change. Some processes involved in this stage are setting realistic goal targets or milestones, process consulting, and ongoing support of employees. Rothwell et al. (2007) cite Rothwell and Sullivan (2005) who describe three change management approaches. According to Rothwell et al. (2007) HPT practitioners should be familiar with all three approaches and know when to use them. The first approach is the coercive approach, which is more like a dictator approach where people are given an ultimatum and forced to adapt to the change. Although this approach is very effective for emergency or crisis situations, it is often inappropriately used. The second approach is the persuasive approach, which is where the change is marketed as being in the best interest of all stakeholders. People are given detailed information about the initiative, and the benefits and

consequences. Support is solicited from people, measurable outcomes are established, and progress monitored and communicated. Some systems that may need to be established with this approach are a communication plan, tracking systems, and reward/incentive systems. The third approach is the normative re-educative approach, which is where people are not told what to do, but they become the drivers of change. It is based on the action research model. This approach requires working with individuals or groups within an organization that want change. The HPT practitioner will therefore help with background research, goal setting, communication plan, and so on.

Evaluation. Even though evaluation is looked at as a stage by itself, from the HPT model one can see that it is an iterative phase of constantly assessing the validity of information collected and monitoring progress of the intervention to make sure goals are being met. According to Van Tiem et al. (2000) there are three types of evaluation: formative (evaluation that is ongoing and provides information about improvements), summative (evaluation of effectiveness after intervention has been implemented) and confirmative (evaluation of the long term effects of intervention). In addition, there is a process known as "meta evaluation", which deals with the quality assurance measures that are put in place to ensure that the evaluation process is both valid and reliable.

Studying knowledge surrounding critical incidents. The study of knowledge involves employing some of the techniques and tools used by the HPT practitioner. It involves examining the cognitive processes of those involved and thus falls under the umbrella of Cognitive Task Analysis Techniques (CTA). According to Crandall, Klein, and Hoffman (2006) CTA refers to a body of research methods:

> used for studying and describing reasoning and knowledge. These studies include the activities of perceiving and attending that underlie performance of tasks, the cognitive skills and strategies needed to respond adeptly to complex situations, and the purposes, goals, and motivations for cognitive work…Cognitive Task Analysis methods provide procedures for systematic, scientific examination to support description and understanding (p.3).

Organizations are complex dynamic systems and often the various tasks involved in the operation are not linear or self-contained from other activities but in a wholistic sense all come together to achieve organizational goals or outcomes (Crandall et al., 2006) The study of knowledge in organizations requires selecting the most feasible tools and methods. CTA involves three major processes: knowledge elicitation, data analysis, and knowledge representation. Knowledge elicitation involves getting information from participants with regards to the knowledge surrounding their performance ensuring to capture the "what" and "how."

Knowledge elicitation can be conducted using a variety of methods. The main determinants of which method to use are based on (a) the source of the data, that is, is the investigation surrounding past events, or events in real time, and (b) the best means of acquiring the desired data. Crandall et al. (2006) divide sources of data or "where to look" in three different categories: Time (past, present, future); Realism (real world, simulation or scenarios); Difficulty (routine task, challenging tasks). Generality (abstract knowledge/specific events). For how to look the main ways are interviews, self-report, observation, automated capture.

Critical incident technique. CIT is considered to be a cognitive task analysis method (Crandall et al., 2006; Hanson & Brophy, 2012). CIT has its roots in Industrial Organizational Psychology since World War II where it was developed by John Flanagan who used it to analyze

success and challenges of aviation training (Butterfield, Borgen, Amundson, & Maglio, 2005; Flanagan, 1954; Hettlage & Steinlin, 2006). Since its inception over fifty-years ago, CIT has evolved and is recognized as a very reliable and valid tool for qualitative investigations (Butterfield et al., 2005; Chell, 2004; Chell & Pittaway, 1998). CIT does not refer to a strict specific set of rules, but the methodology is governed by principles that must be adjusted to meet the needs of the context and subject being studied (Flanagan, 1954) The main principles are that facts surrounding an incident can be effectively studied through collection of various perspectives, and data should only be collected regarding activities that have proven to have a significant impact on what is being studied (Flanagan, 1954). Initially it was set out as a technique using direct observation primarily as seen in Flanagan's (1954) definition, "The critical incident technique consists of a set of procedures for collecting direct observations of human behavior in such a way as to facilitate their potential usefulness in solving practical problems and developing broad psychological principles" (p.327). However, it has evolved from being positivist in nature to being more social constructivist and interpretivist (Butterfield et al., 2005; Chell, 2004) as seen in Chell's (2004) definition:

> a qualitative interview procedure which facilitates the investigation of significant occurrences (events, incidents, processes or issues) identified by the respondent, the way they are managed, and the outcomes in terms of perceived effects. The objective is to gain an understanding of the incident from the perspective of the individual, taking into account cognitive, affective and behavioral elements (p.48).

Hettlage and Steinlin's (2006) definition of CIT expresses similar sentiments like Chell's definition: " CIT is an open-ended retrospective method of finding out how the people concerned situate themselves with regard to the field being explored. It focuses on patterns of behaviour,

resources, skills and knowledge" (p. 6). CIT is also very ideal for studying organizational behavior as a whole according to Guimarães, Arce, and Mattos (2013) "CIT is adequate for exploratory research that seeks context-rich insights on events and their impacts on people and organization" (p.787). More specifically the technique is said to be useful for studying KM because of "its potential to help researchers understand the knowledge-related behaviors critical to complex situations and proceedings in and between all kind of groupings" (Hettlage & Steinlin, 2006, p. 4). CIT also helps with eliciting authentic information; as interviewees become immersed in their narratives they tend to give detailed responses and not what they think the interviewer would like to hear and in the process, tacit knowledge is evoked (Hettlage & Steinlin, 2006).

Summary

The knowledge life cycle processes of creation, dissemination, and preservation are crucial to the growth and survival of any organization; systems need to be in place to facilitate these processes under various constraints, such as in a fast-paced environment. In the fields of IDT and HPT practitioners deal with more than formal training and there is a need for practitioners to be involved in creating the environments and systems that facilitate management of the knowledge life cycle. Due to the contextual and dynamic nature of knowledge there are many debates with a clear move towards paying keen attention to not only technological factors but also the environment that the knowledge is situated in. More organizational case studies are therefore needed to provide insights in the contexts of various categories of organizations. From the overview of the literature, the value of studying knowledge in an organization from the perspective of the knowledge life cycle is evident as it provides a way to comprehensively analyze and report what is happening. Involvement of HPT and IDT practitioners requires an

understanding of how best to intervene and one way is to investigate through studying critical incidents. Both the conceptual literature and the literature regarding the process of studying knowledge emphasize that context and knowledge are inseparable and as such the methodology that follows is based on this premise.

Chapter 3: Methodology

From the literature review it is evident that there is a need for more studies that capture various contextual intricacies of the life cycle of knowledge within an organization. One such factor is during a period of high demand for service. This chapter outlines how a case study research design was used to investigate the knowledge life cycle specifically among a group of technicians as it relates to the critical incidents they dealt with during the period of very high demand for service.

Purpose Statement

The purpose of this study was to examine how workers in a fast-paced environment go through the knowledge life cycle when dealing with critical incidents and the factors that acted as driving and restraining forces.

Research Questions

1. How do workers in a fast-paced environment go through the knowledge life cycle processes (create, preserve, and disseminate) when dealing with critical incidents?
2. What are the factors that act as driving and restraining forces with regards to going through the knowledge life cycle when dealing with critical incidents?

Research Design

A single instrumental case study design (Stake, 1995) was used for this research. According to Stake (2005), an instrumental case study is where a "case is examined mainly to provide insight into an issue or to redraw a generalization. The case is of secondary interest, it plays a supportive role, and it facilitates our understanding of something else" (p. 445). Case

studies are valuable and have been used as building blocks in many disciplines to improve current practices as well as aid in the development of theory, interventions, policy, criteria for evaluating programs, and future research (Baxter & Jack, 2008; Eisenhardt, 1989; Merriam, 1998).

However, case study as a research method has evolved through many misconceptions. Case studies were formerly viewed as an exploratory component of other research methods rather than a research method in themselves; thus many definitions seem to reflect this misconception (Flyvbjerg, 2011; Merriam, 1998; Yin, 2009). In an effort to fully define case study as a true methodology, Yin (2009) provides a two part technical definition that addresses the scope, design, data collection and data analysis involved in a case study. Part one of the definition states, "a case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not easily evident" (p.18). The second part of the definition states, "The case study inquiry copes with the technically distinctive situation where there will be many more variables of interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from prior development of theoretical propositions to guide data collection and analysis" (p.18).

According to Merriam (1998), case studies are especially useful in studying process. Process may be seen as monitoring (for example, extent to which a phenomenon exist or is implemented) or finding causal explanations (for example, investigating how different variables affect a phenomenon). Yin (2009) further states that "case studies are the preferred method when (a) 'how' and 'why' questions are posed, (b) the investigator has little control over events, and (c) the focus is on contemporary phenomenon within a real life context" (p.2). Case studies

are also deemed the best way to study organizational behavior because they provide the opportunity to study context (Hartley, 2004) and thus may reveal intricacies surrounding the complex issues of work place learning and KM. Organizational case studies are needed as the findings help with informed decision making rather than assumptions (Fuller et al., 2007). A case study methodology was well suited for this study as the purpose of the research seeks to examine the "how" of the KM processes employed by the organization, and knowledge cannot be studied outside of the context in which it is used.

Case Selection and Unit of Analysis

According to Yin (2009), one rationale for a single case study is the typicality or representativeness of the case that is the findings from the single case can be assumed to reflect the experiences of similar people or environments on average. Yin recommends that the environment that will be used to do the single case study need to be investigated thoroughly to ensure it is representative; otherwise the researcher runs the risk of studying an environment that may not be as representative as believed. In addition Stake (2005) recommends selection of the case that offers the best opportunity for learning. Stake (2005) further suggests that we learn best from cases that we have easy access to and also ones where we can spend a reasonable amount of time.

In this case, participants were employees from a walk-in help desk in one of the technical colleges of a land grant university located in Southwest Virginia. This help desk from here on will be referred to by the pseudonym Software Help Desk (SHD). SHD falls under the supervision of the Associate Dean of International Programs and Information Technology. SHD was selected after preliminary discussions with the Associate Dean, the Director of Information Technology, the Manager of Information Systems and the SHD Supervisor. The discussions

surrounded the nature of the work environment and how knowledge flowed. From the discussion SHD was deemed to be representative of fast-paced environments during the period of the study. In addition, the researcher works with the Associate Dean of International Programs and Information Technology in another capacity and had easy access to the environment as well as the ability to spend sufficient time studying the case.

Boundaries

A challenge associated with case studies is scoping the study and framing the research questions in such a way that it is clear what is being studied and what is not being studied; researchers have therefore found it useful to place boundaries on the cases (Baxter & Jack, 2008). Baxter and Jack (2008), based on a synthesis of the work of qualitative research scholars, propose three possible ways to ensure that research questions for a case are not too broad and that the case is well defined, " (a) by time and place [based on Creswell]; (b) time and activity [based on Stake]; and (c) by definition and context [based on Miles & Huberman]" (p.546). This case study was bounded by time, activity, and context; data collection took place in August and September of 2013, and spanned the Summer and Fall semesters of 2013. From here on references to Summer, 2013 refers to that last month of the semester (August 8th – 25th) and Fall, 2013 refers to the first month of the semester (August 26th - September 27th). Data collection comprised of data collection related to gaining an understanding of the context, and also knowledge that was generated in response to critical incidents. The researcher and the organization collaboratively developed the definition for what was considered a critical incident. In addition, critical incident reports were only collected during the season that SHD had its highest demand for service, the time they referred to as 'rush' (August 26- September 27, 2013).

In order to truly understand the knowledge life cycle activities, a systemic approach, based on HPT, was adopted and used to align all the data collected.

Brief Description of Case

SHD assists undergraduate students in a technical college with software installation, operating system installation, driver issues, virus removal, networking issues, and hardware diagnostics. Based on preliminary discussions with the IT Director, the SHD team deals with approximately 7,000 incidents per year, on average, and each year the number increases. This number is derived from a customer log in system, where students who come for assistance swipe their ID cards and their visit is logged.

The SHD workforce is primarily comprised of student wage employees who are segmented into two groups: temporary workers who are hired for the first month of the new school year (some return the following Fall as temporary employees) and permanent employees who stay on until the end of the year and most likely for their entire time at the university. SHD usually starts the semester with 14-16 student employees and then after the first month of 'rush', around 6 - 8 remain. In addition to student employees, there is a SHD supervisor and a graduate assistant (GA), who acts as an assistant supervisor. On the day before the beginning of every Fall semester all the technicians (temporary and full time) meet for a one day orientation where they go over procedures, such as, installing common software; and expectations, such as, office code of conduct.

The beginning of the Fall semester (August 26, 2013 –September 27, 2013) is the busiest time of the school year for SHD and it is for this reason that critical incident reports were collected during this time. The team has to learn about features of updated technologies or brand-new ones that were implemented. There are usually several critical incidents that the team has to

troubleshoot as well. Preliminary discussions with the director and IT manager, who reports to the director and oversees the SHD supervisor, revealed that critical incidents that occurred in the past were related to licensing issues, hardware problems, downloading issues, viruses, driver problems, and similar issues. Based on preliminary discussions, at its simplest level an incident may be considered critical if it is a unique problem that has never been solved before and there is no documented procedure on how to solve it. A description of SHD and the work they do was published in the 2012 annual report from the college's Dean's office. Based on the 2012 annual report, of the problems that SHD deals with, "seventy percent of the time, the problem is one the technicians are already familiar with. The other 30 percent require the technician to perform research – talking to other technicians or searching the solution out online. Sometimes the manufacturer is consulted, and at times, learns of this new problem for the first time as well" (p.19). This study was concerned with the issues that fall under "the other 30%." Additionally, the IT manager stated an incident may be considered critical if one or more of the following criteria are met:

- Impacts the classroom and students' ability to perform.
- Lengthy repair/complicated fix (no solution after one hour) because the cause of the problem and/or solution is not immediately known and additional research needs to be done.
- Large/increasing number of occurrences.

The SHD supervisor reported that on average at the beginning of the Fall semester, critical incidents may occur daily. As the semester progresses, they may occur weekly and toward the end, just a few random problems may pop up from time to time.

Data Collection and Analysis Framework

Researchers that study knowledge in work place settings are strongly advised to examine the systems that surround the environment being explored (Fuller et al., 2007; Hartley, 2004). With this in mind the systemic and systematic thinking of the HPT model along with principles and procedures of CIT were used to create a framework for data collection, analysis and interpretation. This framework consists of three main phases:

1. Understanding the System, which is geared at collecting contextual information about SHD and is divided into two sections: organizational analysis and environmental analysis?
2. Critical Incident Analysis, which is geared at a detail examination of knowledge flow during the critical incidents that occurred using CIT.
3. Data Analysis and Interpretation of Findings, which is geared at putting all the pieces of the case study together to answer the research questions.

Figure 10 is a diagram illustrating the framework. Table 1 presents the alignment between the data collection analysis framework and the research questions, and Table 2 gives an overview of all the data collected from each phase and the participants that were involved.

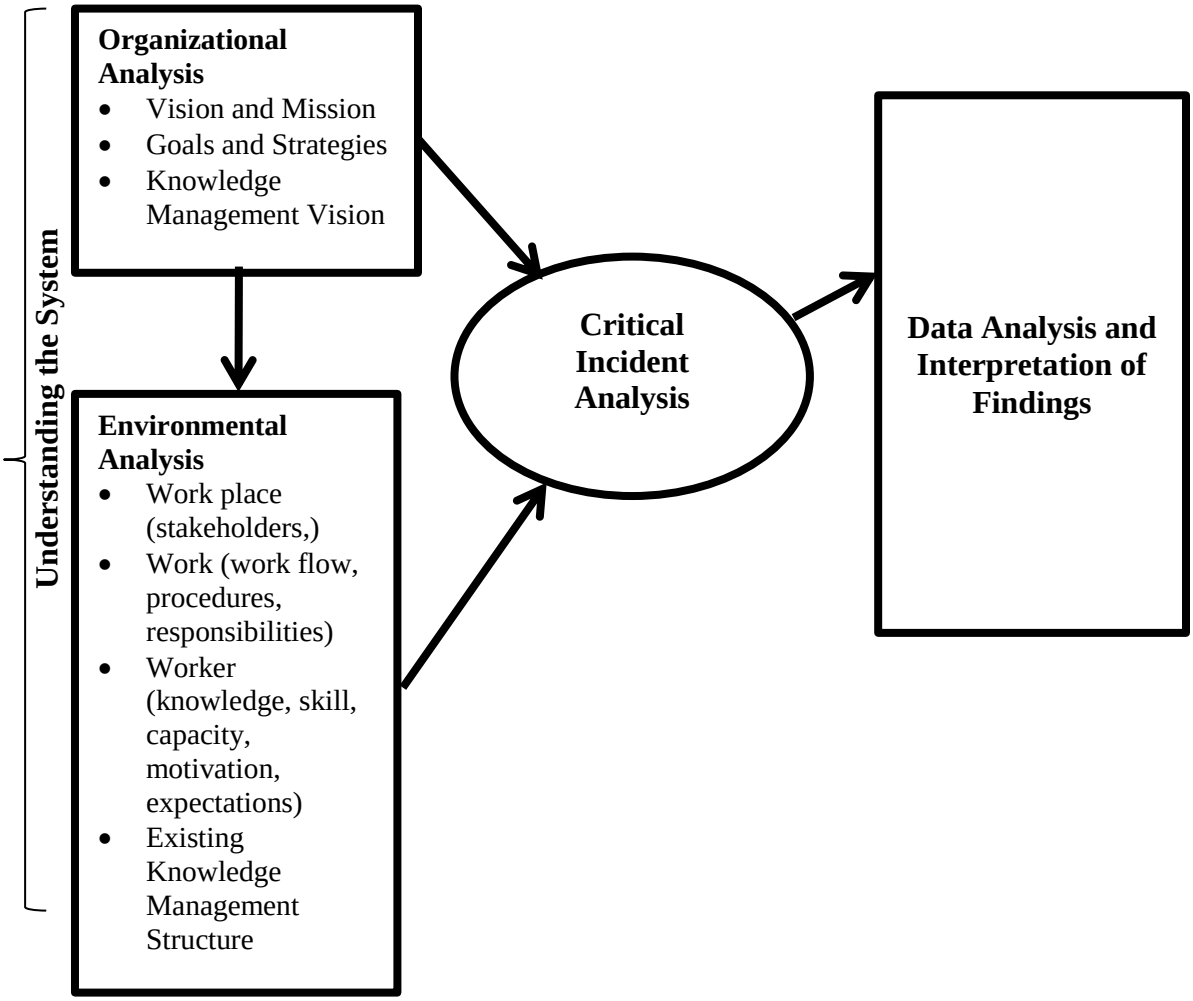


Figure 10. Data collection and analysis framework

Table 1

Alignment Between Data Collection and Analysis Framework with Research Questions

Phase	Overview	RQ 1	RQ 2
1A. Understanding the System: Organizational Analysis	Interview with the director of IT to understand the vision and mission of SHD overall and as it relates to managing the knowledge life cycle. Examination of 2012 annual report.	X	X
1B. Understanding the System: Environmental Analysis	Interview with SHD supervisor to understand how SHD actually operates and expectations for the semester. Examination of training agenda, wiki, and job descriptions.	X	X
2. Critical Incident Analysis	Focus group to get baseline data and definition of critical incident to the group. Individual interviews on critical incidents using CIT.	X	X
3. Data analysis and interpretation of findings	Each source of data was analyzed separately and then analysis aggregated.	X	X

Table 2

Overview of all the Data that was Collected for the Study for Each Phase

Phase	**Data Collected**	**Participants**
Understanding the System	2 Interviews	Director of IT SHD Supervisor
	Document Analysis	Annual Report Training Agenda Job descriptions
Critical Incident Analysis	1 focus group	Manager of Information Systems SHD Supervisor SHD Technicians
	19 reports of 11 incidents through interviews	SHD Supervisor SHD Technicians
	Document Analysis	Wiki

Phase I: understanding the system. In order to understand the SHD system, the first phase of data collection was centered on understanding SHD at the organizational and environmental level as defined by the HPT model.

Organizational analysis. The aim of the organizational analysis was to develop an organizational profile of SHD in order that the knowledge context can be situated. This was achieved by first examining the 2012 annual report mentioned earlier. The report gives the history of SHD and statistical data on services provided up to Fall, 2011. Based on the findings of the 2012 annual report, a semi-structured interview was conducted with the IT Director to obtain additional information and discuss insights gained from the report. According to Van Tiem et al. (2000), interviews are a useful tool for deciphering both facts and perceptions. The interview questions acted as a guide and leeway was given to further explore thoughts and ideas derived from the conversation (Van Tiem et al., 2000; Yin, 2009). Questions general to the organization were adapted from Van Tiem, Moseley and Dessinger's (2012, pp. 140-142) *Performance Support Tool: Organizational Analysis Survey* and *The Malcolm Balridge Criteria for Performance Excellence Award* preface section (see Appendix A). This criteria for performance excellence (CPE) is designed to guide the application process for the award managed by The National Institute of Standards and Technology (NIST), however it also acts as a useful instrument for organization self-assessment (Ford & Evans, 2000). See Appendix B.1 for interview protocol that was used with the director.

Environmental analysis. The aim of the environmental analysis was to get a greater understanding of how SHD operated, the workers, and existing KM structure. Information was ascertained from the supervisor using a semi-structured interview, as he works directly with the SHD team and thus he was the best person to provide the information. Questions were derived

from the Baldrige assessment and Van Tiem et al. (2012). See Appendix B.2 for interview protocol.

Phase II: critical incident analysis. Guidelines provided by Stitt-Gohdes, Lambrecht, and Redmann (2000) on how to use CIT were used in this study as their guidelines are rooted in the work of Flanagan (1954) and organized in a way appropriate for research in organizations. Stitt-Gohdes et al. (2000) recommend three main steps: step 1 is planning, step 2 is data collection, and step 3 is sorting and analyzing incidents. However, seeing that CIT is just one element of this bigger case study and one of the phases of the data collection and analysis framework for this study is 'Data Analysis and Interpretation of Findings', the following discussion will explain only steps 1 and 2 and how they were addressed in this study. Step 3 will be addressed in the data analysis section.

***Step 1*:** Develop plans and specifications for collecting factual incidents (e.g., determine from who the information is to be collected. Determine methods of collection. Develop instructions about the data collection).

The study's aim was to gain an understanding of how SHD went through the knowledge life cycle when dealing with critical incidents and the factors that acted as driving and restraining forces. First, it was integral that the researcher established a definition of critical incident in the context of SHD; a focus group was suited for this as it brought together a representative sample of the organization and provided opportunity for discourse among the group and ultimately agreement on what constitutes a critical incident. The preliminary criteria for critical incident mentioned earlier were ascertained from informal conversations with the IT manager and the director and reflected their views. It was vital that the definition of critical incident was clear and agreed upon by not only the core leadership of SHD, but also the workers/technicians, whom

the researcher primarily depended on for reporting when and if a critical incident occurred. As Yin (2009) points out, "key informants" are integral to the success of a case study as they are able to provide the researcher with in-depth information on issues (p.107). Key informants may be able to identify additional data sources that may converge or contradict the findings from the initial data collected, and in doing so provide for a more comprehensive study.

Focus group participants included the IT manager, supervisor, and two employees that worked with SHD for at least one year. The employees that participated were among the group of workers working for the summer semester as all other employees were away and thus participation was not feasible. According to Butterfield et al. (2005) consensus on what constitutes a critical incident is very important for research credibility. They report that in previous studies consensus was reached through "independent extraction" where experts determined whether the incidents identified by the researcher were critical or not (p.486). In this study the experts were the employees of SHD and plans were made so that all the critical incidents collected were self-identified incidents by SHD.

Second, during the Fall semester data was collected using interviews regarding the specific critical incidents that occurred. According to Crandall et al. (2006), it is not enough to just observe "what" people do with regards to complex task, but it is crucial to understand the "how" behind their actions and behavior, "how they think and what they know, how they organize and structure information, and what they seek to understand better" (p.3). On this premise they recommend interviews as they are less time intensive and allow the researcher to capture information that can easily be missed by other methods such as observation, especially if the researcher is not part of the organization, as is the case with this research study. Critical

incidents are not predictable and can occur at any given time; therefore observation was not an appropriate or effective method for this study.

Third, after determining the methods that were most appropriate, the researcher created a CIT interview protocol based on the purposes of the study and in accordance with the guidelines, for ascertaining a credible report, provided by Flanagan (1954). The protocol included guidelines for the researcher as well as questions that were placed in categories related to the study such as knowledge creation, knowledge preservation, knowledge dissemination and barriers and drivers. The same procedure and protocol was used for all interviews to maintain consistency. Please see Appendix E for a copy of the protocol.

Fourth, the decision was made to use the same protocol for the focus group and the CIT interviews. In this way, the focus group session was designed to serve a trifold purpose: (a) To obtain baseline data of what constituted critical incidents and how they were dealt with in the past; (b) To provide the researcher an opportunity to practice eliciting information about critical incidents before larger data collection started during the Fall semester, and ; (c) To determine if any changes should be made to the interview protocol for the Fall semester. Due to time constraints the researcher was unable to conduct a pilot study and the focus group acted as an alternative.

Fifth, people have a tendency to recall critical incidents better than routine events (Chell, 2004; Crandall et al., 2006) as critical incidents tend to be very pressuring and require a person to draw upon all their knowledge and skills to solve the problem (Crandall et al., 2006). However, studying retrospective incidents have the disadvantage that people may not be able to recall all the details of past events or may recall them inaccurately (Crandall et al., 2006). To combat this and help with the self-identification of incidents, an information sheet was created

for workers to briefly make notes at the time when the incident occurred (see Appendix D. 1). In addition, plans were made to get a report of each incident from all the workers involved, thus allowing for comparison of reports.

Sixth, According to Flanagan (1954), in CIT sampling is not done based on the number of people but based on the number of incidents and an incident is considered valid if it is specific, detailed and rich rather than general and full of 'fluff'. Therefore, plans were made to collect incidents until the point of saturation was reached; that is when new categories stopped emerging in the data, it is "considered a sign that the domain activity being studied has been adequately covered" (Butterfield et al., 2005, p. 487). Also, because the research is only concerned with the period where the services offered were highest in demand, the number of incidents was limited to only those that occurred during that time period.

Seventh, it was necessary to formally meet all the workers that would be working at the beginning of the Fall semester and introduce the study so that everyone shared a common understanding. The only time before the semester began that all the workers would meet was for SHD orientation on Sunday, August 25th, a day before the semester started. The SHD supervisor agreed to allow the researcher to speak to the group during the orientation about the goals of the research and participation requirements. The brief overview outlined the objectives of the research, issues of consent and participation, and endeavored to help participants feel comfortable giving information. During the orientation and throughout the study, the researcher did not use the term critical incident to participants as recommended by previous studies (Hanson & Brophy, 2012), instead the term uncommon problems was used and explanations focused on the definition that was derived from the focus group.

***Step 2*:** Collect episodes/critical incidents from knowledgeable individuals.

The first data collection regarding CIT was done in the summer via the focus group. In the focus group session the CIT interview protocol was used to guide participants in giving detailed descriptions of some uncommon issues they encountered in the past 12 months. They were asked what steps were taken to resolve the issues and what the outcomes were. The aim was to get an account that met the basic criteria outlined by Butterfield et al. (2005) and Hettlage and Steinlin (2006); that is, the account includes a description of the incident, a comprehensive rich description of the experience (actions or behavior) of dealing with the incident, and the outcome.

As noted in step 1, a form was developed to record brief details of the critical incidents encountered by workers. The beginning of the semester is very busy for SHD and the form was intended to allow employees to record brief details of the critical incidents they dealt with. However; during the SHD supervisor interview and the focus group session it was revealed that SHD already had a form/ information sheet in place for collecting similar information. The information sheet was used to record information about an incident if the customer had to leave before the problem was resolved or if a technician had to change shift before resolving an issue and no one else knew about the problem. In an effort to make data collection as seamless and non-intrusive as possible, the researcher did not use the original form she created (see Appendix D.1). Instead, the existing SHD information sheet (see Appendix D.2) was modified to serve the original SHD purpose and also the research purpose with the help of input from the focus group participants (see Appendix D.3 for modified form).

During the orientation the revised information sheet was introduced to the SHD employees and they were invited to fill it out whenever they encountered an uncommon problem. On the form they were asked to indicate if they may be contacted for an interview. Technicians

were asked to place their account of the incident in the same area they would put the information sheet they used previously.

Based on SHD's historical trends, critical incidents are likely to occur every day during the first two weeks of the semester. For this reason, the researcher visited the site every day during this period. This also provided an opportunity to assess if participants understood the expectations of the study and if the plans for data collection were working as intended in the real setting. After this initial period, the researcher visited the site twice per week in order to collect completed forms and double check with the SHD supervisor to see if any critical incident had occurred that was not recorded.

SHD had a whiteboard at the front of the room that served as a platform for brainstorming solutions and highlighting things that the technicians needed to remember on a regular basis. Seeing that this was a potential source of data collection the researcher asked technicians if they could place their initials when they wrote on the board. During the visits the researcher paid attention to the board. If something new was written on the board, but not recorded on the information sheet, the researcher inquired about it from the SHD supervisor or the technician who wrote it. See Figure 11 for an example of the whiteboard recordings.

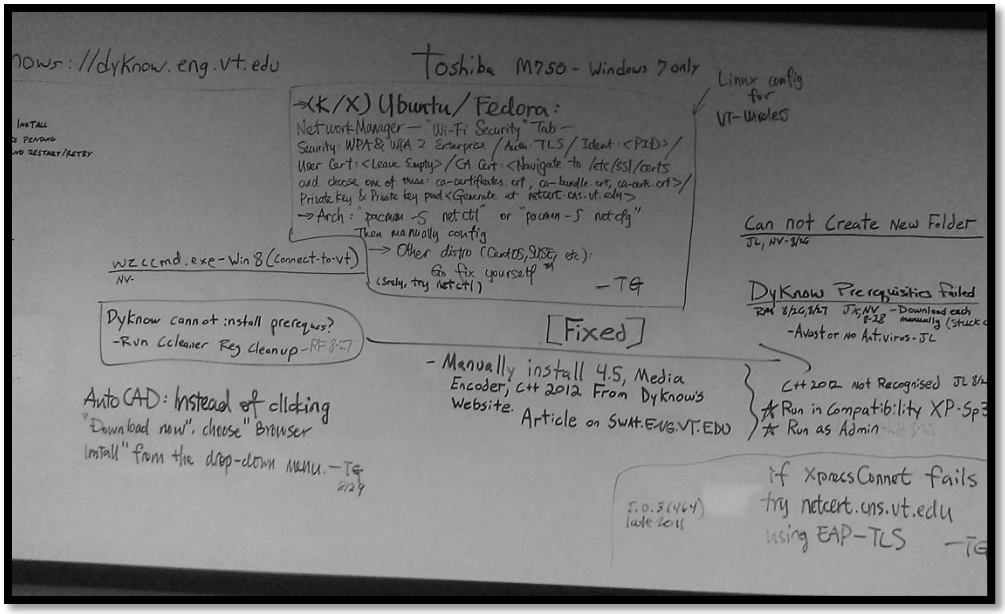


*Figure 11***.** Example of notes that were made on the board by technicians

Copies were made of the completed information sheets. If the customer has to leave before an incident is fixed, SHD requires that the person's email address and phone number be included on the form. Therefore, when photocopying an information sheet for a critical incident, identifying customer information was blocked out as this study is only interested in the technician's information.

After forms were collected, technicians who gave consent to be interviewed were emailed to schedule an interview to see how they went through the knowledge life cycle. The interview was crucial as previous studies found that respondents tend to leave out rich details when asked to record on their own (Urquhart et al., 2003). At the beginning of each interview, participants were given a copy of the information sheet they filled out and given time to read over what they wrote. Participants were also given the option to contact me if they would like to review the transcripts and categories. Descriptive validity was achieved through audio recording interviews and transcribing them (Butterfield et al., 2005).

An integral step to data analysis is data management (Merriam, 1998), so data management and tracking was done using one Excel file with different tabs. The first layer of tracking was done when the information sheet was collected. The information from the information sheet was used to create a critical incident profile and a record was made of things such as, the date the incident occurred, the technicians who were involved and the outcome. The incident was assigned a number and a short name. There was also a column that tracked how many of the technicians involved were interviewed (see Appendix E.1). The second layer of tracking was done while scheduling the interviews. There were times when one technician was involved with more than one incident at the time of the interview, so the researcher had to keep track of the incidents that each interview would focus on. This interview schedule Excel sheet helped to keep track if participants were sent an email to schedule an interview, when they scheduled, and the incidents that should be discussed. There was also a column for general notes after the interview (see Appendix E.2). The third layer was a more detailed account that summarized each interview based on the categories of questions asked. The "detail" Excel sheet included the incident name and number, the technician's names and coded what was said based on categories like, knowledge creation, knowledge preservation, etc. (see Appendix E.3).

Phase III: data analysis and interpretation of findings. Yin (2009) states that analyzing a case study can be very complex as it involves analyzing several different sources of evidence. Another factor is that very few resources are available that provide guidance in analyzing case study research, therefore he advises that the onus is on the researcher to devise their own empirically based methods of analyzing and to ensure that findings are presented with supporting evidence and consideration given to alternative explanations. The following macro guidelines provided by (Yin, 2009) were used to guide the analysis of the data:

1. The alignment between all evidence collected and the research questions were examined
2. Analysis focused on the important issues as identified in the research questions. Initial coding categories came from the literature/framework of the study but flexibility allowed for other categories to emerge.
3. Interpretations of findings were examined from alternative perspectives

Additionally, Baxter and Jack (2008) highlight their belief that the findings of each data source should not be treated independently, instead they should be combined and synthesized with regards to the case as a whole. With this in mind, the main strategy for analyzing the data was through direct interpretation and categorical aggregation (Stake, 1995); that is each incident and data source was interpreted first directly and then through aggregation with other sources and incidents, quite similar to the constant comparative method proposed by Glaser and Strauss (1967). The aim was to find patterns through examining relationships between categories that emerged in themes; as Stake (2005) explains "the search for meaning often is a search for patterns, for consistency, for consistency within certain conditions, which we call 'correspondence'" (p.78). After this, naturalistic generalizations (Stake, 1995) can be made, that is, the lessons that can be learned from studying the case.

Data analysis was tied to data collection and was an ongoing process (Ely, 1991; Hartley, 2004; Merriam, 1998) where by the researcher used memoing and reflective field notes (Miles & Huberman, 1994) to keep track of things noted and hunches, as well as the data management strategies outlined previously. After all the data were collected, audio recordings were transcribed by a professional transcriber and a confidentiality agreement was signed by her. Each completed transcript was checked against the audio recording for accuracy and corrections made, where necessary, using track changes in Microsoft Word. In some cases the technician

was asked to help in identifying things that were inaudible as well as to clarify sections. The review process for accuracy also acted as an avenue for preliminary coding or pre-coding (Saldaña, 2013) . Pre-coding was done inductively (Norman, Redfern, Tomalin, & Oliver, 1992; Schluter, Seaton, & Chaboyer, 2008) with the aim of identifying the nature of the activities that took place at each phase of the knowledge life cycle and the participants' experiences.

During the pre-coding I combed through the data or what Yin (2009, p. 129) refers to as "playing" with the data. Anything that stood out was highlighted, bolded etc and the comment feature in Microsoft Word was used to annotate the transcriptions. In addition, for each interview an analysis file was created in Evernote that included the notes that were made after the actual interview. Memos were made of any hunches and first impressions while listening to the interview and these also guided further analysis (Saldaña, 2013) and in vivo quotes were copied as well. In addition, in vivo quotes were used to substantiate notes made in the Excel sheets that were used for data management (see Appendix E.3). This process involved the recurring steps of "data reduction (breaking data down in to manageable and meaningful chunks) and interpretation (extracting meaning from data)" Marshall & Rossman (2011, p. 209).

As I began noticing trends and was able to identify patterns, I created a coding scheme which involved categories and sub-codes and the qualitative data analysis software, MAXQDA11was used to support more detailed descriptive coding (Miles & Huberman, 1994; Saldaña, 2013). The categories for the coding scheme were "distilled from the literature" (Ely, 1991, p. 143). However room was left for analytical categories (Ely, 1991) based on what emerged from the data. The main categories were based on the knowledge life cycle and those were create, disseminate, and preserve. Two others were directly based on my research question, driving forces and restraining forces, which also came from the literature. Others were based on

segments of questions on the interview protocol that I wanted to examine in more detailed (wish list and understanding the system). Pre-coding revealed an overlap between some of the phases of the knowledge life cycle. To further examine the overlap and minimize confusion, each overlapping sub-category was labelled based on the phase of the knowledge life cycle for example, email/preserve, email/disseminate. During pre-coding as well, I noticed that the supervisor was important in all the stages of the life cycle and I wanted to isolate quotes that referenced him so another coding category called SHD supervisor was created. It was also noticed that mention was made of the temps on various occasions and wanted to isolate these quotes as well so another category using versus coding (Saldaña, 2013) called "Temp vs. Full Time" was created. A "code memo" was created for each sub-code in MAXQDA 11, where I made note of exactly what the code meant especially when things were similar. For example, under the category of restraining forces there was the sub-code "other system issues" the code memo for that was:

> "This includes quotes that mention a lack of a system to easily access knowledge as well as problems with existing system that did not include the whiteboard or history of actual problem. Also quotes that included people not using the system or flaws"

The Table below represents my start list of codes (Miles & Huberman, 1994).

Table 3
Start List of Codes for MAXQDA 11

Category	Sub-codes
Create	• Talk with customer • Information from whiteboard/information sheet • Wouldn't do anything differently • Would do something differently • Going About connections • Inquire from vendor/manufacturer • Consult/handover to other technician • Search online

Preserve	• Email/Preserve • Information Sheet • Website • Wiki • Whiteboard/Preserve
Disseminate	• Inform Supervisor • Share on website • Email\disseminate • Word of Mouth • Whiteboard\Disseminate
Driving Forces	• Infrastructure and Resources • Shared understanding/Standardization • Awareness of expertise • Successful online search • Information from whiteboard • Help from other technicians
Restraining Forces	• Whiteboard Limitations • No History of actual problem • Other System Issues • Poor Communication from manufacturer • Time/High Demand • Unsuccessful online Search
Wish List	• SHD Related • Manufacturer\External Related • "We have everything we need"
SHD Supervisor	No sub-codes
Temp vs. Full time	No sub-codes

The software helped me to organize the data, ensure that all evidence was attended to and provided a visual way to examine the dominant things that were emerging. I already had impressions while pre-coding so this was also a way to see the alignment between my impressions and the magnitude of the evidence. While coding in MAXQDA11 my coding scheme evolved when I found something that was important and realized I did not have a code/category for it. For example, one of my questions asked participants to describe the problem; I did not have a code for this so created one called "Critical Incident Described."

Coding was based on quotes from interviews that represented category/code. Therefore, an interview could contain several of the same codes. While coding in MAXQDA11, I also created a Word document where I created memos and I copied over quotes that were striking and I did not want to forget and also made notes of analytical insights. This marked my second phase of analysis and a more detailed examination of the data. Figure 12 is a screen shot of the Word document. Please note that any identifying information was erased from the screenshot. I also isolated some variables that kept coming up and created a matrix based on incident and technicians that were interviewed in Excel. The variables I isolated were the first steps the technicians took, whether they Googled or not, if they would do something differently, if they had a 'wish list', if they wrote on the whiteboard, if they informed the SHD supervisor and whether or not they were unaware of what a previous technician that worked with the same customer did. Figure 13 is a screen shot of the matrix in Excel. Please note that any identifying information was erased from this screenshot as well. Analyzing the data with MAXQDA11 and manually with Word and Excel gave me an opportunity to comb through the data in different ways.

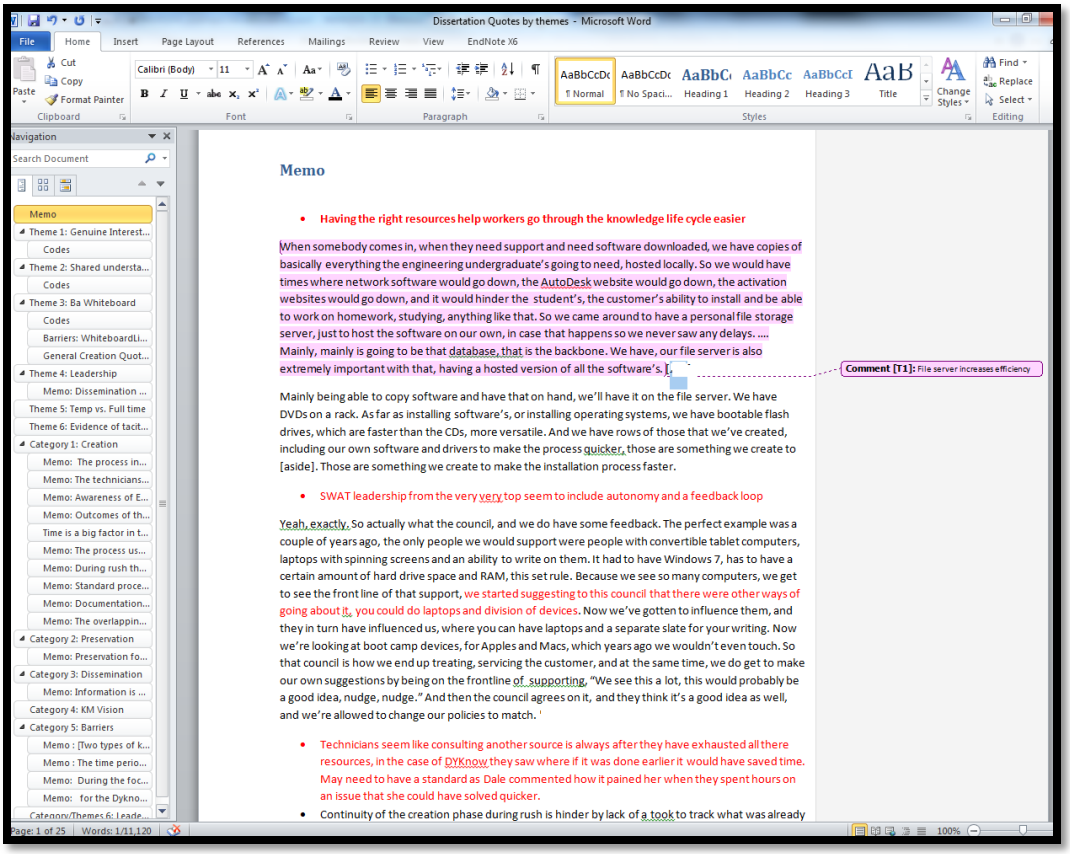
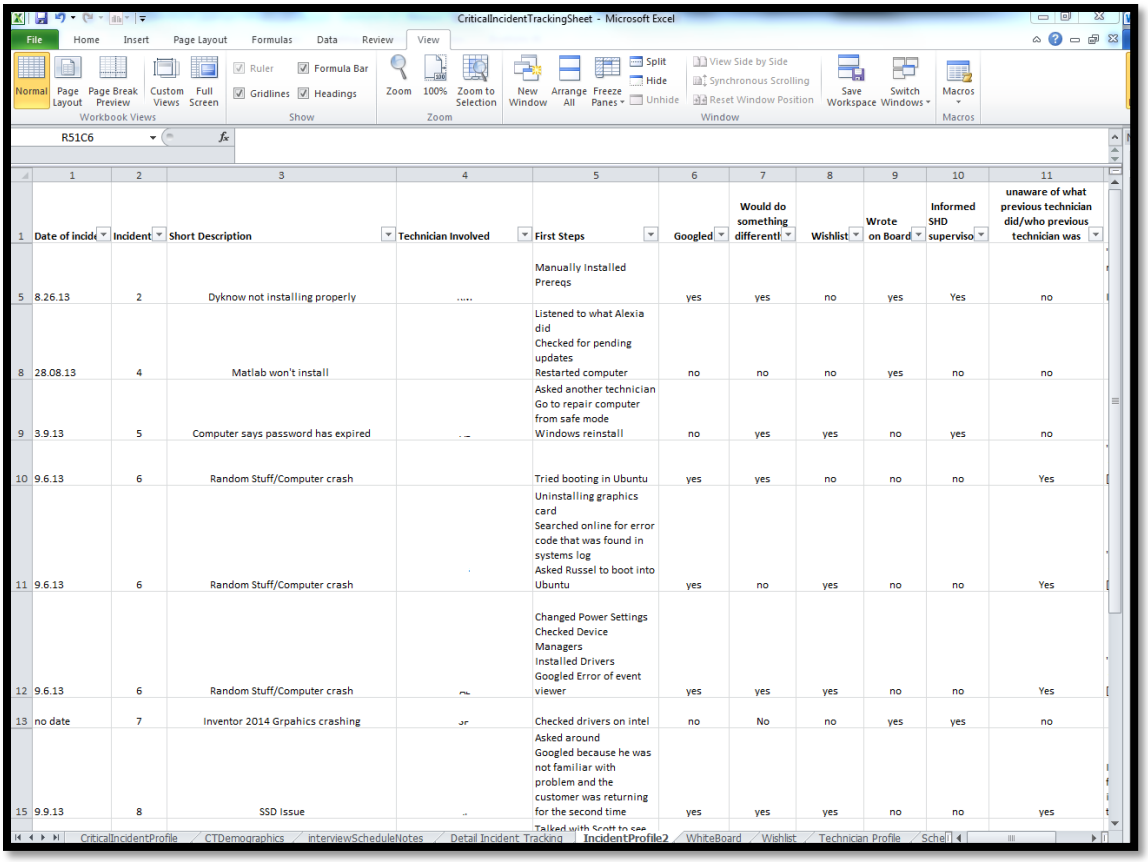


Figure 12. Screen shot of memo in Microsoft Word



CriticalIncidentTrackingSheet - Microsoft Excel

	1	2	3	4	5	6	7	8	9	10	11
1	Date of incid	Incident	Short Description	Technician Involved	First Steps	Googled	Would do something differentl	Wishlist	Wrote on Board	Informed SHD supervisc	unaware of what previous technician did/who previous technician was
5	8.26.13	2	Dyknow not installing properly	.....	Manually Installed Prereqs	yes	yes	no	yes	Yes	no
8	28.08.13	4	Matlab won't install		Listened to what Alexia did Checked for pending updates Restarted computer	no	no	no	yes	no	no
9	3.9.13	5	Computer says password has expired		Asked another technician Go to repair computer from safe mode Windows reinstall	no	yes	yes	no	yes	no
10	9.6.13	6	Random Stuff/Computer crash		Tried booting in Ubuntu	yes	yes	no	no	no	Yes
11	9.6.13	6	Random Stuff/Computer crash		Uninstalling graphics card Searched online for error code that was found in systems log Asked Russel to boot into Ubuntu	yes	no	yes	no	no	Yes
12	9.6.13	6	Random Stuff/Computer crash		Changed Power Settings Checked Device Managers Installed Drivers Googled Error of event viewer	yes	yes	yes	no	no	Yes
13	no date	7	Inventor 2014 Grpahics crashing		Checked drivers on intel	no	No	no	yes	yes	no
15	9.9.13	8	SSD Issue		Asked around Googled because he was not familiar with problem and the customer was returning for the second time	yes	yes	yes	no	no	yes

Figure 13. Matrix showing variables based on incident and technicians.

MAXQDA 11 was helpful, however as Yin (2009) points out, the researcher "will need to study the outputs to determine whether any meaningful patterns are emerging" (p.129) as the output of the software presents information that is descriptive rather than of a higher conceptual level which is required for answering "how" and "why" questions as is the case in this study. Phase 3 was then to see the higher patterns that were emerging across categories and across data sources and this is where categorical aggregation (Stake, 1995) and theme formation occurred. In order to see the themes that emerged from the data as a result of detailed analysis (Saldaña, 2013), I looked at the statistics of sub-codes generated from MAXQDA 11 and I read over my reflective notes and memos. During the process I realized that the in vivo sub-code "Going about

Connections" that I placed under the category of create was larger than that and could be used to explain the big picture.

First, going about connections could be seen in how they problem solved or created knowledge: they connected with their previous knowledge, they connected with what the customer said, they connected with what was already shared or documented (which is disseminate and preserve). Also I examined the statistics of sub-codes from MAXQDA 11 for restraining forces (see Appendix F.1) and I realized that the biggest barrier was no history of the actual problem and I realized that one possible reason could be that it prevented them from "going about connections." I also looked at the statistics of sub codes for the category 'driver' and the biggest driver was information from the whiteboard. Second, I revisited the KM vision that the director had and I also realized that one outcome that she wanted from managing the knowledge life cycle was to be able to derive a pattern of analysis from all the incidents that may influence future processes. So based on multiple sources of evidence, "going about connections" was one theme that emerged. I immediately started doing an outline to see how this theme played out and sought other themes that explained the process. I identified "working together" as a theme as I saw that throughout as well. In gathering the evidence for that I realized that it could be placed under the theme of "going about connections." I did this for several ideas again and realized that the answer to my "how" question was "going about connections." My next step was to look at the driving and restraining forces to them going about connections, whereas before I separated the restraining and driving forces in terms of create, preserve, and disseminate. The results of this analysis are presented in Chapter 4.

Research Quality and Rigor

Qualitative research is most commonly judged by standards of trustworthiness, which deal with issues of credibility, transferability, dependability and conformability based on the work of Lincoln and Guba (Anfara, Brown, & Mangione, 2002; Ely, 1991; Krefting, 1991; Miles & Huberman, 1994). Taking these issues into consideration throughout one's research ensures the integrity of the study; that is data collection is done with great rigor, findings are derived from sufficient evidence that truly reflect the context and constructs studied, and methods are described in sufficient detail so that another research can replicate the study.

Credibility refers to the believability of the findings to the population studied as well as the audience that will read the findings; it also refers to believability regarding the constructs that were examined. Some of the ways that credibility can be achieved includes collecting data from multiple sources of evidence and people, spending sufficient time in the field, member checking, and having peers examine findings (Anfara et al., 2002; Ely, 1991; Krefting, 1991; Miles & Huberman, 1994). In this case study, the phases of the knowledge life cycle were derived from the literature. The interview questions were created for each phase and were based on the definitions in the literature. In addition the questions were categorized accordingly, making it easy to identify the specific concepts that each question addressed. Integrating the criteria for what is considered a credible report of an incident along with questions that were based on the literature helped in ensuring that the study examined the knowledge life cycle process surrounding critical incidents as intended. Another layer of credibility was the fact that the definition of what constitutes a critical incident was based on the organizational context and all the incidents that were collected were self-identified and reported by members of the organization. Furthermore, the fact that multiple sources of data were collected helped with

triangulating the data. After preliminary findings were derived, member checking was done individually with all the members of the management team and a sample of technicians who were available; all confirmed that the findings were an accurate representation of SHD. The findings were also reviewed by my academic advisor and several colleagues; their suggestions were taken into consideration and informed further revisions.

Transferability refers to the level of applicability and generalizability of the study's findings to similar settings. Some of the ways for achieving transferability are by providing a detailed description of the context studied and through purposefully selecting the population studied (Anfara et al., 2002; Krefting, 1991; Miles & Huberman, 1994). In this case study preliminary research was done to ensure that SHD was a good fit for the study. In addition, a comprehensive description of the context studied and the participants is given that will enable others to sufficiently determine if the findings can be applied to their setting. The interpretation of the findings takes into consideration the big picture and includes general interpretations.

Dependability refers to the level of consistency throughout the study and the extent that the study can be replicated. Some ways to achieve dependability are by providing a detail description of the data collection and analysis process, collecting information from more than one sources or people, having someone else examine the data and to do several iterations of coding (Anfara et al., 2002; Krefting, 1991; Miles & Huberman, 1994). In this case study data collection and analysis was done rigorously and details of the steps taken are provided so that another research could follow the procedures. Data was collected from various sources and people. In addition the data was combed through several times and in different ways before finalizing findings.

Conformability is closely tied with dependability and refers to the level of objectivity in the findings. Some ways to achieve conformability are through memos and audit trails, collecting data from multiple sources and people, and being cognizant of possible researcher biases (Anfara et al., 2002; Krefting, 1991; Miles & Huberman, 1994). In this case study memoing was done throughout documenting all hunches and insights and making sure they were validated through the data and through double checking with participants before they were incorporated in the findings.

Chapter 4: Results

This chapter gives a report of the findings as they relate to the purpose of this study, which was to examine how workers in a fast-paced environment, go through the knowledge life cycle when dealing with critical incidents and the factors that acted as driving and restraining forces. The discussion begins with an overview of the participants involved, and the data collected. After which, findings are broken down in alignment with the data collection and analysis framework (see Figure 10) which was used for the study. The findings are broken down accordingly with the following major sections: "Understanding the System," "Critical Incident Analysis," and the aggregated analysis of these two pieces which is titled, "Putting all the Pieces Together." In the Understanding the System section a report of the setting studied is presented using the categorization of environmental and organizational analysis from the HPT model which influenced the framework, highlighting what was learned about the organizational context including its mission, vision, processes, leadership, and so forth. In the Critical Incident Analysis section, the results are discussed primarily based on the MAXQDA11 statistical sub-code analysis for each phase of the knowledge life cycle (create, preserve, disseminate). Finally, the Putting all the Pieces Together section presents the "big picture" view that emerged from connecting the insights gained from Understanding the System and Critical Incident Analysis. Assertions are illustrated with selected quotes. However, substantial evidence was found for each assertion.

Research Participants

SHD was the population for this case study and thus by virtue of working for SHD all consenting employees were potential participants of this study. As was discussed in Chapter 3 the methodology for this case study adopted a phasic approach and participants varied primarily by participation in the Critical Incident Analysis, and Understanding the System phases of this study. Significant amount of the contextual information was collected from the leadership team during the "Understanding the System" phase of this study. The leadership team was comprised of the director of information technology, the manager of information systems and the SHD supervisor (see Table 4 for the demographics of the leadership team). From here on the director of IT will just be referred to as "director" and the manager of information systems, will be referred to as "manager" and the SHD supervisor as "supervisor."

Table 4:
Software Help Desk (SHD) Leadership Team Who Participated in the Study

Title	Gender	Number of Years at SHD
Director of Information Technology	Female	8
Manager, Information Systems	Male	6.25
SHD Supervisor	Male	3

Phase two of the study was on critical incidents. The main sources of data comprised of consenting technicians who were involved in finding a solution for a critical incident that occurred during the period of this study in the Fall of 2013. By virtue of this criterion, technicians who did not participate in a critical incident did not have an opportunity to participate in this phase of the study.

Of the 16 technicians that worked at the beginning of the semester 8, in addition to the supervisor, were involved in the critical incidents that were reported, bringing the total to 9

participants. Incidentally, the two technicians that participated in the focus group in Summer, 2013 were among the technicians that were involved in the critical incidents collected during Fall, 2013. Two of the 8 were temporary workers and one of the temporary workers indicated that he is usually full time, but was taking this semester off. Most of the participants were students from varying departments within the College of Engineering with varying majors, such as Computer Science (CS), Aerospace and Ocean Engineering (AOE), Electrical and Computer Engineering (ECE), Engineering Science and Mechanics (ESM), and Mechanical Engineering (ME). Five of the technicians were juniors and three were seniors. The time that technicians have been working with SHD varied from very first time to 3 years with most working with SHD more than one year (N=6). Most of the technicians were males (N=6) with only two females. It is interesting to note that most of the participants (N =5) only had informal work experience and learned a lot on their own, while the others (N=3) had both informal and formal work experiences. Figure 14 below provides a visual representation of the demographics of the technicians by categories discussed.

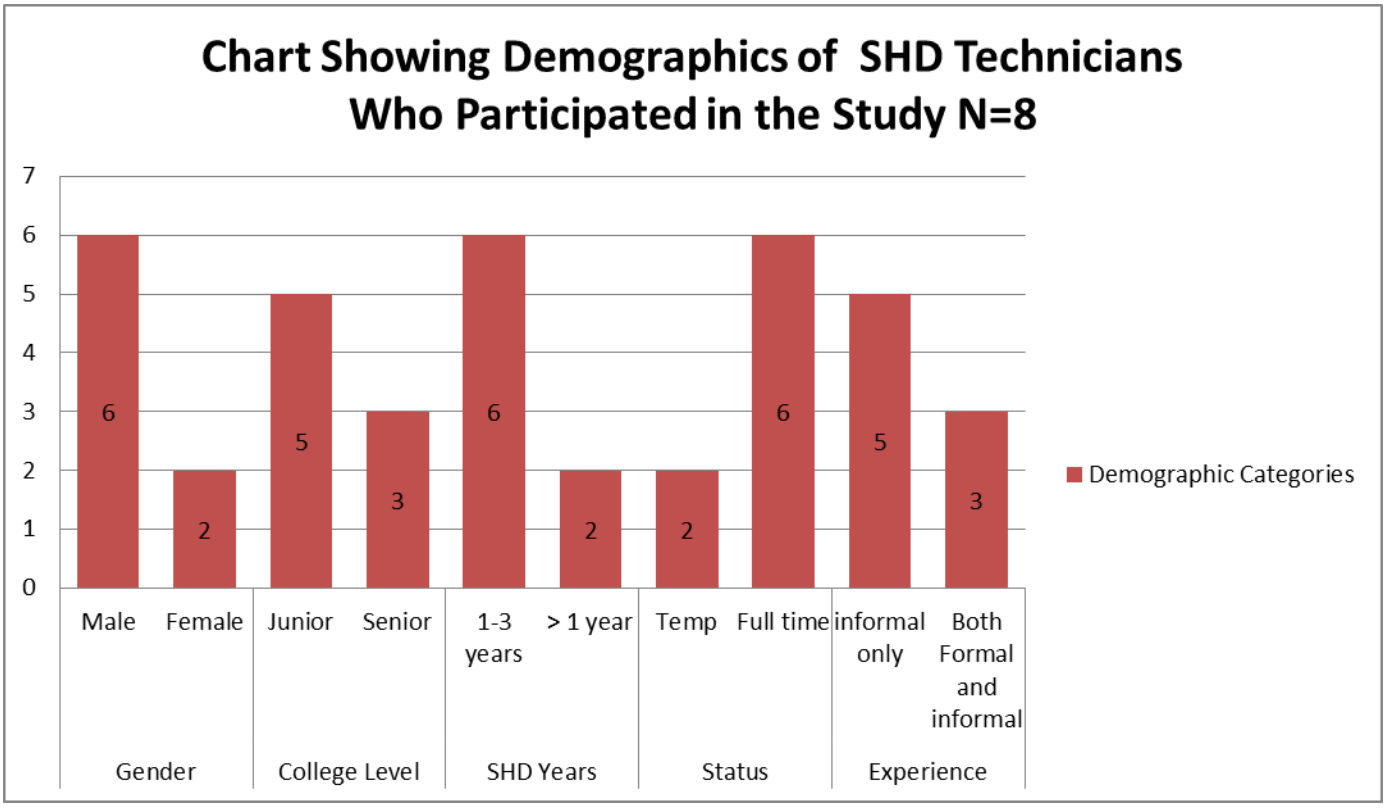


Figure 14. Chart showing demographics of SHD technicians who participated in the study.

Understanding the System

In the framework influenced by HPT that was used for data collection and analysis of this study, the Understanding the System phase was broken down into Organizational Analysis and Environmental Analysis. Organizational Analysis aimed primarily at ascertaining the vision, mission, goals and strategies of SHD and more specifically the vision as it pertains to KM, while Environmental Analysis zoomed in on the reality of SHD and how things are done especially with regards to KM. The following discussion presents the findings.

Organizational analysis. According to the director, SHD distinguishes itself from the typical help desk for students that can be found at other universities as well as similar supports at the university where it is located. The distinguishing factor comes from the fact that other student help desks usually only help the students for a limited time while SHD will diligently work with

the student to fix the problem and if they can't fix it they will refer the student to someone else. Though SHD does not have a formal mission statement, the ultimate mission or goal of SHD, as reported by the director, is to make sure that students have technology they can use in their classes and this forms the basis on which the success of SHD is measured. The following quotes illustrate the mission of SHD from the director's perspective.

> Director: So we're really unique in the fact that our motto is to work on it until it's fixed. You know, we don't turn people away with a problem.
>
> Director: Right, if we can't fix it, we can find somebody who can. So you know, if we can't solve a problem, for example, we had an Autodesk problem, we went to Autodesk and found the problem for the student, that particular one, we couldn't solve, we kept pursuing it until we did solve it. So we try to solve 100% .

In keeping with the mission of ensuring that students have technology they can use in classroom SHD has expanded its services over the years. Initially, they only helped students with tablet computers; now they help with a variety of computers including Mac's. The director envisions that the trend of expanding the services offered will continue. She wishes that the services could be extended to other colleges in the university. However, due to limited resources (budget, people, and space) that is a far-fetched vision. Below are samples of quotes from the director that illustrate her vision and examples of how SHD has expanded its services.

> Director: For a long time we were turning away engineers with Macs, because their computers didn't meet our requirement. Now we're helping them with Macs. Now the next step is, well, okay, now we only help them with Windows on their Macs, maybe soon we'll be able to help them with Mac.

> Director: It would be nice if we could provide support even beyond just our computer requirement, but it does get, you know, what they need in the classroom. Phones, for example, I mean, iPads.
>
> Director: the other thing is we're still turning away other colleges, and it would be great if we could see a way that this, maybe not, I don't know how, I don't really have any vision of how we could do this, maybe, you know, if we got funding from the University, we could just open [SHD] up and help everybody, we'd have to hire technicians, there's a lot ramifications to that.

In addition to the vision of expanding the service of SHD, from the interview with the director and the supervisor, very specific vision statements were made relating to SHD's KM processes and systems.

KM vision. Findings from both the interview with the director and supervisor indicates that SHD has a KM vision for using technology to integrate some of their KM processes and to make going through the phases of the knowledge life cycle more efficient. At the very high level the director wishes that all the help desk type departments at the university could come together and just have one common knowledge base for solving problems, but differences to approaches to solving problems may prevent that vision from becoming a reality as expressed in the quote below.

> Director: It would be nice to be able to have a shared knowledge base…It would be nice if it was more open so we didn't have to repeat the effort. And I think part of the problem is their answers aren't always our answers for the same problem. Every problem can have multiple solutions, and we don't always like theirs, and they don't always like ours. But it

would be nice if we could come to an agreement and work together and have a common knowledge base for solving problems.

At SHD's level, the director spoke about SHD having challenges with documenting lessons learned from one incident in a way that is efficient, especially during the period of high demand, and her vision is to have a solution for this challenge. In the quote below she describes the situation and challenge.

> Director: I mean, when you see two students a day, or ten students a day, the documentation is a non-issue. It's that first week when we're in that big, huge glut. *How do we manage that kind of numbers of students in such a short time frame and still get some documentation out of it so we can go back and analyze it later* and come up with better ways to solve it so that next time we can do that quicker, and more efficiently.

In addition to documentation, she wishes that whatever is documented could be stored in a form that is easily retrievable and that analysis can be derived from the data in order to improve their practices as illustrated in the quotes below.

> Director: So that's where our dilemma is, how do we get that knowledge that we have documented when we get it so we can share it with other people and make it easily findable.
>
> Director: And we could find commonalities in there to develop a knowledge base of some sort where we could consolidate 20 tickets, they all ended up the same way, and we could say, well . . . you see what I mean, and we can't do that right now. *There's no way to consolidate all the knowledge*. And we would really, we really need a way to do that, and they did try using Scholar, and I don't think that's working well.

Based on her vision, which I was not aware of when I started my case study, she mentioned that my research is important to the organization with solving these challenges. The quote below highlights the value of the findings of this case study to SHD in meeting the goal of, "making knowledge there for everyone."

> Director: So what you're doing your research on is really important, because that's one of our biggest dilemmas, I get so frustrated when I hear of a problem that's not solved that maybe I had the knowledge to solve and I could have solved in five minutes and they've been working on for 20 hours, or something ridiculous like that, *my knowledge wasn't there for them*.

The supervisor reinforced the visions mentioned by the director by describing what functions the system would have. From his perspective, his vision is for SHD to move from a log in system where customers just log a visit to a ticketing system where more information is documented for retrieval. He mentioned that work on this vision has started, but it is not complete. The quotes below represent the supervisor's views regarding the KM vision of SHD.

> Supervisor: Now as far as ticketing system, that's just something that we want to do, we've been trying to do for some time, is when they sign in, giving a similar ticket like this, the time, what their issue is, and having a display with that information on it…What we would like is something similar to what we're doing with the whiteboard as well, if somebody has a very particular issue, say Autodesk not installing, something like that, where we're seeing a problem, we can make a note on the ticket, and say, this issue, this issue again. *And we can see it from a much more detailed and comprehensive view than starting with a whiteboard*.

> Supervisor: The idea is, we want a slightly more advanced digital version of this, that's the ticketing system we want. So it's not just helping us record the issues over time, but if somebody has to leave, they can pick up the ticket, and say, "Okay, I know exactly what's going on." What else do we have?"

In addition to the explicit KM vision statements made by the director and supervisor, the job descriptions of the supervisor and graduate assistant (GA) stated that they are to "plan, document and implement best practice procedures for daily operations for the [SHD] office." This provides an added layer of evidence that SHD values KM and sees it as a way to make its services better.

Leadership and planning. SHD is definitely a growing organization. Interviews with both the director and supervisor pointed to the fact that every year the demand for their services increase, "steadily that student load has been increasing, so we only saw a thousand students the first year, and then 2000 the second year, and what, 7000, and that's in four years, we're up to 7000." When SHD initially started the director and the manager coordinated and supervised the activities of SHD with the help of a GA. However, this was an added task as they still had to carry out their full time responsibilities. In 2010, the supervisor was hired and the director and manager took a step back from directly supervising the activities of SHD. Having the supervisor made a huge difference and created stability. The supervisor mentioned that because GA's changed frequently, it was difficult to have standard processes, but now several things have been standardized and that has made things more efficient. During the focus group discussion the manager confirmed that SHD, under the supervision of the supervisor, has been going well and because of that, there is no need for him to be heavily involved as he did before. He stated, "you guys handle things awesomely, so things just happen. I don't get involved too often, really."

Though the director and the manager are not directly involved in the day to day activities of SHD they still influence the activities through planning meetings, which they have as a group. One example of the flow of influence is where the director felt that there was a need to standardize the training of the SHD technicians, and then the manager and the supervisor developed the training and the supervisor implemented it. The quote below by the director illustrates this flow of influence.

> Director: I sort of steered them in that direction and said, "You have to have training." So then, [the supervisor] has developed the training, not me. [the manager and supervisor] have developed the training. I just sort of just pushed them in the direction that you can't just wing it, which is what we were doing before that, we do on-the-fly training, and I was like, "We need a standardized sort of training.

According to the supervisor, the planning meetings usually take the form of a brainstorming session where the director, manager, and supervisor share a range of ideas from "something simple and reasonable to completely far-fetched." The quote below by the supervisor illustrates the nature of the planning meetings and how all members of the leadership team collaborate.

> Supervisor: We'll brainstorm our own ideas of what we want, something simple and reasonable to completely far-fetched, which actually we just did the other day, just five year plan of this office, and come up with a list of about 10 to 20 ideas, ranging from simple and reasonable to extremely expensive and far-fetched, or incredibly unlikely.

There is "no central documentation" or minutes of these brainstorming sessions as each person takes away different aspects of the meeting and then work on developing their ideas, as highlighted by the supervisor in the quote below.

> Supervisor: There's no central documentation on it, because we're all taking away different aspects of it, so I have my documentation, [the manager] has his, [the director] has hers, so we're all working on different aspects. I'm going to be working on the [SHD] office itself, [the director] is going to be looking at proposals and budget and these kind of things, [the manager] is looking at networking and, we all take away our own thing from it.

Even though there is no "central documentation" of the ideas that emanate from the planning meeting they are blended together in creating an annual report, as the supervisor describes, "So that kind of goes hand-in-hand with our once-a-year report of here's what we've done, here's what we want to do, here's what we think we're capable of, and this is what we want to be able to accomplish it"

Organizational analysis summary. SHD is a growing organization with visions of expanding services. One of their distinguishing features is that they ensure that all problems are fixed; if they can't fix it they will refer the student to someone who will fix it. Their motto of "to work on it until it's fixed" helps them in meeting their measure of success, which is that students have technology they can use in class. The leadership structure may be described as middle-top-down as the supervisor reports to the manager and the manager reports to the director. Despite varying hierarchal levels the director, supervisor, and manager work as a team. Planning is done together in a form of brainstorming meeting. Regarding KM, SHD has a vision of using technology to integrate their KM processes and make the process more seamless and efficient.

Environmental analysis. The evidence for this section was derived from interviews with the director, the supervisor, and the technicians. Most of the evidence appropriately came from the supervisor as the aim was to get an idea of SHD's current processes and environment and the

most credible sources are the people that work in SHD on a day to day basis, the supervisor and technicians. This section will be divided in three primary sections: Stakeholders and Influences, which addresses the main policies and governing bodies that influence the operations of SHD; Culture, which addresses the type of working environment that is fostered by SHD and their value system; Technicians, which addresses the type of technicians that work at SHD and; finally the Resources and Processes, which addresses the tools and systems in place that enable SHD to carry out its essential services.

Stakeholders and influences. In general the main stakeholders of SHD are the technical college which it serves and its students. However, during the interview with the supervisor, it was revealed that the technical college has a council that determines the computer hardware and software requirements for the students and this directly influences what SHD does as they are not allowed to help students who have computers that do not meet the requirement; this was also mentioned by the director as well. Thus their main goal is "to support students within the guidelines of that requirement" and as the requirement changes, so does the capacity with which they serve students. This further confirms that in this setting their knowledge needs are not static. The supervisor further mentioned that this is the only restriction to their services and he thinks SHD is very fortunate that they get to "kind of create their own program."

Though the policies have such a great influence on the services offered by SHD, SHD workers do have some input on the policy making as they make suggestions to the council based on things they observe while working with the students. In addition, the director is a member of the council. In the quote below the supervisor gave an example whereby initially the requirement only allowed them to support people with convertible laptops, and through their suggestion, the services offered where diversified to include other devices.

> Supervisor: Yeah, exactly. So actually what the council, and we do have some feedback. The perfect example was a couple of years ago, the only people we would support were people with convertible tablet computers, laptops with spinning screens and an ability to write on them. It had to have Windows 7, has to have a certain amount of hard drive space and RAM, this set rule. Because we see so many computers, we get to see the front line of that support, we started suggesting to this council that there were other ways of going about it, you could do laptops and division of devices. Now we've gotten to influence them, and they in turn have influenced us....

In fact, the period that this study was conducted, was an important semester for SHD as the freshmen that came in were the first class to have the option of multiple devices, including boot camp Macintosh computers running Windows, as oppose to the convertible tablet. The quote below was in response to my question about the expectations of Fall, 2013.

> Supervisor: Fall '13? One of the big ones we're going to see, is we just changed the policy in the spring, where you're allowing multiple devices instead of the just the one convertible tablet, and this is the brand-new class of freshmen coming in with that option open to them, I think we're going to see a lot more of those slate devices, and whatever issues come along with those. We are allowing boot camp Macintosh computers, which we never allowed before, so that's going to provide some, hopefully no challenges, because we're just installing Windows on the Mac, we're not actually supporting the Mac operating system, just the hardware.

Culture. SHD seems to have a positive culture that is purposeful and where workers are given a sense of autonomy and are integrated in the decision making processes. The supervisor describes the environment as "good pay, relaxed environment, good people, the whole works,

it's just a little bit of everything." Based on the interviews with the director and the supervisor two dominant characteristics emerged: that of a genuine interest in helping others and also autonomy and input.

Genuine interest in helping others. From examining the mission of SHD and their motto "to work on it until it's fixed" one gets a sense of diligence in problem solving. This diligence could mean that SHD is goal oriented and diligent in meeting their goals. However, based on the interview with the director and the supervisor, the diligence was attributed to a genuine interest in helping others, which in turn also helped them in meeting their goals. Throughout the interview with the director there was a high level of empathy and she commented how she and the technicians felt really bad that because of limited resources and the computer requirement they have to turn away students that are not from the college as well as students within the college that have devices that do not meet the requirements. The quotes below illustrate the director's experience with having to turn students away and her negative feelings toward having to do so.

> Director: Right, so it's really hard for them to turn away people, so we have students coming in crying, and they're from other colleges, and you know, "I'm not an engineer, but I need help," and it's really hard to turn them away, and you feel really bad that you can't, when you can't help students.
>
> Director: and it was awful having to turn away that poor kid, who their parents gave them a Mac and they had no money to buy a new computer, and they came in and had a Mac, and we'd say, "Sorry, go away." I mean, it's not easy to do that.

In addition, in response to the question, "how would you describe the culture of SHD?" The director mentioned that hiring is not just based on technical skills but they hire people who have a genuine interest in helping other students as seen in the quote below.

> Director: The culture. Well, they're students that are actually interested in helping other students, so it is students that want to help other students that we hire, we're not just hiring people based on their technical skills, it's more than just having a technical skill, it's really having that desire to help the other students.

The supervisor confirmed that hiring is not just based on technical skills, but they look for good customer service and a positive attitude overall, "well, I guess first off, I'm really picky when it comes to hiring, so I definitely want people who have a good technical knowledge, good customer service, I want positive people in here to begin with." The director further mentioned that "it's a good feeling helping people" and that she could also speak on behalf of the technicians, "it's a good feeling helping people, and I think you can talk to all of them, it makes you feel really good when you go home at the end of the day when you solve most of the problems that come to you. I'm sure they would agree with that." The supervisor confirmed this "good feeling" that they get from helping people when he pointed out that a secondary goal of SHD is to empower the students to be able to solve simple problems on their own and maintain the health of their computers. The supervisor recalled with great excitement how one of his favorite moments is when students walk in and are able to say that they already did basic troubleshooting (which they learned from SHD) and because those steps didn't work they have brought their computers to SHD. He remarked in the quotes below, that the students exhibit a sense of pride in their ability to apply the knowledge learned from SHD and he loves seeing that.

Supervisor: If they come in with a general issue, some students just aren't as technology literate, so they come in to install Office or something simple, we'll, instead of doing it for them, we'll have them follow the tutorial, or walk them through the tutorial so the student learns how this particular software works or how these issues are resolved, so the student gains some knowledge out of it, and we've trained them on, so if they come back another time, they've already attempted these things, it makes it easier for them, it makes it easier for us.

Supervisor: That's actually one of my favorites, getting to teach some of the students, and they come back so proud of their knowledge, they're like, "Oh, I've tried all of these things, now it's something different." A little bit of pride there, I like that.

Autonomy and input. Autonomy and input seems to be another phrase that can be used to describe the culture of SHD as it permeated through several of the previous discussions and was evidenced from varying levels of the organization. First, in examining the leadership structure of SHD earlier, it was brought out that though there was a hierarchical structure the manager and the director have given the supervisor a level of autonomy and are not as involved in the day to day running of SHD as they use to be before he was hired. In addition, the planning activities for SHD are done as team where each member of the leadership team provides input. Second, in addressing the stakeholders and influences that affect SHD, the supervisor highlighted that SHD was very fortunate to have a level of autonomy in coordinating their services, stating that, "we're actually very fortunate that we get to kind of create our own program." Added to this was the fact that though the requirements set by the council governed the activities of SHD they were allowed to have an input in the decision making process. Third, even the technicians are given a level of autonomy and input as the supervisor reported in the quote below, technicians are given

"freedom and creativity" to do their own thing when it is not busy and that all the improvements that have been made were based on suggestions from the student technicians.

> Supervisor: When it's not super, super busy in here, like during the rush, the technicians kind of get free reign to do what they want, they get to work on, they'll have time to do homework or something like that, but they'll have time to do their own computer projects to work on. Kind of giving them that freedom and creativity to do their own thing, all of the improvements for this office over the past like three years were student-suggested. They get to have an input into the office and get to see that become a reality.

The level of autonomy that is given to the technician drills down to how they go about solving problems. The technicians are expected to carry out some general basic steps especially when determining if the issue is hardware related. However the exact route taken to solve a problem, especially for software issues is left to the technicians. The supervisor reported in the quote below that giving technicians this level of autonomy has resulted in the creation of new knowledge and he has learned more from the technicians than he has from any explicit forms of instruction, like internet forums.

> Supervisor: There's the set couple of things that, if somebody comes in with a hardware issue, I'll want everybody to see if they can replicate the issue, check drivers, make sure there's nothing, make sure nothing's missing, and then if the problem persists, boot it up into a different operating system, and see if the problem continues on there…As far as software, most of the technicians have their own, I guess, way of diagnosing the problem. We end up hiring pretty tech-savvy people, so everybody has gone through and solved some sort of computer issue before, everybody has their own method to fixing the problem, *which is actually really useful, because I've been here for like three years, and*

I've learned more from the technicians than I have from anything on the internet forums. So letting them have their own method of behaviors is really useful.

Technicians. Up to this point a lot has been reported about the technicians from the supervisor's and the director's perspectives. The technicians were described as students who have a genuine interest in helping others, positive people, initiative and "pretty tech savvy." During the first interview for each technician, I asked them about the previous experiences they had before working at SHD and based on their responses they can also be described as having a high level of curiosity and informal learners. Of the 8 technicians I interviewed, most (63%) of them only had informal experiences and those that had formal learning or working experiences also reported informal ways. Some of the informal ways included just opening up their devices and experimenting as Vaughn stated, "I used to open up my computers, my phone, everything. It was just curiosity"; others learned from parents, like Bethany, who stated, "My dad actually like made me build computers, reformat them, and do everything that he had to do since I was a little kid." Some also mentioned building their expertise so much that they became the computer technicians of their neighborhood, like Mark, in the quote below.

> Mark: I've never had any professional work experience, per se. I grew up in a small town, not very many people were technology oriented, and so during the course of my childhood and young adulthood, I kind of grew into the IT specialist of the area, so my friends and family members would be like, "Oh, can you come fix this? I think there's something going on.

While others, like Fernando had a mix of both formal and informal experiences, as illustrated below.

Fernando: I started working at [SHD] just after high school actually, my freshman year. And I had actually taken a class, kind of teach us about computer repair in high school. And I was kind of the guy who kind of fixed the neighborhood computers, stuff like that, so I had some experience, just nothing like [SHD].

The level of curiosity was also evidence from some of the critical incident reports as on several occasions it was mentioned that when there was a difficult problem the technicians liked "to come around."

Even before this study began, there was a sense that although the SHD technicians found an uncommon problem challenging, there was a great feeling when they solved these problems. I got this impression after reading the 2012 annual report, where the supervisor described such problems as "delicious." During the focus group session as well, after discussing a critical incident one of the participants remarked "yeh it was a fun one." Nonetheless, in the same breath the positive words were used to describe the victories of solving a difficult problem, opposing words such as "giant pain issue" were used to reflect the challenges they posed. Mention was also made by the supervisor of instances where a problem was not solved fully and technicians would use their own initiative when they had time and solve a problem as seen in the example given by the supervisor: "Oh, the issue comes up fairly frequently. I think it's skipping the problem instead of uninstalling and cleaning, that was on his own initiative, he just decided to do that one day and just came up with that solution."

Resources and Processes. The SHD office has 11 tables with several chairs around each table and to the sides of the room against the walls. The supervisor and the GA have their own cubicles and the rest of the space is open almost like a classroom. From interviews with the supervisor and director, one of SHD's primary resources is their log in system or what the

director calls their "cursory ticketing system." When a student comes in, they have to swipe their ID card and fill out a few fields about the nature of their problem. The log in system is located at the entrance of the SHD's office. The system currently only keeps track of visits to SHD and problems as reported by the students, not exactly what the problem is, as explained by the supervisor and director in the quotes below.

> Supervisor: So a student comes in, logs into the office, this is a generic ID, their PID, what time they came in, and this is information they're entering at the front desk computer, so what computer, what they're looking for, their sign-in category. A little detailed description of what's going on, so if we have to look it up later, we can. This becomes convenient later when the student has multiple visits to the office in the same semester.
>
> Director: and we have a ticketing system, a cursory ticket system, so students log in, so we're tracking their PID, what department they claim to be from, not necessarily are from, you know, and what they think their problem is, not what their problem actually is, because a lot of times what they say their problem is, is not what it actually is. So a student will say, "LabView doesn't work." The problem is that they have a virus. Or they'll say, "I can't get my camera to work," and they haven't done any Windows updates on their machine at all. You see what I mean? So they never really, they never get to the end to see what their problem really was.

The information that is tracked by the log in system is very helpful, as reported by the supervisor and director in the quotes below, when the student has multiple visits to the office, and also for accountability purposes with faculty. So if a student reports that they had computer issues, faculty members will only excuse them if there is proof that they visited SHD.

Supervisor: So if somebody's having trouble with their computer, a professor wants to know why the student isn't turning in their homework, and, "My computer's broken, I've been to [SHD] to get it fixed, it's not a simple fix," we can look up in the database, and say, "Yes, this person has been here one, two, three, four, wow, actually a good five, six times, in a period of two months." So clearly their computer is having more issues than this guy, who shows up once a semester.

Director: But a lot of the faculty members won't accept late, excuses for late homework's because of computers not working, because then they ask to document that they came to [SHD], and if they didn't come to [SHD], they don't accept their late homework.

To meet their goal of ensuring that students have technology they can use in class, SHD has a loaner system as well. If a student's computer (that meets the requirements) requires an extended repair time, they can borrow a computer from SHD. The director reported in the quote below, that both the service piece and the loaner piece complement each other and are heavily used by students.

Director: The loaner system ensures that the students always have a computer available to use in class, because we don't have labs anymore, right, so that piece is really important. And the software piece is important, because if the computer doesn't work for a student, then they can't do their work, and they can't take, they can't be successful as a student without their computer functioning, so the service piece is really important, too. So I would say they are both equally important. And they're both heavily used, so we loan out over 1000 laptops a year. They go out multiple times.

The log in system syncs also with the loaner system, so if a student needs to borrow a computer once they swipe their ID their information automatically gets populated. The quote below from the supervisor illustrates the relationship between the log in and loaner systems.

> Supervisor: The front sign-in also gives a little bit more information about the customer, as far as like phone number or something like that, so when they come over, and if they need a loaner, the information is automatically populated for them, just as long as they swipe their ID, they can get the rest of the information.

The log in system is a self-operated system for the students, but the loaner system is governed by SHD employees. Both the login system and the loaner system form a database which the supervisor deems as "the backbone" of SHD. A table is designated for the loaner system, located to the extreme right corner of the room, with a laptop/tablet storage cabinet nearby. To make the problem solving and solution process more efficient, SHD has a file server which hosts copies of all the engineering software so they are easily accessible. In case the manufacturers' sites go down as seen in the Autodesk example below, technicians will still be able to assist students with installations. The file server is located on a computer at the front of the room and the computer is also used to look up information when necessary as explained by the supervisor below.

> Supervisor: When somebody comes in, when they need support and need software downloaded, we have copies of basically everything the engineering undergraduate's going to need, hosted locally. So we would have times where network software would go down, the Autodesk website would go down, the activation websites would go down, and it would hinder the student's, the customer's ability to install and be able to work on homework, studying, anything like that. So we came around to have a personal file

storage server, just to host the software on our own, in case that happens so we never saw any delays…

In addition to the file server, SHD uses other technologies to make installation faster like DVD's as well as bootable flash drives which are faster and more versatile than CD's. The supervisor also reported in the quote below that SHD has even created their own software and drivers to make the process quicker.

> Supervisor: We have DVDs on a rack. As far as installing software's, or installing operating systems, we have bootable flash drives, which are faster than the CDs, more versatile. And we have rows of those that we've created, including our own software and drivers to make the process quicker…Those are something we create to make the installation process faster.

SHD also has a website on which there is information about their services, announcements of current issues, for example if Autodesk's website is down, as well as tutorials for basic fixes that they think students can do on their own as explained in the quote below by the supervisor.

> Supervisor: The Autodesk website just goes down once a year. So we have an article on the website saying, "Be patient, it's going to fix itself." Or if it's a prevalent enough issue with a simple fix, it will also make it onto the website.

SHD also has a wiki that is hosted on the university's learning management system, which only the technicians have access to and they post steps to more complicated fixes. The supervisor explained in the quote below the circumstances that the wiki would be used.

> Supervisor: Since we don't want a user trying to mess with registry files, because that could cause a lot more harm than good if it's done incorrectly, that's something that we will leave on our [SHD] wiki, which is only available to the technicians.

So far the resources and processes mentioned involves some form of computer technology, however SHD also uses simple resources, like a whiteboard. In the SHD office there are two whiteboards one to the front of the room and the other to the back of the room. According to the supervisor, problem solving begins with brainstorming ideas on the whiteboard. It is also used to communicate things that technicians need quick access to, almost like a cheat sheet. In the quote below the supervisor gave an example of how the whiteboard is used.

> Supervisor: So if a student in the morning starts seeing Autodesk registration not working, they'll make a note on the board for everybody to see. It's less for the customers and more for the technicians working on the computer. The same thing with, any issue that we've seen that ends up making it onto the articles, at some point was on these whiteboards, it's where the entire process starts.

Another non-computer technology resource and process that SHD has is what the call an information sheet. These are used if a customer has to leave their computer as well as if a technician has to leave in the middle of troubleshooting and no one else is aware of what they did.

Environmental analysis summary. The main body that influences the operations of SHD is the college's council that determines the computer requirements. SHD is only allowed to help students with devices that meet these requirements. They have an input in determining the requirements and the director is a member of the council. A genuine interest in helping others and autonomy and input were two dominant themes that emerged in describing SHD's culture and was seen at all hierarchical levels of the organization. SHD ensures that the technicians hired are in line with their culture and possess more than just technical skills. SHD has several technology and non-technology resources in place that enable them to work efficiently. Among

the technology resources/systems are a log in system and file server, and among the non-technology resources/systems are two whiteboards and an information sheet.

Critical Incident Analysis Overview

The preceding section outlined the SHD system and examined issues such as its mission, culture, values, and the resources and processes in place. This section gives a very basic overview of the Critical Incident Analysis results in terms of each of the phases of the knowledge life cycle. The next section combines the results from the analysis of the system and critical incidents to answer the research questions wholistically. Data for this section were derived primarily from the critical incident analysis of 11 incidents that occurred during the "rush" period of Fall, 2013. Data from the focus group session that was conducted in Summer, 2013, was used to provide baseline data. Overall 8 technicians and the supervisor were interviewed, making the total 9. Fifty percent of the technicians who participated were interviewed more than once as they were involved in 2 or more incidents. A total of 19 reports were collected for the 11 incidents. Table 5 provides a brief description of the incidents and from here on the incidents will be referred to by their short names.

Table 5
Name and Brief Description of Incidents

Incident Name	Description from Sheet
Folder Issue	The option to create a new folder was missing
DyKnow Issue	DyKnow Prerequisites fail to download from installer
Office Issue	User installed 64-Bit with issues. [SHD] technician installed 32-Bit without uninstalling 64-bit. Office Products do not function
MATLAB Issue	MATLAB won't install, fails at VC Redist install (No errors, just stops).
Password Issue	Computer says password has expired, user boots into safe mode and sees the same thing. Safe mode auto restarts.User said laptop was taken to the bookstore (monitor replacement) user logs on once, it logs itself out and problem starts.
Random Stuff Issue	Random Stuff…crashed when typing, couldn't put to sleep, wake up
Inventor Issue	Inventor 2014 Graphics crashing

SSD Issue	Laptop has 1TB HDD + 25 GB SSD for Cache we were previously unable to see SSD after install so it was not able to use it.
EAP Issue	EAP Method Corrupt or missing
VT wireless Issue	Correct credentials do not work for VT-Wireless. Field pops back up blank
AutoCAD Issue	AutoCAD Cwp 3D fails at checking license

Everyone who was involved in the various incidents were interviewed, except in one case where the technician did not respond to my email or reminder to schedule an interview. Most of the incidents had one or two technicians involved as seen in Figure 15.

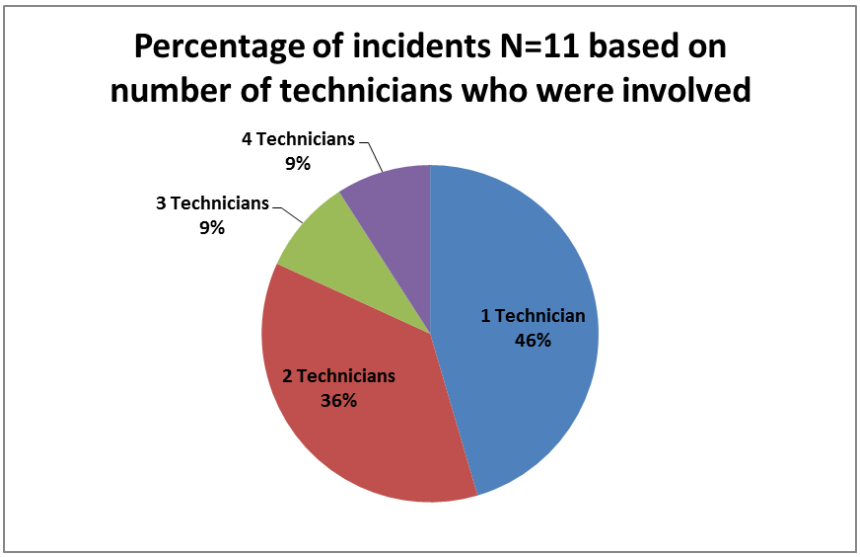


Figure 15. Percentage of incidents based on number of technicians.

The uncommon incidents that were examined can be classified in two primary ways: an uncommon challenging fix, and uncommon quick fix. The adjectives challenging and quick refer to the level of difficulty in finding a solution. An example of an uncommon challenging fix was the incident that involved the DyKnow issue. It took the technicians about one day of trying different solutions to solve the problem, which turned out to be vendor related and was the only incident that had four technicians involved. An example of an uncommon, but quick fix was the issue that had to do with VT wireless issue. Shortly after doing the regular checks the technician

discovered that the solution was to "click 'ok' with the mouse instead of hitting enter to send credentials." Under these two broad categories are two other categories as well. Some of the uncommon incidents were only seen once by one customer and never again, as was the case for the password issue. Other incidents were uncommon initially and then increased in appearance. The DyKnow issue was an example of one where the occurrence increased after the problem was first discovered.

Create. Figure 16 presents the percentage that each sub-code for the create category was found in the data and revealed that the primary way they created knowledge was through "going about connections" which as discussed in the data analysis emerged to have a greater meaning for the entire knowledge life cycle process. In its initial sense as a sub-code of the create category "going about connections" referred to technicians using various heuristics to diagnose and solve an uncommon issue. The in vivo quote "going about connections" was in response to me asking Peter, a technician, what was most effective in solving the problem and he responded, **"**I guess being able to connect, okay, this is a graphics-intensive program, might be a graphics issue, so going about connections, I would say." Other dominant ways of creating knowledge was by asking other technicians for help, talking with the customer to learn more about the problem, as well as using the whiteboard to brainstorm ideas. Searching online was another method used in the creation process; in fact of the 19 interviews conducted, 58% mentioned searching online.

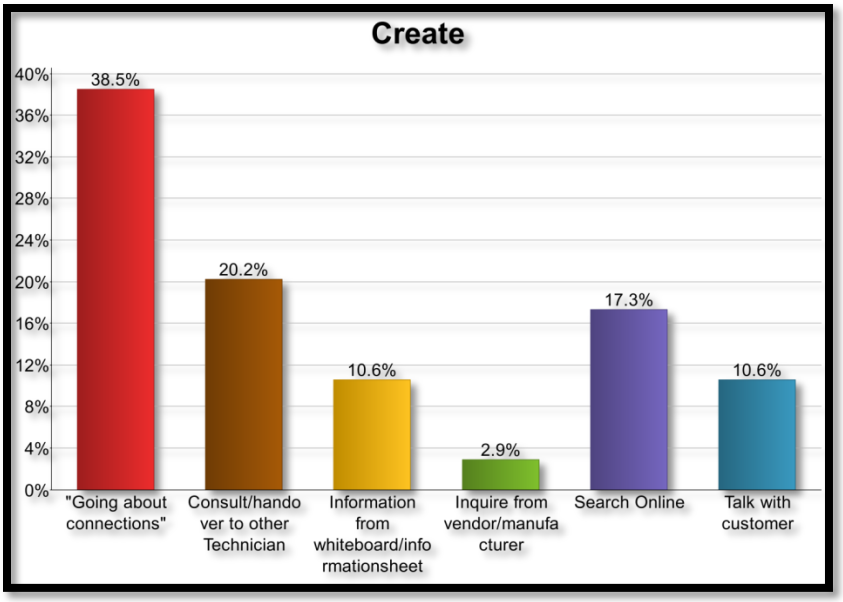


Figure 16. MAXQDA 11 statistics of sub-codes for the create category.

Preserve. From Figure 17 it is seen that the primary method of preserving knowledge was through writing it on the whiteboard, next was the information sheet and the wiki, and in a few cases through email or the website.

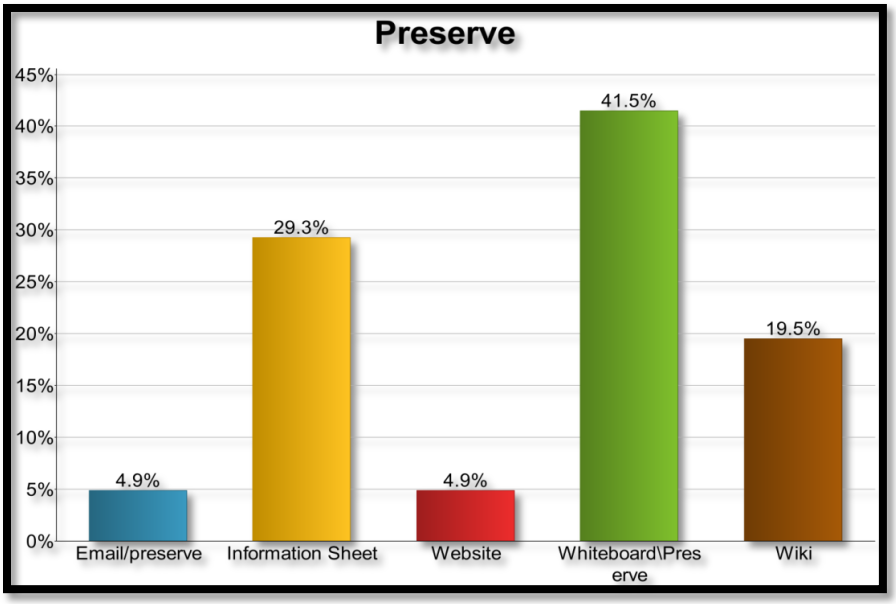


Figure 17. MAXQDA 11 statistics of sub-codes for the preserve category.

Disseminate. From Figure 18 it is seen that the primary way of disseminating knowledge was through "word of mouth." The relationship between preserving and dissemination is also depicted as the whiteboard ranked high for both disseminate and preserve as seen in Figure 17. This is not surprising as in most of the interviews the participants gave the same response for preserving and disseminating knowledge.

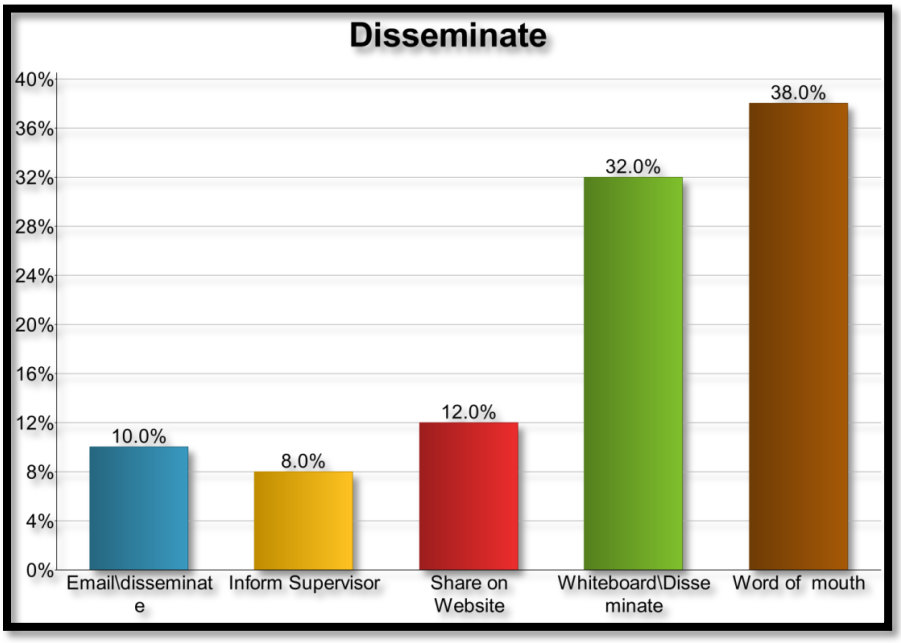


Figure 18. MAXQDA 11 statistics of sub-codes for the disseminate category.

Summary of Critical Incident Analysis

For the Critical Incident Analysis phase of this study data was collected using CIT for a focus group session, in Summer, 2013, and for individual interviews with technicians in Fall, 2013. The focus group session provided baseline data of previous experiences with critical incidents. In Fal1, 2013 11 critical incidents were reported and a total of 19 individual reports were collected for the 11 incidents. The nature of the uncommon problems varied in complexity. Eight technicians and the supervisor participated in the Fall, 2013 Critical Incident Analysis

interviews. Fifty percent of the technicians who participated were involved in 2 or more incidents.

From the descriptive coding analysis of the sub-codes for each category of the knowledge life cycle (create, preserve, disseminate) it was revealed that SHD's primary way of creating knowledge was through "going about connections" which included making deductions using heuristics, technical knowledge, and so on. Other means included consulting with other technicians, brainstorming on the whiteboard, searching online, and getting more information from the customer. The descriptive coding analysis also revealed that the primary means of preserving knowledge were through using the information sheet and the whiteboard. The primary means for disseminating knowledge was via "word of mouth" and the whiteboard. The close relationship between preservation and dissemination was seen as the whiteboard ranked high for both categories. The following section titled, Putting all the Pieces Together discusses the overarching theme that emerged from aggregating the insights gained from the Understanding the System and Critical Incident Analysis phases of this study.

Putting all the Pieces Together

"The product of analysis is a creation that speaks to the heart of what was learned"

(Ely, 1991 p.141).

A case study report should tell a cohesive story. It is a narrative of how all the pieces fit together (Ely, 1991; Stake, 1995; Yin, 2009). My approach thus far was to give you an overview of the two main components of the data collection and analysis framework (Understanding the System and Critical Incident Analysis). In the following section, the discussion addresses the overarching theme of "going about connections" which emerged from an examination of both

the Understanding the System and Critical Incident Analysis phases of this study. "Going about connections" best describes how SHD navigated the knowledge life cycle and the barriers and drivers are discussed as they relate to "going about connections." Evidence for this section represents a triangulation of all the data collected and aggregation of analysis. Going about connections speaks to the connection process that was seen throughout the knowledge life cycle. The connections may be divided primarily in terms of internal and external connections. Internal connections refer to connections that the technicians made with their own cognitive processes and external connections refer to connections that the technicians made with other information sources: human and technology.

Internal connections. As I interviewed technician after technician and listened to all the recounts of the incidents in the focus group discussion, the one thing that struck me was that all the technicians gave an explanation for why they did what they did. None of my questions asked them to tell me why, but it came out naturally. Something about the problem seemed to trigger a connection with how a previous similar incident was solved or just their technical knowledge. At times making this connection led directly to the solution and at other times it did not but helped in eliminating causes as well as initiated the step toward going about external connections.

In speaking to Brandon about the MATLAB incident, in the quote below, he remarked how, from working with similar problems he figured he would try updates. Though it was not the solution in this case the connection between the problem and previous incidents influenced his decision.

Brandon: Yeah, like previous experience with similar problems, trying to install these PC distributable things while you have pending system updates, sometimes it will throw

an error saying that you have an installation currently going, and you need to restart first. This time it didn't, but I figured I try it.

Likewise, Lisa, when dealing with the password issue, recounted a similar experience of trying a method that worked on a similar problem previously; in this case it was a computer virus problem that her brother had, " so if you press F8, you can go into safe mode, but there's also a repair computer. My brother had gotten the FBI virus last week, and that's how we fixed his. So we went to the repair computer."

Vaughn used knowledge of previous incidents to develop his own heuristics and he used that to create a temporary fix for the DyKnow issue by installing in compatibility mode as that worked most times. The quote below illustrates Vaughn's experience with using heuristics.

> Vaughn: I tried to manually install the prereq's from a different website, even that didn't work because after installing the prereq's, if I tried to run the installer for DyKnow again, it was still looking for those prereq's, and it was not finding those, so for the fix, this is one of the things I do, I just right-click, go to troubleshoot, and then I change the compatibility to XP mode, and then once I did that, everything started running fine. Yep. So if you run the program as compatibile with XP, it runs fine. And I tried this on different machines, and it was successful on all the different machines… That solution works, like 40% of the time if the install fails, I just install it using compatibility mode. That works like, not even 40, 60, 70% of the time, so that's how I approached it and fixed it.

The supervisor recounted employing a similar connection strategy to Vaughn as he recalled that they were standard steps that he would take for "odd problems" and because the

folder issue was deemed an odd problem, he utilized those steps which included looking for Malware, as explained in the quote below.

> Supervisor: Um, first thing, since it's such an odd problem, the first thing I did was start to look for malware. That seems a really likely thing for a virus or something to do. So we made sure Symantec was, Symantec or Microsoft Security Essentials was there and installed and up-to-date. And then we also ran malware bites, these are all precautionary things, nothing turned up there.

In other cases, like Mario's, it was about relying on "gut instincts." After all the steps that he usually would try failed Mario relied on his instincts. He explained, "and then disabling Avast, I was, that was my next gut instinct, was that the antivirus was blocking it." On other occasions the technicians were able to explicitly say what the symptoms of the problem indicated by connecting with their technical knowledge. For example, in speaking about the Inventor issue the supervisor remarked, in the quote below, that a program crashing means one of two things.

> Supervisor: That case, it's usually a driver issue. If a program's crashing like that, it's one of two things: the driver, since we knew it was a graphics issue, either graphics driver, or something was amiss with the program, those are just the most common issues when the program flat out crashes.

Lisa employed a similar strategy in dealing with the password issue as based on her technical knowledge when a computer is unable to boot in safe mood it means they have a virus, "usually when something can't boot to safe mode, to me that's an indication of a virus, because usually that's what viruses tend to do." Bethany made mention of trying steps based on the nature of the problem as well and connecting to her technical knowledge when discussing the

random stuff issue. The quote below illustrates Bethany's experience with making internal connections.

> Bethany: Because I think something was happening with her touch at one point when we tried to get it out of sleep mode, so we were like, "Let's try that first," because there was also the problem with Google Chrome, where she was unable to type or unable to just access it.

In the interview with the director she also re-called, as seen in the quote below, an example where connecting with her technical knowledge helped her to progress through solving an uncommon problem.

> Director: I'm thinking of a specific example, there was, it was a browser thing that keyed me into the fact that it was malware, the browser wasn't behaving properly. And then I went a dug a little further and found out that it was malware,…because I asked the [SHD] technicians, and they hadn't seen the problem before, so then I had to rely on my own skills to figure out what was going on. Initially I thought it was a browser issue, so I was sitting there plugging away trying to fix the browser, and then I realized, "Hey, wait a second, what would cause a browser to be this weird?" You know? And then I looked a little further, and I found some malware, and I you know.

For Peter, in dealing with the Inventor issue, he made two connections one was to his technical knowledge, and the other was based on his experience of the manufacturer. The quote below illustrates how Peter made those connections.

> Peter: so I decided to check for graphic drivers because it relies heavily on graphics cards. So I noticed that they were outdated. I know manufacturers are not good at keeping up with new drivers. So usually I go to the Intel site, or to a video card or component

manufacturer, and I get the drives from them. So I tried that, I downloaded the newer ones, I updated, and Inventor worked.

External connections. External connections examine the connections that were made when the technician connected with someone other than himself, and is also where the interconnection between the different phases of the knowledge life cycle was primarily evidenced. It is important to note that in connecting externally, more internal connections were triggered so the two ways of connecting are integrated. The decision to connect with an external source varied among technicians. As a matter of fact during the focus group the supervisor mentioned that the macro approach of going about connections is "pretty universal" as highlighted in the quote below.

> Supervisor: I guess the mode of behavior that leads up to fixing it is pretty universal, it's same way we approach most of the problems. Tap on our own wealth of knowledge, and then ask somebody who we think knows better, then go to Google.

In reality this seems to vary slightly for some technicians, at least in the case of Vaughn, where in reporting the DyKnow incident his method was to ask last; nonetheless in both cases internal connection was the first. The quote below illustrates Vaughn's way of going about connections.

> Vaughn: I just, yeah, these are the things that I usually do before I go to Google or ask someone, because if all fails, you ask Google, and then if Google fails, then you ask the other techs, because they might have seen this issue again and again.

The most prominent way of going about connections externally was through connecting with each other. This was seen through technicians asking for help from another technician either because they had reached their wits end with the problem or they had to leave. Other times

technicians extended help based on cues they received through overhearing, seeing another technician struggling, or awareness of an issue that was not solved.

With each other: asking for help: can you take a "crack at it?" From the focus group discussion to interviews with the director to the critical incident analysis, almost all reported that they asked another technician about the issue if they were not able to make connections internally. In the focus group discussion mention was made of asking someone else to "have a crack at it" as illustrated in the quote below.

> Focus Group: Otherwise, if somebody comes in at the end of a shift, and the problem is still there, it's usually like, I don't know how to fix this problem, can you have a crack at it? And then it just spreads among the technicians

Asking for help took on a slightly different meaning with regards to the DyKnow incident. Here it not only referred to asking another technician within SHD for help, but it referred to escalating the matter to the director and then to DyKnow. In the quote below the supervisor explained how this process occurred.

> Supervisor: Yeah, we went to [the director] first, because she's going to be our DyKnow liaison, and talked to her…she suggested calling up DyKnow directly, and considering the College of Engineering at Tech is one of DyKnow's biggest customers, we were hoping to get a quick and prompt solution to this.

After taking the director's advice and calling DyKnow, it was discovered that the problem was caused by an error on DyKnow's end and if they hadn't called they would not have known and a full fix to the problem would not have been found. In reflecting on what could have been done differently in this situation the supervisor said, "I would have probably called DyKnow a little bit sooner. I think once we saw the volume of people that were coming in with the same issue,

probably should have called them then. But, we were still troubleshooting in our own way at that time." In this case knowing when to stop going about internal connections and asking for help was integral to solving this problem.

An awareness/perception of expertise influenced the way connections were made through asking for help; it determined who was asked. Though this was mostly evidenced in quotes from Lisa, it was a very dominant influence as it was seen in more than one incident and by multiple technicians. It should be noted that Lisa was involved in four incidents and was the highest participating technician, tying with the supervisor. She made continuous references to exactly why she asked specific technicians for help. For example in the random stuff incident she asked Fernando as he previously worked with the manufacturers of the computer that was giving problems and she mentions that, "it's just easier to give it to a technician who is familiar with things that I might not be familiar with."

Regarding the same random stuff incident, Lisa recalled how helpful it was that Fernando helped her, and again she mentioned something about the type of expertise he had. In the quote below Lisa stated that Fernando was very good with incidents that are outside the scope of typical technical diagnosis.

> Lisa: having [Fernando] there really helped, because he just was able to give quick ideas as to what to pull up, because when this is outside the scope of technical, or typical diagnostics, it's like, he's usually, he usually likes taking the time to go in and see what the computer is telling you through all those logs and stuff, and a lot of people just don't like to do it that way.

Another example of the awareness or perception of expertise influencing who was asked was seen in the DyKnow incident with Fernando. He stated, "Before I took any steps, I just asked, I

don't remember who was there. Probably if [Vaughn] was there, I would have asked him. This implies that Vaughn is considered a "go to" person. Vaughn's expertise was also mentioned in the focus group discussion, where he was referred to as the Autodesk "go to person." The quote below from the focus group session illustrates the value of Vaughn's expertise to SHD.

> Focus Group: Usually problems like this, like with the Autodesk, [Vaughn] just comes in and says, "This is how you fix it… I think Autodesk specifically, because he worked for them, but he also works two other jobs in IT fields, so if he hears the problem somewhere else, like For Help, then he'll know about it. And so he's our link between [SHD] and all the other IT offices on campus. So that's how he knows.

Another example of awareness or perception of expertise determining who will be asked was seen with the "temps," short for temporary workers. In discussing the DyKnow incident with Vaughn I asked if he had asked any other technician for help and he replied, "No. I don't think there were any permanent technicians at that time, all were temps, so." His response implies that he did not think it was worthwhile to ask the temps, and quite possibly it could be because he thought they did not have enough expertise. Incidentally, Vaughn was one of the names mentioned earlier in terms of a "go to person" so quite logically he may feel if he doesn't know the answer a temp would not know. Fernando, also alluded to this as well, in speaking about the DyKnow incident he said that, "the other more senior technicians are who I usually ask." The use of the word "other" indicates that Fernando is a senior technician and also implies that he, like Vaughn, may not deem it worthwhile to consult another technician who is deemed to have less experience and expertise. The distinction between the temps and the permanent technicians was also highlighted in the interview with the supervisor, where he mentioned that the permanent

technicians had more responsibilities and he would hold the permanent technicians' word a little bit higher, as mentioned in the quote below.

> Supervisor: Um, I guess they're kind of divided when they first start. The permanent tech, well, I mean, during the rush, the permanent technicians, I guess, they're going to have a little bit more responsibility, I'll let them image computers, they'll help me out with some training. If they're giving suggestions to the office, I'm going to hold their word a little bit higher. Temps are just temps, unless they decide to stick around.

Mention was made of not knowing the answer but knowing who knows the answer or where the answer could be found, and this was deemed most important. This ties the discussion about asking for help with awareness of expertise. It also illustrates the overlap between the creation and dissemination phases when connecting by "asking for help." For example, the knowledge that was created in the incident, mentioned in the quote below from the focus group discussion, was not preserved, but was disseminated to technicians who were around. Though they may not have gotten the full breadth of the "fix" what was most important was that they knew who to ask.

> Focus Group: So it's like, if he had the problem, and he fixed the problem, and then somebody came in after me, but I was there for both of them, I might not know the answer, but I'll be like, "[Brandon] knows." So it's easy to know at least who knows the answer.

With each other: extending help. Extending help refers to instances where a technician was not explicitly asked for help but because of a need that they saw, they responded. There were several instances where mention was made of a technician stopping by to help, or where a technician overheard another having problems and decided to help. In speaking about the EAP

issue, Brandon mentioned that his involvement in the incident was because he overheard the other technicians having difficulty and since he was not busy, he stepped in and helped, "so I just overheard them talking, and I guess the problem was that they were trying to connect to VT wireless…, he was still helping him, I was just sitting there eavesdropping because I didn't have anything to do." Regarding the Inventor issue, Peter reported making a similar connection with the supervisor due to the fact that he "heard" him having troubles, "[The supervisor] was working on that problem before, and I heard him having trouble, so I was like, so what's the problem? And he told me, and I was like, well, get the new ones."

Lisa recalled that for the password issue the supervisor stopped by, and for the random stuff issue Fernando stopped by to help and he had "this epiphany" that helped to solve the problem. The "epiphany" that Lisa speaks of refers to an internal connection that was made while connecting externally. The quote below illustrates Lisa's experience with another technician "extending help."

> Lisa: Fernando, he came over and he looked at some of the stuff, because we were looking at event viewers to see if there were any bugs, and he looked back further than we had, and he had this epiphany, and he was like, Ah, I think I know the problem! So I went to work with somebody else and he was fiddling with it

In offering to help, sometimes the technician that offered to help would disseminate knowledge that was learned from a previous incident to see if that would help in solving the new problem. Here the technician first connected internally to make the decision that the knowledge they learned from one incident may help another technician, and second, by disseminating that knowledge, an external connection was made on the other technician's part. This resulted in the application of the knowledge, as well as the potential to create even more knowledge. Lisa

reported that she usually extends help by listening if someone has a problem similar to hers, "Whenever somebody would say AutoCAD was crashing, I would always say, oh, we had a problem like that."

Seeking for help using preserved knowledge. If a technician is not able to make any strong connections internally and after asking around no one has the answer, the next step is usually to connect with some form of preserved knowledge which the predominant reported method was to search online using Google's search engine or going directly to a manufacturer's or vendor's website. SHD has a wiki but limited mention was made of its use. Lisa was the only one that mentioned trying to search for an issue using the wiki, which she was unable to find. In the focus group session, the wiki was a good resource for reminding the supervisor of some past critical incidents as he jovially said, "It's a lot harder to come up with them right off the spot. I'm going to cheat. I'm going to bring up the wiki." Thus the discussion will focus on online sources external to SHD. In some cases solutions were found and in other cases it was not helpful. The art of searching preserved information may be a skill. For example, in the focus group discussion it was mentioned that they searched unsuccessfully for a solution, but found the answer after removing "DyKnow" from the search terms that were used. The quote below illustrates this search experience.

> Focus Group: Once we took DyKnow out of the equation and just looked at graphical issues, I think that was most helpful. We stopped thinking about it as just a problem with this specific program and think of it as just a general problem that just happened to be the one we encountered it on.

Another example is, in speaking about the EAP issue, Brandon mentioned that after speaking with the other technician about what was already done, he just Googled and he found

the answer. When I heard that, I asked him if the other technicians had tried Googling as well and he responded, "I think they just Googled something different. I'm just good at Googling, I guess…. Which is why all my answers are that I Googled it."

Trying to use preserved knowledge from online sources proved very helpful especially in the cases of Fernando, Bethany, the supervisor and Brandon, as it pertained to the SSD, random stuff, folder, and EAP issues. No one knew the answer and the solution they found, they probably would not have thought of, so they were able to solve the problem quicker. The quotes below by Fernando and Bethany capture this well.

> Fernando: I'd say, I guess looking online, because there would have been so many different things I could have tried before I would have figured out that.
>
> Bethany: Going online and looking it up. A lot of the technicians didn't know what the problem was; because we all thought it was either a hardware issue or it could have been something else, so going online and looking it up actually helped.

In other cases searching preserved forms of knowledge was not effective in finding a solution as they were not well documented or referenced links were broken, which seemed to be the case in several of the reports mentioned in the focus group session, as well as various critical incident analysis interviews. For example, for the DyKnow issue, Mario and the supervisor reported that they tried searching online but found nothing useful as seen in the quotes below.

> Mario: Yeah. I mean, I went to the DyKnow site, too, and tried to look up any kind of forum board or something that they had of support, but they didn't have anything, so. I didn't see anything else.

Supervisor: Yes, we did, but Google's not really helpful with DyKnow, because DyKnow is a small company, or fairly small in comparison to Intel or something like that, so it wasn't really that much information

Examples of searching and finding hints to the solution, but with broken links or a random post "I fixed it" with no solution were given in the focus group session and also by Fernando in one of his interviews. The quotes below illustrate this seemingly frustrating experience.

Focus Group: Really aggravating and ineffective, you find a forum for exactly the problem you're looking for, and just a comment says, "Hey, I fixed it." And then nothing else. [Laughter] Thanks, thanks for the help.

Fernando: I think. A lot of them, it had some guides at one point to fix this very problem. But most of them got taken down, because the Lenovo site, honestly it's very bad. It's not very helpful, usually.

Making deductions. Through going about connections internally and externally, the technicians were able to make inferences and were able to narrow down the cause and possible solutions, thus moving them closer to solving the problem and to the end of the create phase in the knowledge life cycle. For example, in stepping in to help with the EAP issue, Brandon asked the other technician what he had done so far and because it was what he would have done, it helped him to move a step further in deciding the solution as seen in the quote below.

Brandon: So I just talked with [other tech] about what he had already tried, asked if he had tried some of the more frequently, things that fix the problem, like just like there's the windsock reset, he said he did that, I asked if he did the TCPIP reset, he said he did that, and then I asked him if like, or he mentioned that the error message that they were getting was the EAP thing, and so I Googled that and the first result was the fix.

Another example, was when dealing with the folder issue by booting the computer into safe mode the supervisor was able to deduce that the computer had the ability to create a folder but something was just preventing, thus leading him closer to finding a solution, "so we tried, I think I tried going into safe mode, and if I was in safe mode, I could create a new folder, so the ability was there, it's just something that was missing while Windows was running normally." This process of connecting and making deductions often times gets random as sometimes a direct connection does not evolve. In those cases it can be described, as mentioned in the focus group discussion as a "pot-shot", "scatter shot", "hit or miss;" or trying "little bitty things" like Lisa said in dealing with the AutoCAD incident, "What I tried to do, was I tried running as administrator, I tried running in compatibility mode, I tried running registry clean, I tried booting into safe mode, I tried a bunch of things, little bitty things."

In speaking about the VT wireless issue the supervisor described the process of finding the solution as dependent on luck, " this where it becomes kind of luck of the draw, whatever we could find at that point, it was trial and error, like [the manager] so eloquently said, 'Sometimes there's a lot of error first'." Interestingly, toward the end of the focus group session, the manager remarked with a laugh, "we use trial and error a lot more than I thought we did." I responded by saying, "it's called troubleshooting, not trial and error." The humor continued with the supervisor commenting that the rephrased version would be, "we were troubleshooting the issue over and over and over." After the analysis, I'll rephrase a second time and say they were "going about connections."

Connecting platforms. So far it has been illustrated how SHD went about finding the solutions to uncommon problems by making internal and external connections. In the process knowledge was created and it was evident how dissemination of knowledge from previous

incidents played a role in the connection process to create new knowledge. In addition, accessing preserved knowledge also helped in solving issues. Throughout the entire study there were various platforms that connected all the phases of the knowledge life cycle, which I refer to as connecting platforms. The primary connecting platform for SHD was the whiteboard.

The whiteboard. In using the whiteboard to make internal and external connections, knowledge was created, it was disseminated, and to some extent it was preserved. The supervisor quite rightly said, "you've seen the whiteboards on the side? That's where the entire, the whole process starts… any issue that we've seen that ends up making it onto the articles, at some point was on these whiteboards, it's where the entire process starts." The whiteboard was mostly used for complicated issues like the DyKnow issue that took an extended time to solve. Whenever a technician encountered an issue that seemed more complicated than he or she thought, the technician's next step was to write the issue on the whiteboard along with a brief record of what had already been tried with his or her initials. I chose my words very carefully in saying "more complicated" rather than "unable to fix", as I remember while interviewing Mario, I asked "So what did you do after you realized you couldn't fix it?" His response was very insightful in the way he said "it wasn't that I realized I couldn't fix it, it was more of like, okay, this is a little more complicated than I originally thought." Writing the issue on the board represents "asking for help", but in a more global manner, as a specific individual was not asked. This in turn triggered "extending help" from any technician who thinks he or she can "take a crack at it." The supervisor explained, in the quote below, that another student would see the note, and try something, make a note and the cycle continued until the problem was solved.

> Supervisor: Another student will see it, they'll make a note of what they tried, or they'll just make a tick mark saying, "I've also seen this issue." And if, throughout the day, or

the rest of the week, depending on how busy we are, we'll make more notes, try to look up more information.

Repeated mention was made of the value of making sure everything was written down on the whiteboard as it helped in the process of deduction and in finding the ultimate solution for several problems. For example, the supervisor shared how they figured out the solution for an Autodesk issue through making internal and external connections via the whiteboard and he saw it as a good example of "where the team collaborative effort comes in along with the whiteboard notes." The quote below illustrates this experience.

> Supervisor: So Autodesk coming in, the installation would freeze halfway through. And it would just stop, nothing would get done. After some time, and seeing this issue over and over again, a lot of people making notes on the whiteboard, you can see those up there now, we discovered that it would freeze on one particular part. So installing Visual C++. When that happened, we started breaking it down, like, okay, why isn't this working? It's either already installed, or there's an older version of it installed and it's not working. Basically this is where the team collaborative effort comes in along with the whiteboard notes. Okay, why is this issue happening? Eventually we figured it out.

In some cases information from the whiteboard triggered internal connections to previously solved incidents and helped in deriving solutions for similar incidents. This was the case for Lisa in dealing with the AutoCAD issue; something that was written on the whiteboard about MATLAB gave her an idea on how to solve the AutoCAD issue as seen in the quote below.

> Lisa: The fact that we had the MATLAB thing on the board that said, "Run updates," and the fact that we had the DyKnow thing on the board that said, "Run updates." It just seemed to

be a really update-y sort of week, so I figured if this program worked that way and that program worked that way, then we could try this one. So if that wasn't on there, I probably wouldn't have thought about it.

So the question may be asked, what happened to the knowledge that was not created using the whiteboard, especially things that involved one technician making internal connections? How did those ideas get disseminated and preserved? The answer for the most part was the whiteboard. Of the 19 interviews I did for the critical incident analysis, 63% mentioned the whiteboard and they all reported using it as a way to disseminate and preserve the solution. This finding is in alignment with what the supervisor said, in the quote below, when I interviewed him.

> Supervisor: I guess if it's going to be recorded in any way; it's going to go back to that beginning process with the whiteboards. If there's something that is important and needs to be recorded, that's where it's going to start all over again. It's a vicious, vicious cycle.

Interestingly, during the focus group session, mention was made of having an issue on the whiteboard for over a year as it had become increasingly common after it was solved.

Peter, in informing me how he shared the information, mentioned that he wrote it on the board and also explained the general procedure for writing things on the board. His comment below highlights that "asking for help" was a method used to make external connections and how the whiteboard aided connections between incidents and the knowledge life cycle as a whole.

> Peter: Well, what we do is we write everything out on the board, if it's a common issue or something that's occurring a lot, you just put it right on the board, and if anyone asks

because they missed it or something, we say, “Oh, yeah, it’s right there on the board. That’s what you have to follow.”

Other connecting platforms. Though the main connecting platform was the whiteboard, the office space acted as another connecting platform which allowed technicians to easily collaborate with each other and pass on information through “word of mouth.” As illustrated earlier in Figure 18, “word of mouth” was the second most mentioned way for sharing information. After an incident was solved, several technicians made mention of sharing the information with the other technicians who were present and those that came after, as seen in the supervisor’s quote below:

> Supervisor: [I shared the solution with] whomever was standing around at the moment when we figured it out. And later on, I had conversations with a couple other technicians that were there when the problem first came up…and then if we overheard anybody seeing a similar issue, we would just conversate it then.

For others “word of mouth” involved informing the supervisor of the solution for the problem, which was the case for 40% of the 15 interview reports that did not directly include the supervisor. As highlighted by Vaughn, “I don’t think I emailed everybody about this issue. But I told [the supervisor] about the issue.”

Email, the website, and the wiki were other connecting platforms. Email was used to share knowledge of critical information with the technicians and also with outsiders. Vaughn gave one rationale, as seen in the quote below, for when he would email everyone; that’s when the previous solution to a problem was to reinstall, as if an alternative to reinstalling, was found, that’s better.

> Vaugh: if it's really hard to fix and we have been working on it for like, three, four weeks, we've been seeing issues, but are not able to fix, and the ultimate fix is reinstalling Windows, so if I come across that issue, I just email everybody… Yes, so if you find a fix for such issues, then email everybody, because we don't want to reinstall Windows again and again and again for someone, for multiple people if a solution was found.

Sometimes there is a need to share information with the manufacturer/vendor. When the solution for the Inventor problem was discovered, the supervisor thought it was necessary to inform the manufacture so he sent an email to the contact person as seen in the quote below.

> Supervisor: I sent an email to … our Fujitsu contact, and just said, "Hey, heads up, your most updated driver for these models doesn't work with Inventor 2014, it works with Intel's newest." And just a quick bit of information to him so he can pass it along to the right people.

The website was used to share knowledge of the DyKnow issue. After the solution was found, a tutorial was created and posted on the website so students could resolve the problem on their own. While most of the information that was erased from the whiteboard made it to the wiki as seen in the comment from the focus group discussion, "yeah, it was the same thing, we actually just cleared it off the whiteboard the other day, copying everything onto the wiki," earlier in this study, I was granted access to SHD's wiki and I noticed that after the "rush" period ended my email inbox was flooded with update notifications of changes that were made to the wiki. Several of those changes were solutions for the critical incidents that were collected during this study. There was a sense that the knowledge derived from the critical incidents was given a

resting place and the cycle had ended. However, the cycle doesn't literally end as new knowledge is always being generated from elements of existing knowledge.

Summary of How the Technicians Went Through the Knowledge Life Cycle

SHD's primary way of going through the knowledge life cycle was through making connections. With the technician being the unit, those connections may be internal, which refers to the cognitive steps of connecting prior experience and technical skills to solve a problem and/or external, which involves other technicians and other sources of information. The move from internal to external usually takes place by asking for or seeking for help as well as extending help. Asking for or seeking help is an action generated by the technician that is dealing with the problem and extending help is an action that is generated from another technician. Despite the method of connection, there is usually a process of making deductions that lead to the solution. These processes primarily describe the creation phase of the knowledge life cycle, however the process was iterative and evidence was seen of new knowledge being built on old knowledge; in this case those connections were made primarily through dissemination of previous knowledge that was preserved in the "heads" of technicians that were around when the relevant knowledge was generated.

On a bigger scale, with the organization being the unit, different phases of the knowledge life cycle were connected through various platforms. The whiteboard was the predominant one where knowledge was created, disseminated and preserved. When the whiteboard was not used, the office space acted as a connecting platform, but primarily for creation and dissemination. The wiki was used primarily for knowledge preservation with an intention for long term dissemination. Email and the website were primarily used to disseminate information to outsiders as deemed necessary and on some occasions to the technicians. Figure 19 below

provides a visual representation of how the technicians went through the knowledge life cycle through making internal and external connections which were facilitated by various connecting platforms.

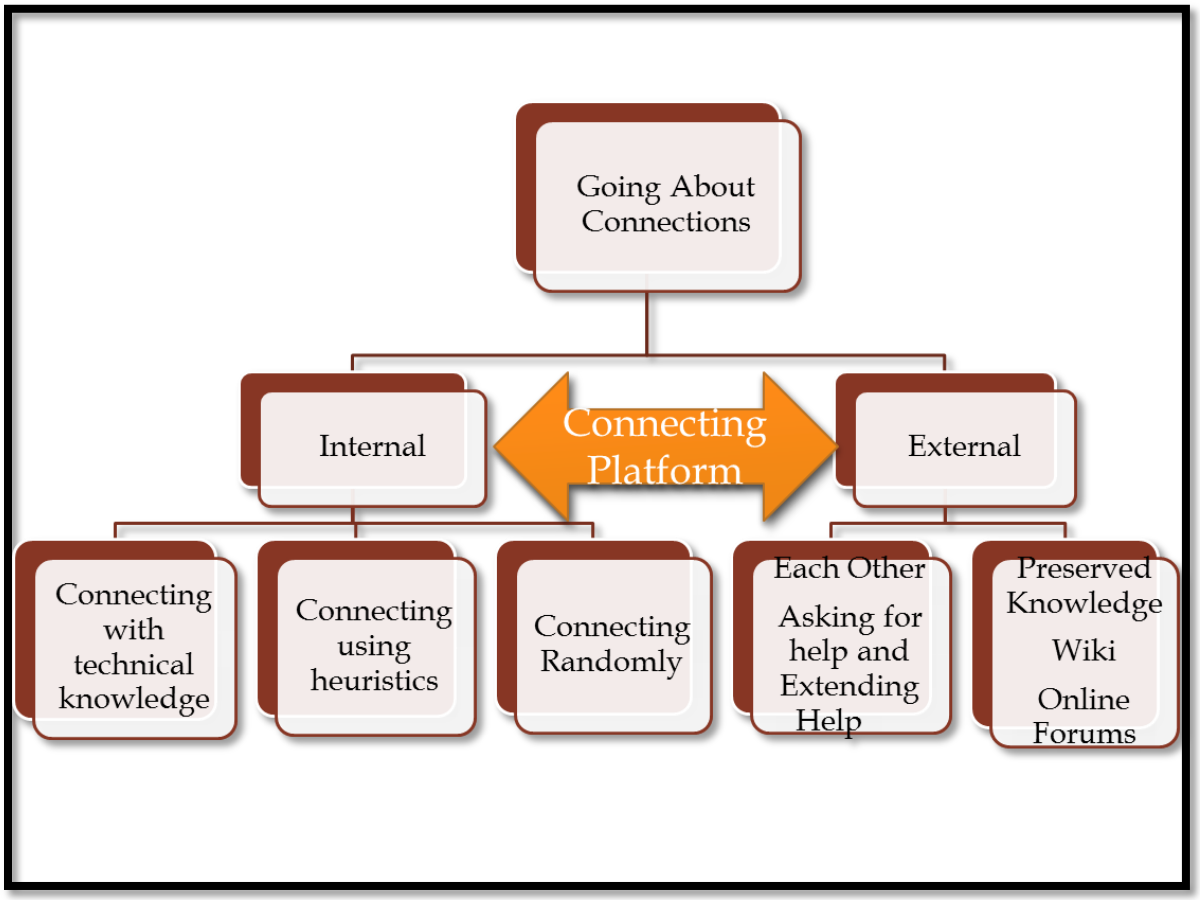


Figure 19. Visual representation of how workers went through the knowledge life cycle processes by going about connections.

The following discussion will now delve deeper into the findings of the "how" to discuss what were the driving and restraining forces to going about the connections that were made while creating, preserving, and disseminating knowledge in the life cycle.

Driving and Restraining Forces

After examining the "how" behind the knowledge life cycle it was evident that for the process to work it was both an individual and organizational effort, and so the HPT's model

categorization of "individual factors" and "environmental factors" as well as the subcategories under each were useful in discussing the restraining and driving forces. The discussion that follows uses subcategories derived from the HPT model to discuss the individual and environmental factors.

Environmental drivers.

Mission and culture. The biggest driver, environmentally, seemed to be the culture and mission of SHD. The technicians were diligent in giving help to the customers and seemed comfortable in asking each other for help, in giving help to each other, and overall in sharing their knowledge. Without these activities it is very doubtful that the knowledge life cycle would have started in the first place. Evidence was seen of accommodation being made for people with complicated, uncommon problems during "rush" which triggered the cycle. Accommodations include getting people with more routine problems situated first or having people leave their computers for repairs. The motto of "to work on it until it's fixed" and the practice of not turning people away seem to drive the process. Otherwise the technicians could have easily sent away anyone who had an issue that was not routine and that was too complicated. The supervisor explicitly stated, in the quote below, it is not his desire to send anyone away without some kind of help.

> Supervisor: Yes, like this is going to be a bigger issue, so I try to write it down. I mean, the student's not going to be able to leave, and we really don't want to send somebody away without some kind of help, but if it's going to be a bigger pain problem, you know, get everybody else situated really quick.

From the Understanding the System phase results, one of the characteristics of the culture was a genuine interest in helping others and this could have contributed to a communal

environment that fostered working and learning together to achieve the goal of ensuring that all students had technology they could use in class. This could further explain why they felt comfortable asking each other for help and extending help. In doing so they learned from each through the sharing of experiences and ways of doing things. In addition the technicians are able to learn from each other because there is a level of autonomy and input in SHD's culture. Autonomy and input acted as driver as the technicians seemed very comfortable in trying different methods to solve a problem and also providing input to problems on the whiteboard.

Leadership. In the Understanding the System discussion, the focus was on leadership from a very high level. For this discussion, the focus will be on the supervisor specifically, and how he seemed to drive the process of knowledge flow along the life cycle. First there was evidence that his leadership style was participatory. Of the 11 incidents I collected he was actively involved in four. Peter confirmed this when he explained, "well, [the supervisor] is the one who started on the problem, because we were swamped that day, so [the supervisor] was helping around." It could be said that the supervisor holds the knowledge life cycle together as there were times when an incident occurred and when I asked how it was disseminated, the answer was that the supervisor knows about it. Lisa validated this point in saying that really complicated things get escalated to the supervisor and he should be able to say he has seen the issue before, so he becomes the source of wider dissemination.

Lisa also gave an example of how she and the other technicians had thought an issue was uncommon and spent hours trying to figure it out, but after asking the supervisor, it was revealed that the incident was not uncommon to SHD. There was even an article on the wiki about it. The supervisor was able to connect with previously created knowledge to solve a current problem.

The evidence of the supervisor driving the flow of knowledge along the knowledge life cycle was very strong regarding preservation, as the director highlighted that it is quite possible that there are some documentations that she has no idea about. In addition, Fernando remarked that the wiki, which is the main preservation tool for SHD, is mostly updated by the supervisor. The supervisor mentioned, in his quote below, that things became more consistent since he was hired. This highlights his important role and in general having a consistent manager of SHD.

> Supervisor: Before I started working here, the office was basically just run by students. And the GAs would you know, would change over once a year, the students would change over several times a year, so it was really, really difficult to keep anything consistent, keep any kind of training or skillset consistent was near impossible. Ryan and [The Director] worked with that when they started, but at the same time, they were working with their own job descriptions. [The Director] is the head of IT, [The Manager] is the systems administrator, and they both have to do their jobs and try to support and run this office at the same time, which was kind of a beast of burden. When I jumped in, I got to basically just set everything to a standard.

Resources, tools, and processes. The third driver environmentally was resources and tools. Of the 9 technicians I interviewed, including the supervisor, 6 of them, during at least one interview, told me they had everything they needed to solve the problem in response to the question: "what experiences/resources would you like to have that would have helped you or could help you solve the problem?" For example, Mario and the supervisor gave examples in the quotes below of how the existing resources were adequate.

> Mario: I think we have everything, we used the computer, sit down and say, 'hey, Google." Typically, if no one is using the server that we have set up I can go up there, I

can pull down a computer, it's not a big deal. So I think we had all the resources we needed to fix that problem.

Supervisor: Yeah, I think we pretty much have everything we need, we have a stored server so we can push a fix out quickly if we need it, access to the internet, all other tutorials, I think we're pretty much set on that front

Quite possibly it could be that they had everything they need to solve the actual problem, or like Vaughn mentioned, they were comfortable working with the existing resources and never gave thought to what else could make the knowledge creation, preservation, and dissemination process more effective. Vaughn stated, "That's a good question. I mean, I haven't looked out of the box yet, because everything we have is pretty much all we need. Yeah, I don't know."

SHD provided the technicians with the tools and processes they needed to go through the knowledge life cycle. The biggest resource was the whiteboard, which allowed for all three phases to occur on one platform. The technicians also provided reasons why the whiteboard drove the process: because it was convenient, visible, central, and a point of reference as seen in the quotes below by Vaughn and the supervisor.

Vaughn: I put it on the board so that you know, it's visible, because these papers, they get lost in the pile, so nobody's going to scan through the papers to see if it's an issue, so I just put it on the board so that everybody can see it.

Supervisor: Because we have so many technicians working at the same time, or not, not at the same, specifically not at the same time, a GA in the odd hours, I'm in during certain hours, but not for the rest of the day, or I have meetings or something to that effect. The information can get scattered really easily, especially during the first couple

of weeks of each semester when we see the rush of people, the whiteboards on the side of the room are just a way of communicating difficult problems that are being seen.

Another resource that enabled the flow of knowledge along the knowledge life cycle was the infrastructure of the office. The office, being one room, and the fact that the space in which the technicians help students was open, allowed for environmental cues to trigger the knowledge life cycle. For example, many of the external connections were made through "overhearing", "seeing", or "stopping by" as seen in the following quotes:

Brandon: "So I just *overheard* them talking, and I guess the problem was that they were trying to connect to VT wireless"

Focus Group: if I *overheard* that someone else had the same problem, I would just tell them what we went through to fix it.

Peter: [The supervisor] was working on that problem before, and *I heard* him having trouble, so I was like, "So what's the problem?" And he told me, and I was like, "Well, get the new ones.

The fact that the technicians were keen to responding to things they overheard and saw ties back to the culture as a driver. However, if they were not all in the same room and the space was not open it would not have been possible for them to "see" and "overhear" which triggered the external connection of extending help.

Shared understanding. Complementing the resources and tools was a shared understanding of how to go about using them. All the technicians gave reasons why something should or should not go on the whiteboard, the website and the wiki. For example Lisa and Bethany, as shown below, stated that when an issue increased in occurrence it went on the whiteboard.

Lisa: It is a quick fix. I think if it comes along in magnitude, it will go on the website, because the website doesn't have all the problems, it usually just has the most common problems.

Bethany: It depends. I guess sometimes we do or we don't, depending on if it's an uncommon issue. If someone's had this issue before, where they couldn't figure it out, then we put it on the board.

Having a shared understanding indicates that there is a system in place to facilitate that shared understanding and could be due to standardization that the supervisor and the director referred to especially through the training sessions that bring the temps and the permanent technicians together each year before they start the Fall semester.

In addition, to having a shared open space, the fact that the technicians were scheduled in overlapping shifts helped to drive movement through the knowledge life cycle. The overlapping schedule acted as a connector and dissemination path for things that occurred before another shift started. Given that SHD's predominant method of dissemination, apart from using the whiteboard, is word of mouth, this helped to facilitate that process. The supervisor explains the overlap in the quote below.

Supervisor: There's, the schedule has a lot of overlap in it, so if one person's working from 9am to 12, we're not going to have everyone working from 9am to 12 and then switch over, you'll have somebody working from 9am to 1pm, or, there's always a constant overlap of people.

The quote below is a classic example that was given during the focus group session of how dissemination occurred via "word of mouth" across shifts during rush.

> Focus Group: Word of mouth, mostly. This was during the rush, so we had four or five people on at a time, and I was sitting there for a couple hours, so that's, what two shifts easily, like eight or nine people out of the 16 we had employed at the time. So by the end of day one, half of staff knew about it; by the end of day two, nearly everybody knew about it.

In talking about the folder issue Vaughn also alluded to scheduling being a driver as well, but not in terms of overlapping but just by virtue of making sure more than one technician was working at a time. Not only does that ensure that they meet the high customer demand, but it ensures that external connections can take place when necessary through asking and extending help, " if there was just one technician working at one time, that would be a pain, so it's a good thing that we have three working at the same time.

Rewards and incentives. SHD seems like a great place to work and having that as an incentive may be another driver that motivates the technicians to work in alignment with the mission of SHD and thus create, disseminate and preserve knowledge that will help in improving services. The supervisor mentioned that SHD pays better than the average job on campus in the following quote, "baseline, we pay well for just a starting out job, especially a student job on campus."

A second subtly incentive quite possibly could be public recognition. The whiteboard is visible and when a technician solves a problem and writes the solution on the board, that could act as a form of public recognition. The open space of the office also facilitates seeing and hearing that someone has solved a problem. However, there was no explicit evidence for this except for when Lisa stated that whenever there was a problem, people like to come around and

see what it is and see if they have some sort of insight, to be the one who solves the problem." The use of the phrase "to be the one" implies some form of glory and a sense of achievement.

Individual drivers. The supervisor and the director mentioned that they hire people based on technical competence in addition to other soft skills like good customer service and genuine interest in helping others. The supervisor explicitly stated that he is very "picky" when hiring. The fact that all the technicians were able to clearly articulate to me the steps they took and the reasons behind those steps demonstrated that they have the knowledge and skills to perform the task and to trigger the knowledge life cycle through creation. In addition, they all seemed to love troubleshooting naturally based on their backgrounds, so whenever they encountered, a problem their natural tendencies to want to find a solution drove the process as well, indicating that they were intrinsically motivated to try to find solutions to the uncommon problems.

Summary of driving forces. SHD's driving forces may be divided into individual and environmental factors. Individual factors refer to the technicians' knowledge, skills and capacity. The technicians had sufficient knowledge and skills to effectively solve uncommon problems; additional, they were intrinsically motivated to go through the knowledge life cycle processes. Environmental factors includes SHD's culture and mission, leadership, resources, tools, and processes. The mission of SHD is for all students to have technology they can use in class. Their motto, "to work on it until it's fixed" supports the mission and dictates that students with complicated or uncommon problems will not be turned away during "rush", thus triggering the creation phase of the knowledge life cycle. The culture of genuine interest in helping others is in alignment with SHD's mission and not only refers to technicians helping students, but also helping each other which facilitated external connections with each other to solve a problem.

With regards to leadership, having a supervisor for the office who was actively involved with the day to day operations drove the flow of knowledge along the knowledge life cycle, as knowledge was disseminated to him in many cases when it was not disseminated to anyone else. In addition he was the main person that added items to the wiki, so in this case, in the capacity of supervisor, he also acted as knowledge manager. The resources, tools, and processes drove the flow of knowledge along the knowledge life cycle as they acted as connecting platforms where knowledge could be created, preserved, and disseminated. Having a systemic way of going about the knowledge life cycle resulted in a shared understanding and thus increased the likelihood that the cyclic nature of the knowledge life cycle would occur. The restraining forces will be discussed next.

Environmental restraining forces. Though there is always room for improvement, there was no strong evidence for any individual factor being a restraining force apart from a few instances where using a different search term yielded greater results and in this regard, some technicians' lack of "searching skills" may be considered a restraining force. What was most evident were environmental factors such as time, and limitations of existing resources acting as restraining forces to movement throughout the knowledge life cycle.

Time and high demand. A lack of time was reported as one of the biggest barriers to going through the knowledge life cycle when dealing with critical incidents during rush. It sometimes dictated how far a problem was pursued to find a solution as well as how information was or was not disseminated or preserved. With regards to how much a problem is pursued, Mark highlighted it so well in the quote below, when discussing the Office issue,

Mark: Time was the biggest issue. That's a lot of what it comes down to with most of these issues during rush. It's not that we can't sit down and figure out the problem, it's just that there are so many people, and a limited amount of time to fix things.

When I asked him if he had consulted another source to solve the problem he responded that he didn't this time as during rush it's more convenient to rely on internal connections, "not this time. I find that with my technician work, that if we had the time to sit down and look at something, we'll consult, but this was during rush, so I just did what I knew to do." Similar sentiments were expressed in the focus group session where it was mentioned that during "rush" one only has a certain amount of time for trial and error and so if a problem requires too much time it may have to be dealt with later as shown in the quote below.

Focus Group: but even then, you can't waste too much time on it. You only get a few minutes of trial and error, and if it's not one of those common problems, it's going to have to be dealt with later, just because we don't have the time.

During rush, according to the supervisor, the knowledge creation process is triggered when the technician is not able to make any connections as to what the cause of the problem is or a possible solution after 10 minutes. Then some strategizing has to occur as the problem will require more attention and other people are waiting. During the focus group session an incident was mentioned, where because it became so prevalent, one person, in this case the SHD manager, decided to deal with all the people who had that problem. The quote below illustrates the manager's experience in dealing with the high demand.

Manager: So we would basically grab a couple of people, and it was, at this point, I was just the one helping everyone that had this problem, because they were coming in and just

coming to me with this problem. So I was just sitting with them, working these problems out with them.

The supervisor reported doing something similar as well; when he discovered that a student's problem required more attention, he got everyone else situated, and then spent more time on the complex issue.

Because of time as well some problems are not pursued to the point of finding a specific solution but at times a Window's re-install becomes the most convenient and less time consuming way of fixing the problem which may not result in the generation of any new knowledge. I say "may" as the technician could still make a new discovery in the process. The quote below from the focus group session highlights the time dilemma, where sometimes a problem cannot be fully pursued to find a specific solution, what they referred to as "cutting your losses."

Focus Group: I'd tried, I wanted to have more time to tackle the problem. If I'm distracted, or if there are other things going on, especially during rush, you just have to shove the problem aside and cut your losses, and say, "reinstall Windows, there you go."

Other similar comments mentioned that this approach was especially useful or used if the diagnosis is that the problem is caused by a virus.

Not only did time determine when an uncommon issue was addressed and the extent of the solution, it also determined how knowledge was disseminated and preserved. In reflecting on what he could have done differently for the DyKnow incident, Fernando said he would have documented more but because of time he just wrote one sentence, "I only wrote like a sentence, I probably should have written a bit more. I think it was because it, I was in a bit of a rush, since it was the first week, I believe."

For Lisa and Brandon, time dictated which method was used first in the MATLAB incident. For them the whiteboard was most convenient and then the information sheet that I used for this study was filled out when they had time, "it went on the whiteboard first, and then when we had time, he wrote it down on the paper that you take."

The director also alluded to time being a barrier. When expressing her vision, she stated that documentation or preserving knowledge is not an issue when things are slow and the workers have time, however it becomes a challenge during periods of high demand.

Fragmented system. Although the existing resources, processes and tools were driving factors, their limitations also acted as restraining forces. The major factor was that the systems were not connected. For example, when customers come in, they swipe their ID cards and record in the database what they think the problem is. If the problem is uncommon and more troubleshooting is needed, what the technicians try and the ultimate solution are written on the whiteboard. If during the process, the customer or technician has to leave, an information sheet is usually filled out and then when the problem gets solved, the solution moves over to the wiki. Four separate disconnected systems that rely on information from each other were mentioned, however at no point the systems intersect.

The most evident restraining force was a lack of an effective system that recorded what technicians did so if a customer returned and a new technician decided to assist, that technician would be privy to what had been tried already, as well as the history of the customer's computer in terms of actual problems and solutions. This resulted in technicians starting the troubleshooting process all over again or relying on the customer to convey what was already done and in some cases the customer was not able to articulate it. This was predominantly seen in 4 of the 11 incidents collected: DyKnow, SSD, random stuff, and Office.

Though four incidents represent less than 50% of the total incidents collected, the effect of not having access to what a previous technician did was very strong and was even mentioned in an interview for another incident with Peter. The extent of the challenge was made clear through a response to my question, "Is there anything else you'd like to tell me?" Peter responded, informing me of a general SHD need for a system that allows them to pull up what a previous technician did. The quote below captures the nature of SHD's challenge.

> Peter: Not about this incident in particular, but more for like [SHD]. We're talking yesterday about having a ticketing system so that we know what the previous technician did with the user, so we don't have to go around and try the same things again. Kind of like, I worked for [another help desk on campus] for a while, during the summer, and they have a ticketing system, and you can go back and check what the previous consultant did and what steps they took and a lot of good information, which would be very helpful for us at [SHD], so that way we don't waste time trying to figure out what was done previously, to fix things.

When I asked what triggered the conversation with the other technicians, Peter responded, in the quote below, that several computers were left behind to be fixed and none of the technicians that were there knew exactly what was tried; quite possibly the previous technicians could have been pressed for time and thus did not record enough information that could be used by the next set of technicians.

> Peter: because there were several computers left behind, and this particular one had a hard drive issue, and someone had worked on it previously, but we couldn't find what they did, and the problem was still around, so we basically had to rerun check disc,

formats, do Windows again, and we had no solution to it. So we ended up saying it was a hardware problem, but still, it would have been nice to know what was done previously.

Several of the technicians share Peter's view. Not surprisingly, they were some of the technicians that were involved in one of the four incidents where there was no knowledge of what a previous technician did.

Lisa pointed out that the alternative of not having a system that records what was actually done is to assume that the customer never visited SHD before unless the customer says otherwise and in some cases the customer does not always know what to say, "Because when people come in, we assume that they haven't been in here before unless they actually say that, and not everybody knows what to say when they're coming in."

For the DyKnow issue Fernando mentioned that having access to the information sheet that was used for this study was helpful, as based on what was previously done he was able to make the necessary internal connections. The paper identified the problem as an install that couldn't continue, which helped him to eliminate that it was not an installer that couldn't install at all, as explained in the quote below.

> Fernando: Yeah, it [information from the paper] was [helpful], because that way I could see how it had gotten to that point, because if it was just an installer that couldn't install, then that would be a whole lot bigger of a problem than if it was a failed install that couldn't continue.

Knowing that the information sheet, was for the purpose of this study, I asked Fernando if the information sheet was not used, how would he have known what was previously done. He responded that he probably wouldn't have known and would have had to rely on what the customer told him, which is not always reliable. Likewise Mark pointed out, in the quote below,

that if he had known what the previous technician did it would have saved him time, as the customer was not able to provide the information that was needed.

> Mark: It would have helped a lot. That would have saved me, I think this happened; I probably wasted 10 minutes trying to track down. I kept asking the customer, I would say, What did you do, what happened, what did they do? And she was like, I don't know, they just kept doing this and that, so I had to track down what he'd finally done.

Though the whiteboard was the most effective system as it was central, visible, accessible and convenient and the only system where knowledge was created, disseminated, and preserved, it had serious limitations. Limitations included the fact that it would get full, sometimes items would be erased, and sometimes it was hard to identify what was on it. Lisa, in dealing with the password issue, mentioned that it did not go on the whiteboard because it was full. In tandem with the whiteboard getting full, is also the fact that it gets erased, and at times it's hard to find an issue because the board is filled with various things. In the interview for the DyKnow incident Vaughn also remarked in the quote below that not everyone looks at the board:

> Vaughn: I mean, the thing is, not everybody sees the board. We as permanent technicians, we're used to seeing the board, if the issue's on there before we go to Google, so, but at that point, there were temps who didn't know to, and there are a bunch of issues on the board, it's really hard to find your specific issue, so at that point I would email them.

In other cases it was mentioned that sometimes the whiteboard gets erased. For example, Fernando mentioned, in the quote below, that if the board is getting full, sometimes someone will erase the items and then rewrite them nicely in a column.

> Fernanado: Probably. I just wrote it quickly, so I assumed that they would, because we usually, we write stuff, and then somebody will put it in a nice column somewhere at the

edge, and erase it. So I did not see it there, but there was a similar fix written later. I can look again, if you want.

In addition, not all uncommon problems made it to the whiteboard, especially if the problem was very unique and the fix was a generic one. When I asked Mark how he documented the information from the Office issue, he responded that because it was not different in terms of how he fixed it he did not document it outside of the information sheet for this study. The quote below captures Mark's reasoning.

> Mark: I didn't think it was that much different per se than if like something else had gone wrong, so I didn't document it, outside of the form… It just seems like a typical, it wasn't like Office-specific, that was typically something that I would have done for any other program, had it malfunctioned. And so I think it was, it was unique in and of itself, but it wasn't a common…

Also when I asked Mark how he shared the information he mentioned not sharing it with the other technicians with a guilty look that made me interject and assure him that there were no right or wrong answers or judgments. He responded that my question made him go in self-reflection mode and he would start sharing more. For him the problem was fixed and because it wasn't a unique fix he didn't think of sharing, "Well, I was starting to think a little more about myself, I was like, 'I don't really talk to anyone after I fix these things', I'm just kind of like, 'It's fixed.' So I might start doing that."

Brandon and Lisa gave similar reasons, in the quotes below, for not putting information regarding the random stuff and password issues respectively, because they were really uncommon.

Lisa: But the whiteboard is just, it's way, you don't know how to fix it, so sometimes if it's something where it's like, "I don't think, I think there's a fix, and I just don't know what it is," it'll go on the whiteboard. But if it's something like, it's this complicated, unique problem, then whiteboard might not be the answer.

Brandon: No [we did not write anything on the whiteboard], because it's one of those things that, it's uncommon enough that no one would probably ever need info on the board, aside from generic things, like check the system event log, and then go from there. But it's like this specific thing, it will probably never happen again.

The technicians saw their record of the incident, primarily for this study, as a way of documenting information about the incidents they encountered. However, it was also noted that this method was not very effective beyond providing information for this study, as several comments were made that papers get thrown away and not everyone will sort through the papers to locate the information they need. Vaughn, in talking about the DyKnow issue, mentioned that he made sure to put the information on the whiteboard, "because these papers, they get lost in the pile, so nobody's going to scan through the papers to see if it's an issue." Lisa expressed similar sentiments, regarding the random stuff incident. She mentioned that she advised the customer to tell the technicians to boot into Ubuntu when the customer returned as she knew the technicians would not "rifle through the sheets." Another issue with the information sheet was that it did not allow for more than one technician to record at a time, which posed problems for communication and wholistic problem solving. Like for the DyKnow incident, Fernando knew of the paper and found it helpful, but Vaughn did not know that there was a paper and repeated some of the steps that were tried before. The supervisor explained that they were using the paper and the

whiteboard for the DyKnow incident based on which one was available, as seen in the quote below.

> Supervisor: We had the sheet being passed around, we had a lot of people working on it, so basically anything one of us had tried, if the sheet wasn't available, it went on the whiteboard, and vice versa, we made sure everything was written down

Creating greater challenges is the fact that the information from the paper and the whiteboard is usually transferred to the wiki. One item on the training agenda is: "Go through wiki and just read the articles just to see usual and unusual problems," yet, this tool was underutilized as the supervisor expressed, "people need to read that [the wiki] a bit more."

The technicians confirmed that they do not utilize the wiki and gave reasons for not using it. Lisa, in discussing the MATLAB incident, mentioned that some technicians did not check the wiki. She further stated that they learned the hard way when they spent two hours trying to figure out a problem and once they asked the supervisor, he mentioned that the problem was not uncommon and information was available on the wiki. Lisa mentioned that she did look in the wiki, but did not find the information; she thought it would be there in "blinking lights" but it wasn't. The quote below is Lisa's account of this experience.

> Lisa: There was a guy who came in, and he was there for two hours, and he went through three technicians, and I was the third in line, because somebody else's shift had ended. He had installed a new version of Office, and his pen wouldn't write in One Note or PDF Annotator, it wouldn't work, so I was installing drivers like everybody else was doing, and I was like, "I'm going to go ask somebody." So I asked another technician, and he said he didn't know. I figured [the supervisor] would know. Because in my head, the whole time, it sounded familiar. And I looked through the wiki, but it wasn't apparent in

there. I guess I didn't look hard enough, I just thought it would be in there with blinking lights, I suppose. So I went to [the supervisor], and [the supervisor] turned around and he was like, "That's a really common fix," you just had to drag this thing over, click on it, and it was done. So, he spent, the kid spent two hours for a one click problem that could have been fixed in five minutes.

Bethany also mentioned that the technicians did not really use the wiki and it was not easy to find the information. After having the interview with Bethany I tried to see if the wiki had a search function and it did. However, based on Bethany's and Lisa's comments the search function is probably not very effective. The quote below is Bethany's account of her experience with the wiki and the suggestions she had.

Bethany: I don't think a lot of us go to the wiki [chuckles]. It's not, it's easy to navigate, but at the same it's not, because you have to go through each one to figure out what it's talking about. So if we had like issues that someone couldn't solve, but someone else figured it out, I guess, I don't know, it would be nice to be able to do a keyword and type it up, and it would just come right up.

The director did highlight that using the learning management system's wiki feature was not very effective. The technicians confirmed what she said, as not being able to retrieve something after it was documented defeated the purpose of documenting it in the first place.

Insufficient space and poor phone reception were some other restraining infrastructural issues that were highlighted. For the password issue, Lisa mentioned that she did not Google the problem as during rush there is no space for their personal laptops. Discussions with other technicians and the supervisor indicated that this is not always a big problem as they sometimes use the customers' computers when possible or the computer that host the file server at the front

of the room. With the password issue, Lisa did not have access to the customer's computer. The quote below illustrates the space issue.

> Lisa: Also, during rush, we don't really have our laptops out, because there's not enough table space, so I didn't Google the problem, because my laptop was in my backpack in the other room. But when it's less rushed, we can usually spend time looking it up and trying to see what other people said.

Being aware of the prevalence of Smart phones, I asked Lisa if using her phone to search was an alternative to her laptop and apparently the room has poor reception, presenting another barrier: "there's no signal in that room, it's, there's like the little, it's saying 3G, it's the little circle, and it kills my battery being in that room." These conclusions were confirmed by other technicians as well.

Summary of restraining forces. SHD's restraining forces to going through the knowledge life cycle during rush primarily fell under the category of environmental factors, with a lack of time and a fragmented system being major restraining forces. Time dictated the extent that the solution for a problem was pursued and it also influenced how the knowledge was disseminated and preserved, if at all. Although the whiteboard proved to be the most effective system for knowledge creation, dissemination, and to some extent preservation, it had limitations, in terms of space and organization. The whiteboard got full, sometimes the information was erased, and at other times it was hard to locate a specific issue. In addition the whiteboard was mostly used for certain types of problems. The other KM systems included the information sheet and the wiki. These systems were primarily used for preservation, and had limitations as well. Due to the fact that they were not easily accessible, and information was not easily retrieved, they were not used often by the technicians. At no point did these systems

intersect, resulting in a fragmented system. The biggest challenge that the technicians reported was a lack of a system that documented what previous technicians did in a way that was easily retrievable.

Chapter 5: Findings and Interpretations

This single instrumental case study (Stake, 1995) examined how workers in a fast-paced environment went through the knowledge life cycle when dealing with critical incidents and the factors that acted as driving and restraining forces. Salisbury's (2008) knowledge life cycle model (see Figure 3), which consists of three phases: create, preserve, and disseminate was used to frame this study, along with Nonaka and colleagues' (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka & Konno, 1998; Nonaka et al., 2000; Nonaka, Toyama, et al., 2001) Theory of Organizational Knowledge Creation.

A case study methodology was well suited for this study as the purpose of the research sought to examine the "how" of the KM processes employed by the organization, and knowledge cannot be studied without attention to the context in which it is used (Fuller et al., 2007; Hartley, 2004; Merriam, 1998; Yin, 2009). In this case, participants were employees from a walk-in help desk in one of the technical colleges of a land-grant university located in Southwest Virginia. This help desk is referred to by the pseudonym Software Help Desk (SHD). Data collection took place between Summer and Fall, 2013. The HPT Model (see Figure 8) along with principles and procedures of CIT (Flanagan, 1954; Stitt-Gohdes, Lambrecht, & Redmann, 2000) were used to create a framework for data collection, analysis and interpretation (See Figure 10). In Summer, 2013, two members of SHD's management team were interviewed to get an understanding of the context of SHD, and a focus group session was conducted with technicians using CIT to get baseline data. In Fall, 2013 individual interviews using CIT were conducted with each technician that was involved in the critical incidents that occurred during this period. All

interviews and the focus group session were audio recorded and transcribed. Extant data such as job descriptions, annual report, and technician training agendas were examined as well.

Findings revealed that the workers of SHD went through the knowledge life cycle by forming connections. Connections may broadly be classified as internal and external. The technicians connected internally with their cognitive processes using their technical knowledge and heuristics, and externally with each other and preserved forms of knowledge. External connections that were made with each other were initiated by a technician asking for help or another technician offering help. In making external connections, an awareness of expertise was important. In several cases it was pointed out that knowing who to ask or where to look for the information was very important for knowledge flow, as no one technician had all the answers. The connection processes often occurred in tandem with each other and relied on knowledge being disseminated and preserved. The connections were fostered through the culture of the organization, connecting tools and resources, standard process, and individual capabilities. The connections were apparently hindered primarily due to a fragmented system comprised of four main tools that did not intersect, with the biggest challenge being lack of an effective system that records what previous technicians have already done.

In this chapter, findings are discussed as they relate to the supporting literature. Derived implications for the organization studied are also discussed, as well as for similar environments, and the fields of HPT and IDT. The interpretation of the findings was done through the lens of the literature from KM, IDT and HPT. Findings are discussed both locally to SHD and globally to similar organizations, and the field of IDT.

Study Limitations

Because this was a single instrumental case study (Stake, 1995) and the case was chosen based on the general characteristic of being fast-paced and dealing with critical incidents, it cannot be stated that these findings are applicable to all organizations that are fast-paced and that deal with critical incidents. However, through the detailed descriptions provided of the case, one can determine the similarities with this case and others, and decide if the findings may be applicable or not; this is what Stake (1995), refers to as naturalistic generalizations.

The Knowledge Life Cycle

Studying SHD through the lens of the knowledge life cycle approach allowed for a detailed understanding of the flow of knowledge and the identification of the KM gaps. This case study therefore, validates using this approach for other organizational case studies that aim to investigate knowledge flow within an organization. The iterative and interconnected nature of the knowledge life cycle was confirmed, as well as the importance of systems and processes that facilitate the entire knowledge life cycle. All phases must be facilitated in order for efficient KM to occur and by extension organizational learning (Alavi & Leidner, 2001; Argyris & Schön, 1996; Dalkir, 2011; Nonaka, 1994; Salisbury, 2008, Van Tiem et al., 2012). The knowledge life cycle is enabled by both individual and environmental factors in a system that integrates KM and its core work processes (Dalkir, 2011; Nonaka, 1994; Salisbury, 2008; Van Tiem et al., 2012). The process of "making" connections through the knowledge life cycle is quite similar to the principles of the Theory of Organizational Knowledge Creation (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka, Toyama, et al., 2001). The following discussion addresses each of the issues mentioned in greater detail through examples from the results of this study and reference to the literature.

Knowledge life cycle and the theory of organizational knowledge creation. The supervisor of SHD was quite right when he said "it's a vicious, vicious cycle." The knowledge life cycle as observed in SHD, is a constantly renewing cycle where existing knowledge is built on to form new knowledge. The way the flow of knowledge occurred through making internal and external connections within a shared space, or what I referred to as a "connecting platform," aligns with Nonaka and colleagues' (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka & Konno, 1998; Nonaka et al., 2000; Nonaka, Toyama, et al., 2001) SECI conversion model and the concept of ba. The SECI conversion model is based on the premise that knowledge is created through various conversion modes between tacit and explicit knowledge (socialization, externalization, combination, and internalization), as individuals interact with each other within a shared space called ba.

The whiteboard was very central to the knowledge flow of SHD and enabled all the knowledge conversion modes which facilitated movement along the knowledge life cycle. It was evident that the technicians had a lot of tacit knowledge. In trying to explain to me what they did, they were able to articulate the reasons behind their actions. This is a form of what Nonaka & Takeuchi (1995) call externalization, where tacit knowledge is converted to explicit. Externalization was also seen whenever a technician wrote on the whiteboard. An example of Nonaka & Takeuchi's (1995) idea of internalization (explicit to tacit) was when a technician wrote something on the whiteboard and another technician integrated that knowledge to solve a new problem or even connected the ideas to what was already done to find a solution. This is also an example of the knowledge life cycle occurring, with the application of preserved knowledge that has been disseminated being used to create new knowledge. This indicates the iterative and interconnected nature of the knowledge life cycle. Combination (explicit to explicit)

was evidenced when information was combined on the whiteboard and then used to create a website tutorial or add to the wiki, enabling creation, dissemination and preservation. Socialization was also evident; Nonaka and colleagues highlight that in order for socialization to occur, there has to be some shared experience and this is in fact where the knowledge creating spiral begins. Working on trying to solve critical incidents together created a shared experience for SHD members and having the whiteboard and an open area in which to work, their "ba", fostered this. Mention was made of gathering around when there was an "odd problem" or another technician intervening to help another one. The comment by the supervisor that he had learned more from the technicians than he had from any explicit source aligns with socialization. It also highlights that not all knowledge can be captured explicitly in an organization, but by virtue of having a shared space or environment that connects members with various expertise in the organization knowledge flows (Dalkir, 2011; Rosenberg, 2012; Salisbury, 2008). In the context of SHD, this worked through asking for help and extending help, which were influenced by awareness of expertise. As Salisbury (2008) points out, organizational knowledge is complex and platforms are needed to connect people in order for organizational learning to occur. Salisbury (2008) asserts that organizations can manage the knowledge through "direct **connection** [emphasis added] between two or more people… by facilitating processes where those who need to know something can be **connected** [emphasis added] to those who know it" (p.138).

From the discussion above a relationship between the knowledge life cycle and the Theory of Organizational Knowledge Creation (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka, Toyama, et al., 2001) was established. This relationship was hinted on in Salisbury's (2008) article where he proposed a Collaborative Cognition model that integrated the knowledge

life cycle as an extension of the SECI knowledge conversion model (socialization, externalization, combination, internalization). On a bigger scale the fact that I found the Theory of Organizational Knowledge Creation (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka, Toyama, et al., 2001) useful in explaining the "how" of the knowledge life cycle confirms that viewing an organization's KM activities through the lens of the knowledge life cycle is not sufficient on its own to describe the dynamics of KM in an organization, as Dalkir (2011) points out:

> From a practical perspective, in order to manage knowledge, it is also necessary to have an organizing principle-a framework-to classify the different activities and functions needed to deal with all the knowledge-related work within and between organizations. This framework is often encapsulated in the form of a theory or model of KM. (p.57)

Thus organizations and/or researchers wishing to use the knowledge life cycle approach to study an organization should be sure to complement it with a KM theory or model that matches the context studied. In this regard, findings from this study can be used to contribute to the development of a model that integrates both the knowledge life cycle and principles of the Theory of Organizational Knowledge Creation (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka, Toyama, et al., 2001), and that is geared toward environments similar to SHD.

Impact of individual and environmental factors. Several authors have posited that KM involves multiple factors to be effective, which include, culture, leadership, and technology, as well as others (Cho, 2011; Haney, 2006; Mertins et al., 2001; Nonaka & Takeuchi, 1995; Rosenberg, 2012). The findings from this study indicate that complementary individual and environmental factors are needed for effective KM to occur. Nonaka and Takeuchi (1995) specifically address five enablers to navigating the knowledge life cycle: intention, autonomy,

fluctuation and creative chaos, redundancy and, requisite variety. SHD exhibited intention and autonomy through its culture, mission, vision, and leadership. For example, SHD's visions of having a system for "consolidating" their knowledge, is an example of intention. The culture proved to be a positive one that enabled the workers to work together and exercise a level of autonomy which led to knowledge creation.

Nonaka and Takeuchi (1995) speak of fluctuation and creative chaos as vehicles for creating knowledge. One characteristic of this is to have some form of structure, but with room for comfort with ambiguity. SHD has a systematic way of doing things, as seen in their various processes. However, by dealing with critical incidents, fluctuation is created and creative chaos begins, thus leading to knowledge creation. Nonaka and Takeuchi (1995) emphasize that creative chaos can only work if people are reflecting while acting and this may explain why SHD did not go in a state of panic whenever a critical incident occurred, as the whiteboard system allowed them to "reflect while in action."

According to Nonaka and Takeuchi (1995) redundancy refers to organizational members having a shared repertoire through repeated engagement in similar activities. This was evidenced through the training sessions, and access to the wiki and other knowledge bases. Redundancy was also created through disseminating information on the whiteboard which was visible and central. The other enabler is requisite variety, which refers to having varying skillsets among workers. This was the case for SHD; all the workers had the basic technical knowledge and skillset that was needed in addition to their varying skills.

It is commendable that both environmental and individual factors that enable movement along the knowledge life cycle were evidenced in SHD. This is in line with the literature that purports that these factors will influence how knowledge flows and will affect any

implementation of a KM system or changes to an existing one (Cho, 2011; Gold, Malhotra, & Segars, 2001; Haney, 2006; Nonaka & Takeuchi, 1995; Nonaka, Toyama, et al., 2001). In fact in organizations, corporate culture has been deemed one of the most frequently mentioned success factor (Mertins et al., 2001). To that end, it would make sense for researchers and practitioners to consider enabling the individual and environmental factors discussed in this section for any KM initiative.

Alignment between core work processes and the knowledge life cycle. In order for knowledge to spiral through an organization, the connecting platform must not only connect the workers and their processes, but should also ensure that the processes of the knowledge life cycle are connected (Dalkir, 2011; Heisig, 2001; Rosenberg, 2012; Salisbury, 2008). SHD's biggest challenge, as seen from the data, is tying the phases together. If the phases are fragmented then the value is lost. This situation is not unique to SHD. According to Heisig (2001), KM activities are integrated in the day to day activities and so it is not normal for tools and processes to be geared towards creating, disseminating, and preserving knowledge, rather they are designed to accomplish various work related task. Heisig (2001) provides an example of the results of such disconnection between the knowledge life cycle and core work tasks that is applicable to SHD, that of a database being built, but not used by members or lessons learned are not generated from the application of knowledge.

The whiteboard worked for SHD as it provided the interconnectivity between the core processes and the knowledge life cycle. One core process of SHD is to find solutions for computer problems and the whiteboard provided a way for that knowledge to be created, disseminated and temporarily preserved. However, it was not as effective as it could be, due to limitations of space and permanence, thus the need highlighted by the supervisor "what we want

is something similar to what we are doing with the whiteboard that we can see it from a more detailed and comprehensive view than starting from the whiteboard."

Birkinshaw and Sheehan (2002) highlight that there is value in studying organizational knowledge from a life cycle perspective because it gives an opportunity to see where the strengths and weaknesses of an organization are and strategize accordingly. This can be achieved through a study similar to this case study that seeks to answer relevant questions regarding how the organization creates knowledge, how the knowledge is shared, and how it is stored (Heisig, 2001). The results of such an analysis would reveal the level of connectivity and identify gaps between KM strategies and core processes of the organization.

Based on the evidence provided, SHD does a very good job at creating knowledge, but its weakest area was preserving knowledge in a form that could be integrated with its existing processes, so that it can be applied and fed back into the knowledge life cycle. Knowledge was preserved in the "heads" of organizational members. However, because these are student workers and some workers are temporary, there is a risk that information may not be passed on. As Argyris and Schön, (1996) point out, organizational knowledge gets lost if the only holding place is in the heads of its members; preventing true organizational learning from occurring.

SHD's most pressing need seems to be environmentally related in the form of a technology tool. Although there could be possible improvements with regards to individual capability such as searching for information more effectively, the technicians demonstrated that they possessed the dominant knowledge, skills, and capabilities to effectively perform their tasks. All the intersecting fields of this research -- KM, IDT, HPT, and organizational learning share the tenet that technology should not be selected without first examining the context in which the system will be used. The value of this study for SHD, similar organizations, and the

fields of IDT and HPT is that this study zoomed in on the patterns of the organization with regards to the knowledge life cycle processes and was able to identify things that need to be considered when selecting a tool for this organization and similar ones. Even though the organization had already identified its need for such a tool, studies such as this can offer additional insights through examining the process from outside, as insiders can often miss things that have become so integrated in their daily routines that they become taken for granted (Argyris & Schön, 1996). The findings from this study can therefore be used to comprise what IDT and HPT professionals call a needs analysis (Rossett, 1989), which plays a crucial role in media or tool selection. This leads into the next finding, which is related to recommendations for a technology tool for SHD and similar organizations.

Recommendations for a Technology System

Technology, when used to support organizational goals and processes, has the potential to make KM more effective by affording various phases of the knowledge life cycle (Alavi & Denford, 2011; Alavi & Leidner, 2001; Hayes, 2011; Mertins et al., 2001; Nonaka, Reinmöller, et al., 2001; Rosenberg, 2012). The technology selection process should therefore be based on the context. In examing the context of fast-paced settings, like SHD, the system must take into consideration the time constraints. In fact, time is one of the most commonly mentioned constraints to effective KM (Heisig, 2001). An examination of the features of the whiteboard used by SHD provides some general characteristics that a system for this environment should have in order to be effective -- characteristics such as, convenient, accessible, visible, central, collaborative, and public recognition for solving problems.

The core activities or tasks that the organization performs need to be considered; as mentioned earlier, the work processes and the KM processes must be integrated in order for KM

to be effective. In this case, SHD will need to consider the fact that the customer inputs information in their current log-in system, and then based on that information, the problem may be categorized as a routine problem or an uncommon problem. The uncommon problems may have a unique fix or a generic fix, so this categorization may prove useful. To get to that point, the technicians need a way to document what they have tried and what worked. If the uncommon problem increases in occurrence and complexity, they also need a way so more than one technician can try something and then communicate that to the whole group. Given that retrieving knowledge is important for the knowledge life cycle to flow, a system that allows meta-tagging may be an option as meta-tagging provides a means of shared understanding which ensures that "similar content is stored, and found in similar ways, regardless of who is looking for the information, or who is providing it" (Rosenberg, 2012, p. 160). In addition, SHD seems to need some form of intelligence behind the meta-tagging as the director made mention that she would like to be able to notice trends and patterns and consolidate the knowledge. The fact that an awareness of expertise was important, and researchers state (Dalkir, 2011; Heisg, 2001; Rosenberg, 2012; Salisbury 2008) that one of the most important goals of KM is to connect people to the right resources when they need it, then integrating a method of identifying expertise may prove useful.

The strengths and limitations of existing physical and technology infrastructure is another factor that needs to be considered (Spitzer, 1992). In the case of SHD, the infrastruture limitation of space needs to be taken into consideration, as when the room is full, there is no space for technicians to have their own laptops. Based on the need for doing things in a timely manner, a mobile "app" may be an option because it would allow for input of information based on predermined categories. It was noticed that there are certain standard steps associated with some

issues so creating predetermined categories may allow for fast input, which is an example of how work processes can be integrated with KM processes. In addition, consideration needs to be given to the fact that there is an existing database and there may be a need to integrate all the databases.

Most organizations in the 21st century that are fast-paced are also growing organizations. By virtue of the fact that critical incidents are unplanned for incidents, any tecnology system for this environment needs to be adaptable to the changing needs of the organization (Massey et al., 2005). In the context of SHD, they are contantly expanding their services, and the services they offer change with new computer requirements set by the college's council.

In an organization like SHD, where all the activities take place in a shared space, consideration would need to be given to dealing with a move to multiple locations. In the case of SHD, considerations would also need to be given to the fact that the main ways that external connections took place were based on cues within the environment. If those cues are no longer available because of a lack of shared space, provisions need to be made for faciliting those cues; for example, an alert system could notify technicians when there is an uncommon problem or when a solution is found.

Having a reward and incentive system contributes to the success of any KM initiative (Cho, 2011; Haney, 2006); mention was made that whenever there was a problem all the technicians gathered around to see who would solve the problem. The whiteboard allowed recognition of who solved the problem, as their initials are usually placed by the post. Having the same public recognition affordance in a technology system may provide added incentive to participate in the knowledge management activities.

Lastly, all members of the organization need to have an input in the design of the system (Spitzer, 1992; Van Tiem et al., 2012). This is especially important if there are temporary and permanent workers in the organization or in some cases, contract and full time workers. In the case of SHD, though the tempoary technicians are not given as much responsibility as the permanent technicians, they both need to have input in the design of the system as the system need is primarily for when both groups are working together during "rush."

Conclusion

KM is indeed a complex issue for professionals who would like to make an impact as well as the organizations they work with. This study highlighted the value of studying knowledge in the context of an organization. Using the knowledge life cycle approach and the Theory of Organizational Knowledge Creation (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka, Toyama, et al., 2001) to guide the inquiry resulted in an indepth understanding of the knowledge flow as it relates to critical incidents. The system/ tool that was most effective for SHD was the one that was most accessible and convenient. Importantly, the system/tool was also the one that was involved in the technicians' core work process of finding solutions to problems, and facilitated their core method of making internal and external connections. This emphasizes the importance of integrating the KM system with the work processes of the organization, and ensuring that environmental constraints are accounted for, like a lack of time due to high demand for service. For SHD, KM challenges were seen with system restraints that were not accessible, and that did not effectively consolidate information from one source to another, with the biggest need being for a system that complements the core work process and links information that customers provide with the technicians' knowledge solutions and troubleshooting processes.

SHD did not seem to exhibit many of the cultural and organizational barriers that are seen in many organizations; however the fact that evidence was seen of where these factors acted as driving forces for the knowledge life cycle may provide examples to other organizations of how to develop an organizational environment that fosters knowledge flow, such as having a culture that encourages working together or "helping others", a KM intention or vision, and hiring workers who are intrinsically motivated and value the mission of the organization. KM professionals can use these findings to inform solutions for similar environments. This study also acts as a model for similar studies that would like to investigate how knowledge flows within organizations. Furthermore it suggests areas for additional research, which be examined next.

Suggestions for Future Research

Exploring how technicians "go through connections" the study touched on the decision making processes of the technicians, but that was not the focus of this study. Instead it was just an avenue for exploring the various phases of the knowledge life cycle. Other studies could examine the decision making processes behind each phase and the impact of those decisions. Interestingly, one of the criticisms of the Theory of Organizational Knowledge Creation (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka, Toyama, et al., 2001) is that it does not give an explanation behind the decision making processes (Dalkir, 2011), so a study that examines the decisions could extend the findings of this study, which may be used to develop a comprehensive model that explains the knowledge life cycle in more detail. The findings from the study could also be used to create a diagnostic tool or instrument that can be used to assess other organizations to see how applicable the findings are to other organizations.

Another consideration is to compare the two groups of workers, for example temporary and permanent, to see if there are any differences in the way they go through the knowledge life

cycle and implications for the organization. Also, the role that intrinsic motivation plays in the successful flow of knowledge in an organization could be examined and, ways to foster it. This is particularly important as having a reward and incentive system contributes to the success of any KM initiative (Cho, 2011; Haney, 2006). If organizations can foster intrinsic motivation, this will act as a non-tangible incentive and will be more feasible for many organizations.

This study made recommendations for things that need to be considered when implementing a technology solution for SHD and similar environments. A future study could build on the findings by creating a technology solution and conducting an evaluation. The concept of ba (Nonaka & Konno, 1998; Nonaka et al., 2000; Nonaka, Toyama, et al., 2001) in the organization was identified in this study; further examination of this construct may be valuable in helping organizations to create environments that foster knowledge creation. This study's methodology was influenced by various fields; other studies could try to replicate the methodology used and thus provide results for building a framework for studying organizational knowledge. In replicating the study with other organizations, cross comparisons could be done across cases to identify patterns towards a framework as well.

Concluding Remarks: Implications for the field of IDT

Learning and working naturally occur in tandem with each other (Dalkir, 2011; Fuller et al., 2007; Haney, 2006; Hartley, 2004; Heisig, 2001; Mertins et al., 2001; Salisbury, 2008) therefore, an effective KM or learning intervention should be embedded in the day to day activities of the organization, and allow learning and working to occur simultaneously. This and other learning design challenges of today dictate that, as IDT professionals, we must rethink some of the traditional approaches and devise new ways of investigating and solving learning challenges. New does not necessarily refer to entirely new ideas, but also refers to combining

existing knowledge in new ways to solve problems (Salisbury, 2009). The methodology used in this study is an example of combining existing knowledge to meet the needs of organizations. The methodology combines aspects of the HPT model with CIT and may act as a model for IDT professionals wishing to carryout similar studies. Similarly, using the knowledge life cycle (Salisbury, 2008) and the Theory of Organizational Knowledge Creation (Nonaka, 1994; Nonaka & Takeuchi, 1995; Nonaka, Toyama, et al., 2001) to form a framework for this study, provides another example of combining existing knowledge in new ways. Examining knowledge from the knowledge life cycle perspective has been validated by several researchers (Birkinshaw & Sheehan, 2002; Dalkir, 2011; Haney, 2006; Mertins et al., 2001; Salisbury, 2008), however what is needed are guiding frameworks for practitioners and researchers on the cognitive processes behind the knowledge life cycle and best practices on how to manage it within various settings. The findings from this study add to that discussion by providing insights into the driving and restraining forces in fast-paced organizations; and also by purporting that workers go through the knowledge life cycle by making internal and external connections, which are facilitated through various connecting platforms.

With regards to designing formal training, IDT professionals have a broad repertoire of theories and models to choose from, but regarding interventions that are non-traditional, like KM more guiding frameworks are needed. Another consideration is that the fields of IDT and HPT are evolving and both practitioners are called upon to do similar tasks. As Rothwell and Kazanas (2008), point out IDT has evolved to encompass more than just the creation of instruction, so one wonders if there is a need for the two fields to merge or do we just continue borrowing from each other. In sum, we cannot use the same approaches in the same manner and get different results, today's organizations have different needs and if we as IDT professionals are to be effective we

must rethink the ways in which we apply the foundational knowledge, and modify our schema accordingly. This case study built on the existing literature to create knowledge for the IDT and HPT fields, the knowledge was preserved and disseminated in the form of a dissertation. It is hoped that future research will build on this knowledge and let the knowledge life cycle continue as we advance the field and remain relevant in today's knowledge economy.

References

Alavi, M., & Denford, J. S. (2011). Knowledge management process, practice, and web 2.0. In M. Easterby-Smith & M. A. Lyles (Eds.), *Handbook of organizational learning and knowledge management* (2nd ed., pp. 105-124). West Sussex, United Kingdom: John Wiley & Sons.

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136. doi: 10.2307/3250961

Anderson, J. R. (1983). *The architecture of cognition*. Cambridge, Massachusetts: Harvard University Press.

Andrus, D. (2005). The wiki and the blog: Toward a complex adaptive intelligence community. *Studies in Intelligence, 49*(3), 1-30.

Anfara, V. A., Brown, K. M., & Mangione, T. L. (2002). Qualitative analysis on stage: Making the research process more public. *Educational Researcher, 31*(7), 28-38.

Argyris, C., & Schön, D. A. (1996). *Organizational learning II : Theory, method and practice*. Reading, MA: Addison-Wesley.

Backus, C., Keegan, K., Gluck, C., & Gulick, L. (2010). Accelerating leadership development via immersive learning and cognitive apprenticeship. *International Journal of Training and Development, 14*(2), 144-148.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report, 13*(4), 544-559.

Birkinshaw, J., & Sheehan, T. (2002). Managing the knowledge life cycle. *MIT Sloan Management Review, 44*(1), 75-83.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42.

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities-of-practice: Toward a unified view of working, learning, and innovation. *Organization Science, 2*(1), 40-57.

Brown, J. S., & Duguid, P. (2001). Knowledge and organization: A social-practice perspective. *Organization Science, 12*(2), 198-213.

Butterfield, L. D., Borgen, W. A., Amundson, N. E., & Maglio, A.-S. T. (2005). Fifty years of the critical incident technique: 1954-2004 and beyond. *Qualitative Research, 5*(4), 475-497.

Chadha, O. (2012). Technology and knowledge management. *International Journal of Research in IT & Management, 2*(2), 848-859.

Chell, E. (2004). Critical incident technique. In C. Cassell & G. Symon (Eds.), *Essential guide to qualitative methods in organizational research* (pp. 45-60). London: Sage.

Chell, E., & Pittaway, L. (1998). A study of entrepreneurship in the restaurant and café industry: Exploratory work using the critical incident technique as a methodology: *International Journal of Hospitality Management, 17*(1), 23-32.

Chevalier, R. (2003). Updating the behavior engineering model. *Performance Improvement, 42*(5), 8-14. doi: 10.1002/pfi.4930420504

Cho, T. (2011). *Knowledge management capabilities and organizational performance: An investigation into the effects of knowledge infrastructure and processes on organizational performance.* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Full Text database. (3478650).

Collins, A., Brown, J. S., & Holum, A. (1991). Cognitive apprenticeship: Making thinking visible. *American Educator, 15*(3), 6-11.

Conn, C. A., & Gitonga, J. (2004). The status of training and performance research in the AECT journals. *TechTrends, 48*(2), 16-21.

Cowley-Durst, B., Christensen, H. D., Degler, D., Weidner, D., Feldstein, M., & Dickelman, G. J. (2001). The case for creative abrasion experts speak out on knowledge management. *Performance Improvement, 40*(7), 9-15. doi: 10.1002/pfi.4140400704

Crandall, B., Klein, G. A., & Hoffman, R. R. (2006). *Working minds : A practitioner's guide to cognitive task analysis*. Cambridge, MA: MIT Press.

Dalkir, K. (2011). *Knowledge management in theory and practice* (2nd ed.). Cambridge, MA: The MIT Press.

Davenport, T. H., De Long, D. W., & Beers, M. C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2), 43-57.

De Jong, T., & Ferguson-Hessler, M. G. (1996). Types and qualities of knowledge. *Educational Psychologist, 31*(2), 105-113.

DiBella, A. J., & Nevis, E. C. (1998). *How organizations learn: An integrated strategy for building learning capability*. San Francisco: Jossey-Bass.

Easterby-Smith, M., & Lyles, M. A. (2011). The evolving field of organizational learing and knowledge management. In M. Easterby-Smith & M. A. Lyles (Eds.), *Handbook of*

organizational learning and knowledge management (2nd,ed., pp. 1-20). West Sussex, United Kingdom: John Wiley & Sons.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, 532-550.

Ely, M. (1991). *Doing qualitative research : Circles within circles*. London: Falmer Press.

Fahey, L., & Prusak, L. (1998). The eleven deadliest sins of knowledge management. *California Management Review, 40*(3), 265.

Farmer, J. A., Buckmaster, A., & LeGrand, B. (1992). Cognitive apprenticeship: Implications for continuing professional education. *New Directions for Adult and Continuing Education, 1992*(55), 41-49.

Flanagan, J. C. (1954). The critical incident technique. *Psychological Bulletin, 51*(4), 327-358. doi: 10.1037/h0061470

Flyvbjerg, B. (2011). Case study. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (4th ed.). Thousand Oaks: Sage.

Ford, M. W., & Evans, J. R. (2000). Conceptual foundations of strategic planning in the Malcolm Baldrige criteria for performance excellence. *Quality Management Journal, 7*(1), 8-26.

Fox, E. J., & Klein, J. D. (2003). What should instructional designers & technologists know about human performance technology? *Performance Improvement Quarterly, 16*(3), 87-98.

Fuller, A., Unwin, L., Felstead, A., Jewson, N., & Kakavelakis, K. (2007). Creating and using knowledge: An analysis of the differentiated nature of workplace learning environments. *British Educational Research Journal, 33*(5), 743-759.

Gilbert, T. F. (1987). Human incompetence: The autobiography of an educational revolutionist. *Performance+ Instruction, 26*(2), 4-6.

Glisby, M., & Holden, N. (2003). Contextual constraints in knowledge management theory: The cultural embeddedness of Nonaka's knowledge-creating company. *Knowledge and Process Management, 10*(1), 29-36.

Göker, M. H., & Roth-Berghofer, T. (1999). The development and utilization of the case-based help-desk support system HOMER. *Engineering Applications of Artificial Intelligence, 12*(6), 665-680.

Gold, A. H., Malhotra, A., & Segars, A. H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

González, L. M., Giachetti, R. E., & Ramirez, G. (2005). Knowledge management-centric help desk: Specification and performance evaluation. *Decision Support Systems, 40*(2), 389-405.

Gourlay, S. (2006). Conceptualizing knowledge creation: A critique of Nonaka's theory*. *Journal of Management Studies, 43*(7), 1415-1436.

Guimarães, C., Arce, T., & Mattos, R. (2013). Critical Incident Technique: A methodology to study information used by informatics companies. *African Journal of Business Management, 7*(10), 780-788.

Gunawardena, C., Layne, L., & Frechette, C. (2012). Designing wise communities that engage in creative problem solving: An analysis of an online design model. *Proceedings of the 62nd Annual Conference of the International Council for Educational Media*, 369-379.

Gustafson, K. L., & Branch, R. M. (2002). What is instructional design. In R.A. Reiser & J.V. Dempsey (Eds.). *Trends and issues in instructional design and technology* (2nd ed., pp.16-25). Upper Saddle River, N.J.: Merrill/Prentice Hall.

Halverson, C. A., Erickson, T., & Ackerman, M. S. (2004). Behind the help desk: Evolution of a knowledge management system in a large organization. *Proceedings of the ACM Conference on Computer Supported Cooperative Work*, 304-313.

Haney, D. (2006). Knowledge management, organizational performance, and human performance technology. In J. Pershing (Ed.), *Handbook of human performance technology*, 619-639. CA: Pfeiffer.

Hanson, J. H., & Brophy, P. D. (2012). The critical incident technique: An effective tool for gathering experience from practicing engineers. *Advances in Engineering Education, Winter 2012*, 1-24.

Hartley, J. (2004). Case study research. In C. Cassell & G. Symon (Eds.), *Essential guide to qualitative methods in organizational research* (pp. 323-333). London: Sage.

Hayes, N. (2011). Information technology and the possibilities for knowledge sharing. In M. Easterby-Smith & M. A. Lyles (Eds.), *Handbook of organizational learning and knowledge management* (2nd ed., pp. 83-104). West Sussex, United Kingdom: John Wiley & Sons.

Heisig, P. (2001). Business oriented knowledge management. In K. Mertins, P. Heisig & J. Vorbeck (Eds.), *Knowledge management : Best practices in Europe* (pp. 12-36). NY: Springer.

Hettlage, R., & Steinlin, M. (2006). The critical incident technique in knowledge management-related contexts. *Zurich: IngeniousPeoplesKnowledge. Available online at http://www. ipk. ch/files/CriticalIncidentTechnique_in_KM. pdf*.

Hildreth, P. M., & Kimble, C. (2002). The duality of knowledge. *Information research, 8*(1). *Available online at http://www.informationr.net/ir/8-1/paper142.html.*

Hoadley, C., & Van Haneghan, J. (2011). The learning sciences: Where they came from and what it means for instructional designers. In R. A. Reiser & J. V. Dempsey (Eds.), *Trends and issues in instructional design and technology* (3rd ed., pp. 53-63). NY: Pearson.

Howell, S. L., Williams, P. B., & Lindsay, N. K. (2003). Thirty-two trends affecting distance education: An informed foundation for strategic planning. *Online Journal of Distance Learning Administration, 6*(3). *Available online at http://www.westga.edu/~distance/ojdla/fall63/howell63.html?ref=%C4%B0lkSexShop.com*

Illeris, K. (2011). *The fundamentals of workplace learning : Understanding how people learn in working life*. Abingdon, Oxon; NY: Routledge.

Irlbeck, S. A. (2002). Human performance technology: An examination of definitions through dependent and independent variables. *Performance Improvement Quarterly*, *15*(2), 84-95.

ISPI. (2012). What is HPT? from http://www.ispi.org/content.aspx?id=54

Jasimuddin, S. M., Klein, J. H., & Connell, C. (2005). The paradox of using tacit and explicit knowledge: Strategies to face dilemmas. *Management Decision, 43*(1), 102-112.

Kang, B. H., Yoshida, K., Motoda, H., & Compton, P. (1997). Help desk system with intelligent interface. *Applied Artificial Intelligence, 11*(7-8), 611-631.

Kerssens-Van Drongelen, I. C., De Weerd-Nederhof, P. C., & Fisscher, O. A. M. (1996). Describing the issues of knowledge management in R&D: Towards a communication and analysis tool. *R&D Management, 26*(3), 213-230. doi: 10.1111/j.1467-9310.1996.tb00957.x

Klein, J. D. (2002). Empirical research on performance improvement. *Performance Improvement Quarterly, 15*(1), 99-110.

Klein, J. D. (2010). Trends in performance improvement: Expanding the reach of instructional design and technology. In M. Orey, S. A. Jones & R. M. Branch (Eds.), *Educational media and technology yearbook* (Vol. 35, pp. 135-145). Verlag: Springer. doi: 10.1007/978-1-4419-1516-0_9

Klein, J. D., & Fox, E. J. (2004). Performance improvement competencies for instructional technologists. *TechTrends, 48*(2), 22-25.

Krefting, L. (1991). Rigor in qualitative research: The assessment of trustworthiness. *The American Journal of Occupational Therapy, 45*(3), 214-222.

Kriegsman, M., & Barletta, R. (1993). Building a case-based help desk application. *IEEE Expert, 8*(6), 18-26.

Larson, M. B., & Lockee, B. B. (2009). Preparing instructional designers for different career environments: A case study. *Educational technology research and development, 57*(1), 1-24.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge [England]: Cambridge University Press.

Mager, R. F. (1988). *Making instruction work, or, skill bloomers*. CA: Lake Books.

Marshall, C., & Rossman, G. B. (2011). *Designing qualitative research* (5th ed.). CA: Sage Publications.

Massey, A. P., Montoya-Weiss, M. M., & O'Driscoll, T. M. (2005). Human performance technology and knowledge Management: A case Study. *Performance Improvement Quarterly, 18*(2), 37-55. doi: 10.1111/j.1937-8327.2005.tb00332.x

Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.

Mertins, K., Heisig, P., & Vorbeck, J. (2001). Introduction. In K. Mertins, P. Heisig & J. Vorbeck (Eds.), *Knowledge management : Best practices in Europe* (pp. 1-10). NY: Springer.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis : An expanded sourcebook*. CA: Sage.

Mincer, J. (1962). On-the-job training: Costs, returns, and some implications. *The Journal of Political Economy*, 50-79.

Molenda, M., & Pershing, J. A. (2004). The strategic impact model: An integrative approach to performance improvement and instructional systems design. *TechTrends, 48*(2), 26-33.

Morell, L., Borri, C., Rajala, S., Ramakrishna, S., Quadrado, J. C., Petrie, M. M. L., . . . Fouger, X. (2013). The evolutionary development of the international federation of engineering education societies. *Latin American and Caribbean Journal of Engineering Education, 3*(2).

Murray, M. (2006). Innovations in performance improvement with mentoring. In J. Pershing (Ed.), *Handbook of Human Performance Technology*, 455-477. CA: Pfeiffer.

Nguyen, F., & Hanzel, M. (2007). LO + EPSS = just-in-time reuse of content to support employee performance. *Performance Improvement, 46*(6), 8-14. doi: 10.1002/pfi.136

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37. doi: 10.2307/2635068

Nonaka, I., & Konno, N. (1998). The concept of "ba": Building a foundation for knowledge creation. *California Management Review, 40*(3), 40-54.

Nonaka, I., Reinmöller, P., & Toyama, R. (2001). Integrated information technology systems for knowledge creation. In M. Dierkes, A. Berthoin, J. Child & I. Nonaka (Eds.), *Handbook of organizational learning and knowledge* (pp. 827-848). New York: Oxford University Press.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company : How Japanese companies create the dynamics of innovation*. NY: Oxford University Press.

Nonaka, I., Toyama, R., & Bysoière, P. (2001). A theory of organizational knowledge creation: understanding the dynamic process of creating knowledge. In M. Dierkes, A. Berthoin, J. Child & I. Nonaka (Eds.), *Handbook of organizational learning and knowledge* (pp. 491-516). New York: Oxford University Press.

Nonaka, I., Toyama, R., & Konno, N. (2000). SECI, ba, and leadership: A unified model of dynamic knowledge creation. *Long Range Planning, 33*(1), 5-34.

Nonaka, I., & Von Krogh, G. (2009). Perspective—Tacit knowledge and knowledge conversion: Controversy and advancement in organizational knowledge creation theory. *Organization Science, 20*(3), 635-652. doi:10.1287/orsc.1080.0412

Norman, I. J., Redfern, S. J., Tomalin, D. A., & Oliver, S. (1992). Developing Flanagan's critical incident technique to elicit indicators of high and low quality nursing care from patients

and their nurses. *Journal of Advanced Nursing, 17*(5), 590-600. doi: 10.1111/1365-2648.ep8531132

Nunes, M. B., Annansingh, F., Eaglestone, B., & Wakefield, R. (2006). Knowledge management issues in knowledge-intensive SMEs. *Journal of Documentation, 62*(1), 101-119.

Nworie, J., & Dwyer, F. (2004). Knowledge management & instructional design optimizing organizational knowledge. *Performance Improvement, 43*(7), 27-32. doi: 10.1002/pfi.4140430709

Peroune, D. L. (2007). Tacit knowledge in the workplace: The facilitating role of peer relationships. *Journal of European Industrial Training, 31*(4), 244-258.

Pershing, J. A. (2006). Human performance technology fundamentals. In J. Pershing (Ed.), *Handbook of human performance technology*, 5-34. CA: Pfeiffer.

Plass, J., & Salisbury, M. (2002). A living-systems design model for web-based knowledge management systems. *Educational technology research and development, 50*(1), 35-56. doi: 10.1007/BF02504960

Polanyi, M. (1967). *The tacit dimension*. New York: Doubleday & Company.

Reiser, R. A. (2001). A history of instructional design and technology: Part II: A history of instructional design. *Educational Technology Research and Development, 49*(2), 57-67.

Richey, R., Klein, J. D., & Tracey, M. W. (2011). *The instructional design knowledge base: Theory, research, and practice*. London; New Yor: Routledge Taylor & Francis Group.

Robertson, R. F. (2004). That thing we do: Core competencies of human performance professionals. *Performance Improvement, 43*(6), 24-29.

Robin, S., & Hong, J. (2011). Organizational learning in Asia. In M. Easterby-Smith & M. A. Lyles (Eds.), *Handbook of organizational learning and knowledge management* (2nd ed., pp. 635-658). West Sussex, United Kingdom: John Wiley & Sons.

Rosenberg, M. J. (2012). Knowledge management and learning: Perfect together. In R. A. Reiser & J. V. Dempsey (Eds.), *Trends and issues in instructional design and technology* (3rd ed., pp. 158-168). Boston, MA: Pearson.

Rosenberg, M. J., Coscarelli, W. C., & Hutchison, C. S. (1999). The origins and evolution of the field. In J. Pershing (Ed.) , *Handbook of human performance technology*, 24-46. CA: Pfeiffer.

Rossett, A. (1989). *Training needs assessment*. Englewood Cliffs, NJ: Educational Technology.

Rothwell, W. J. (2000). *ASTD models for human performance improvement: Roles, competencies, and outputs* (2nd ed.): American Society for Training and Development.

Rothwell, W. J., Hohne, C. K., & King, S. B. (2007). *Human performance improvement : Building practitioner competence*. Amsterdam; Boston: Elsevier/Butterworth-Heinemann.

Rothwell, W. J., & Kazanas, H. (2008). *Mastering the instructional design process: A systematic approach*. CA: Pfeiffer.

Ruckdeschel, C., Yarter, M., Rivecdo, M. A., Cortes, I., & Cookson, M. S. (1998). Beyond instructional systems: A performance technology degree. *Performance Improvement, 37*(3), 22-26.

Rummler, G. (2007). The past is prologue: An eyewitness account of HPT. *Performance Improvement, 46*(10), 5-9. doi: 10.1002/pfi.166

Rummler, G., & Brache, A. (1995). *Improving performance: Managing the white space in organizations*. San Francisco: Jossey-Bass.

Ruona, W. E. A. (2001). The foundational impact of the training within industry project on the human resource development profession. *Advances in Developing Human Resources, 3*(2), 119-126.

Saldaña, J. (2013). *The coding manual for qualitative researchers*. Los Angeles: SAGE.

Salisbury, M. (2008). From instructional systems design to managing the life cycle of knowledge in organizations. *Performance Improvement Quarterly, 20*(3-4), 131-145. doi: 10.1002/piq.20007

Salisbury, M (2009). *iLearning: How to create an innovative learning organization*. CA: John Wiley & Sons.

Schluter, J., Seaton, P., & Chaboyer, W. (2008). Critical incident technique: a user's guide for nurse researchers. *Journal of Advanced Nursing, 61*(1), 107-114. doi: 10.1111/j.1365-2648.2007.04490.x

Schwen, T., Kalman, H., Hara, N., & Kisling, E. (1998). Potential knowledge management contributions to human performance technology research and practice. *Educational Technology Research and Development, 46*(4), 73-89. doi: 10.1007/BF02299675

Smith, E. A. (2001). The role of tacit and explicit knowledge in the workplace. *Journal of Knowledge Management, 5*(4), 311-321.

Smith, P. L., & Ragan, T. J. (1999). *Instructional design*. NY: Wiley.

Spitzer, D. R. (1984). Why training fails. *Performance & Instruction Journal, 23*(7), 6-10.

Spitzer, D. R. (1992). The design and development of effective interventions. *Handbook of human performance technology: A comprehensive guide for analyzing and solving performance problems in organizations*, 114-129.

Stake, R. (1995). *The art of case study research*. Thousand Oaks, California: Sage.

Stake, R. (2005). Qualitative case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (3rd ed., pp. 443-466). Thousand Oaks, California: Sage.

Stenmark, D. (2000). Leveraging tacit organizational knowledge. *Journal of Management Iinformation Systems, 17*(3), 9-24.

Stitt-Gohdes, W. L., Lambrecht, J. J., & Redmann, D. H. (2000). The critical-incident technique in job behavior research. *Journal of Vocational Education Research, 25*(1), 63-77.

Swanson, R. A. (1994). *Analysis for improving performance: Tools for diagnosing organizations and documenting workplace expertise*. San Fransisco: Berrett-Koehler.

Swanson, R. A. (1999). The foundations of performance improvement and implications for practice. *Advances in Developing Human Resources, 1*(1), 1-25.

Tee, M., & Lee, S. (2013). Advancing understanding using Nonaka's model of knowledge creation and problem-based learning. *International Journal of Computer-Supported Collaborative Learning, 8*(3), 313-331. doi: 10.1007/s11412-013-9175-2

Tosti, D. T., & Kaufman, R. (2007). Who Is the "Real" Father of Hpt? *Performance Improvement, 46*(7), 5-8. doi: 10.1002/pfi.143

Tsoukas, H. (2011). How should we understand tacit knowledge? A phenomenological view. In M. Easterby-Smith & M. A. Lyles (Eds.), *Handbook of organizational learning and*

knowledge management (2nd ed., pp. 453-476). West Sussex, United Kingdom: John Wiley & Sons.

Urquhart, C., Light, A., Thomas, R., Barker, A., Yeoman, A., Cooper, J., . . . Spink, S. (2003). Critical incident technique and explicitation interviewing in studies of information behavior. *Library & Information Science Research, 25*(1), 63-88.

Van Tiem, D. M., Moseley, J. L., & Dessinger, J. C. (2000). *Fundamentals of performance technology: A guide to improving people, process, and performance*. CA: Pfeiffer.

Van Tiem, D. M., Moseley, J. L., & Dessinger, J. C. (2012). *Fundamentals of performance improvement: Optimizing results through people, process, and organizations* (3rd ed.). CA: Pfeiffer.

Von Krogh, G., Nonaka, I., & Rechsteiner, L. (2012). Leadership in organizational knowledge creation: A review and framework. *Journal of Management Studies, 49*(1), 240-277.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge [England]: Cambridge university press.

Wilmoth, F. S., Prigmore, C., & Bray, M. (2002). HPT models: An overview of the major models in the field. *Performance Improvement, 41*(8), 16-24.

Wilson, T. D. (2002). The nonsense of knowledge management. *Information research, 8*(1), 8-1.

Yin, R. K. (2009). *Case study research : Design and methods*. Los Angeles: Sage.

Yoon, S. W., Song, J. H., & Lim, D. H. (2009). Beyond the learning process and toward the knowledge creation process: Linking learning and knowledge in the supportive learning culture. *Performance Improvement Quarterly, 22*(3), 49-69. doi: 10.1002/piq.20060

APPENDIX A: Balridge Questions and Example of Revisions with Explanation

Organization Profile

The **Organizational *Profile*** is a snapshot of your organization, the key influences on how you operate, and the key challenges you face.

P.1 Organizational Description: What are your key organizational characteristics? Describe your organization's operating environment and your key relationships with customers, suppliers, partners, and stakeholders. Within your response, include answers to the following questions:

A. **Organizational Environment**

1. **Product Offerings** What are your organization's main product offerings? What is the relative importance of each to your organizational success? What mechanisms do you use to deliver your products?

   Revised Version: What are the main services that you provide? What is the relative importance of each to your organizational success? What mechanisms do you use to deliver your service?

   Reason: SHD offers a service and they don't develop a product so it is best to phrase the question accordingly.

2. **Vision and mission** What are the distinctive characteristics of your organizational culture? What are your stated purpose, vision, values, and mission? What are your organization's core competencies and their relationship to your mission?

   Revised Version: What makes SHD unique? What are the distinctive characteristics of your organizational culture? What is the purpose and mission of SHD? What is the Vision for SHD that is where do you see SHD going in the future? What is your vision as it relates to how knowledge is created, preserved and disseminated?

   Reason: Need to make the questions relevant to SHD and need to obtain the desired state for knowledge management and see the alignment.

3. **Workforce Profile** What is your workforce profile? What are your workforce or employee groups and segments? What are their education levels? What are the key elements that engage them in accomplishing your mission and vision? What are your organization's workforce and job diversity, organized bargaining units, key workforce benefits, and special health and safety requirements?

   Revised Version: What is your workforce profile? What are your workforce or employee groups and segments? What are their education levels? What are the key elements that engage them in accomplishing your mission and vision?

   Reason: The last question is good to know information, not need to know and is not applicable to the study.

4. **Assets** What are your major facilities, technologies, and equipment?

5. **Regulatory Requirements** What is the regulatory environment under which your organization operates? What are the applicable occupational health and safety regulations; accreditation, certification, or registration requirements; industry standards; and environmental, financial, and product regulations?

B. Organizational Relationships

1. **Organizational Structure** What are your organizational structure and governance system? What are the reporting relationships among your governance board, senior leaders, and parent organization, as appropriate?

2. **Customers and stakeholders** What are your key market segments, customer groups, and stakeholder groups, as appropriate? What are their key requirements and expectations for your products, customer support services, and operations? What are the differences in these requirements and expectations among market segments, customer groups, and stakeholder groups?

3. **Suppliers and partners** What are your key types of suppliers, partners, and collaborators? What role do these suppliers, partners, and collaborators play in the production and delivery of your key products and customer support services? What are your key mechanisms for communicating with suppliers, partners, and collaborators? What role, if any, do these organizations play in implementing innovations in your organization? What are your key supply-chain requirements?

P.2 Organizational Situation: What is your organization's strategic situation?
Describe your organization's competitive environment, your key strategic challenges and advantages, and your system for performance improvement. Within your response, include answers to the following questions:

A. **Competitive Environment**

1. **Competitive Position:** What is your competitive position? What are your relative size and growth in your industry or markets served? What are the numbers and types of competitors for your organization?

2. **Competitiveness Changes:** What are any key changes taking place that affect your competitive situation, including opportunities for innovation and collaboration, as appropriate?

3. **Comparative Data:** What are your key available sources of comparative and competitive data from within your industry? What are your key available sources of comparative data from outside your industry? What limitations, if any, affect your ability to obtain these data?

B. **Strategic Context**: What are your key business, operational, societal responsibility, and human resource strategic challenges and advantages?

C. **Performance Improvement System** :What are the key elements of your performance improvement system, including your evaluation, organizational learning, and innovation processes?

APPENDIX B: Questions for Organizational and Environmental Analysis

Adapted from Balridge Assessment and (Van Tiem et al., 2012, pp. 141-142; 151-153)

B.1 Organizational Analysis Questions For Director (Vision and Mission; Goals and Strategies; Knowledge Management Vision)

1. From the Engineering now article I see that SHD was born to support the COE policy that each student should have a personal computer. The article mentioned that SHD has a loaner system and the problems that are addressed include driver issues, virus/malware, hardware issues and software installation. To date do you provide any other services?
    a. What is the relative importance of each to your organizational success?

2. What makes SHD unique? What are the distinctive characteristics of your organizational culture?

3. What is the purpose and mission of SHD?
    a. What are the organization's Goals for:
        i. Services
        ii. Customers and markets

4. In the article it was also mentioned that you developed new training policies and practices. Could you please tell me more about these?

5. What is your Vision for SHD that is where do you see SHD going in the future?

6. What is your vision as it relates to how knowledge is created, preserved, and disseminated?

7. Are there any other recorded documents about SHD that you think would be beneficial if I read?

B.2 Environmental Analysis Questions for Supervisor

1. **Work Processes**
    - Tell me about the work processes of SHD. That is the high level tasks and activities that are involved in the operation of SHD. For example diagnostic test, advertisement of services, employee training etc, develop self-help installation guidelines,
        - What is the purpose of each?
        - What are your workflow procedures?

    - What are some of the outputs of these processes? That is the service that is created by the process and handed off to the customer. For example fixed computers, annual reports, trained employees, SHD website,

    Interview Tip: responses should be in the present tense, avoid statements that identify what the process is trying to achieve like solve problems quickly or improve diagnostic capabilities. The same for outputs so avoid statements like satisfied customers.

2. **Customers and Stakeholders**
    - Who are your customer groups, and stakeholder groups? Your customers are those who directly receive the output of your service, and stakeholders are those that have a vested interest in the success of SHD.
    - What are their key requirements and expectations for your services?
    - What are the differences in these requirements and expectations among customer groups, and stakeholder groups?
3. **Inputs**
    - What are the inputs needed for the processes you mentioned earlier to function properly? Example materials, equipment, information, people, funding, regulations, policies

4. **Suppliers and Collaborators**
    - Who are your key types of suppliers and collaborators?
    - What role do these suppliers, partners, and collaborators play in the production and delivery of your key services?
    - How do you communicate/interact with suppliers and collaborators?

5. Workforce Profile

- What are your workforce or employee groups and segments?
- What are their job responsibilities?
- What are their education levels? What are the key elements that engage them in accomplishing SHD's mission and vision?
  - Skills/Knowledge
  - Motivation
  - Expectations

6. Can you please provide me with an overview of what you anticipate Fall, 2013 to look like. That is what factors (new technologies, policies, university wide or COE changes) do you believe will impact the services offered by SHD the greatest?

7. Are there any recorded documents about SHD that you think would be beneficial if I read?

APPENDIX C: CIT Interview Guide

(Same questions were used for Focus Group Session)

Interview Date and Time: _____

Incident #: _____

Interview Length: _____

Introduction

- Introduce self
- Explain the goals and benefits of the research, and the expected length of the interview.
- Obtain written consent.
- Give participant the opportunity to ask any questions.

Prompt: Before I start the interview I would like to get some general information about you
Demographics

- Name:
- Year in College:
- Major:
- Previous related experience before working with SHD:

Interview
Tips

- Let participant know there are no right or wrong answers
- Control gestures that may indicate approval, surprise or disapproval
- Use prompts
    - Tell me more about that
    - What did you do then?
    - Whatever you can remember is fine
    - Take your time; I'm just going to give you some time to think
- Rephrase what participant said to seek clarification

Prompt: Let's now talk about your recent experience with an unusual problem

Description of Incident

1. Describe the problem that you were trying to fix?

Initial Actions Taken

2. How did you try to fix the problem initially?
3. At what point did you decide to consult another source for information?

Knowledge Creation

4. How did you go about finding the solution, who did you go to and where did you look for information?
5. Tell me how did you solve the problem eventually?

Knowledge Preservation

6. How did you document the information you learned?

Knowledge Dissemination

7. How did you share the information and with whom?

Barriers and Drivers

8. What was most effective/helpful in solving the problem and why?
9. What was most ineffective in solving the problem and why?
    - Describe any barriers or bottlenecks you ran into
10. If you could do anything differently in dealing with this situation what would it be and why?
11. What experiences/resources would you like to have that would have helped you or could help you solve the problem?

Concluding Interview

- Give participant opportunity to ask any other questions or make comments.
- Tell participant that they have given very valuable information and express appreciation
- Explain that the next stage is reviewing transcript and categories and ask if they would like to participate

APPENDIX D: CIT Information Sheet

D.1 Original Form Created by Researcher

CIT Form for on the job

Please use this form to record brief information about an unusual problem that you have encountered. That is a problem that was challenging and you could not solve on your own, but had to consult another source (e.g peer, internet, manufacture) and/or one that took a long time to solve. The information you enter will be strictly confidential and will only be used for the purpose of investigating how [SHD] deals with unusual problems with the aim of coming up with a set of recommendations that will make this process more efficient. Findings will be reported in aggregate form and you will not be identified by name.

Date: _____ Time filling out form: _____

Name: _____

Names of other technicians who helped:

_____
_____
_____

Approximate time and date unusual problem occurred: (If different from above)

_____
_____

How would you categorize the problem (select all that apply)

- Driver Issue
- Software Installation
- Virus/Malware
- Hardware Issue
- Other_____
  _____
- Still not know

Briefly Describe the Problem

_____
_____
_____
_____
_____
_____

Status of problem: if at the time of filling out this form the problem was solved briefly state the names of the sources/people you consulted to solve the problem. If the problem is not yet solved please say briefly what you have done so far and what are the next steps

_____
_____
_____
_____
_____

May I please contact you for an interview? Yes No

D.2 Original SHD Information Sheet

Date: _____

Time: _____

Customer Name: _____

Phone Number: _____

Email Address: _____

Description of Problem:

Actions Taken:

Outcome:

Technician Name	Technician Signature	Supervisor Initial
_____	_____	
_____	_____	
_____	_____	

D.3 Revised SHD Information Sheet

Date: _____

Time:_____

Customer Name: _____

Phone Number: _____

Email Address: _____

Uncommon Problem? ☐

Description of Problem:

Actions Taken:

Outcome:

For Official Use Only

Technician Name	Technician Signature	Ok to interview?
_____	_____	_____
_____	_____	_____
_____	_____	_____

APPENDIX E: CIT Tracking Sheets

E.1 Sample Critical Incident Profile Based on Information Sheet

Date of incident	Incident #	Short Description	Technicians Involved	Technicians interviewed	Description	Actions Taken	Outcome
28.08.13	4	MATLAB won't install	Lisa Brandon	All	MATLAB won't install, fails at VC Redist install (No errors, just stops).	1. Used different sources for MATLAB 2. Uninstalled 2005 at redis. 3.Ran MATLAB unarchived as admin	Pending windows updates prevented installation of VC redist packages. In one instance (Win 8), restarting fixed problem. With another had to remove all VC redist. Programs.

E.2 Sample Interview Scheduling and Notes

Name	Email Sent	Interview Scheduled	Incidents that will be discussed	Notes After Interview
Vaughn	Yes	Wed. Sept. 25, 2013, 11:30	Unable to create folders DyKnow not installing properly	Vaughn was interviewed long after the incidents had occurred but he seem like he was still able to recall what had happened and he brought out that "googling" is a skill as well as he found his answer on the fourth page of his search. It seems like Vaughn was the last technician to tackle the DyKnow issue but he was not aware that a paper was written up so ended up trying some things that were already done.

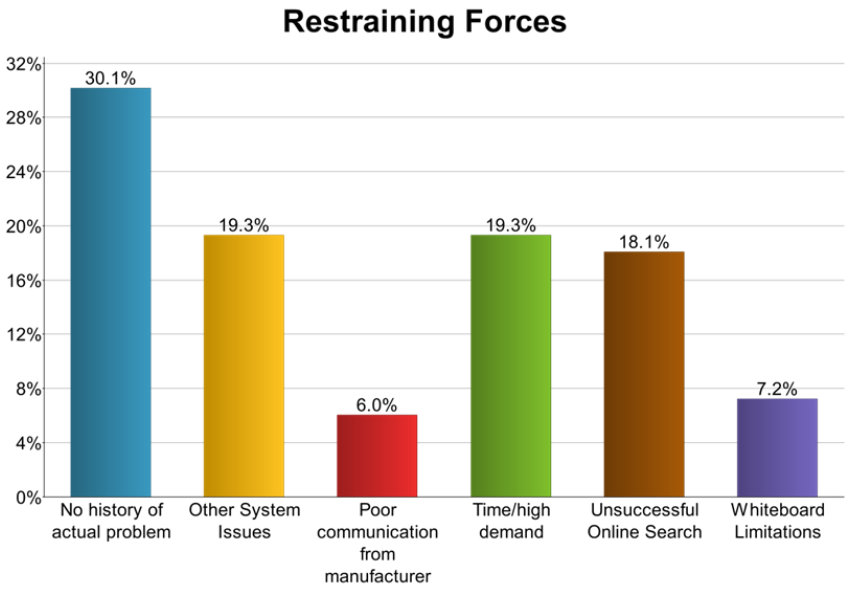
				He highlighted the dynamics between permanent workers and temp as when an issue occurred and there were only temps he didn't ask them as he felt they wouldn't know and he also felt they were not use to the whiteboard so additional ways of sharing information with them, like email, was necessary for really bad problems.

E.3 Sample Detailed Incident Tracking Based on Interviews

Incident # and name	Tech	KC	KP	KD	Drivers	Barriers	Wish list
8: SSD Issue	Fernando	[Asking others, searching online] Because Fernando had never seen the problem before after asking around he Googled. "Because I hadn't seen the problem before, and I asked around first, I guess, and nobody else really, because this is a new thing that they're doing. And so I went and looked on Lenovo forums and some other places" [58-60]	"I wrote it down on this sheet, because I realized this might be something we see again, and you might be interested in it." [111-112] [Information sheet]	"I think I talked to, I was asking a couple of the techs about it, so I think I was telling them how I fixed it afterward. We usually discuss odd problems" [121-122]	[Looking online] "I'd say, I guess looking online, because there would have been so many different things I could have tried before I would have figured out that" [124-125]	Searching online was challenging: "...And so I had to try to find the solution online, which was tough to do, surprisingly. " [50-51] "A lot of them, it had some guides at one point to fix this very problem. But most of them got taken down, because the Lenovo site, it's honestly it's very bad. It's not very helpful, usually. " [76-77] [Manufacturer\ Communication]	[Equipment]: Factory Image Disk [135]

APPENDIX F: MAXQDA 11 Statistics of Sub-codes

F.1 Restraining Forces Statistics Sub-Codes



F.2 Driving Forces Statistics Sub-Codes