# A SOCIO-TECHNICAL ANALYSIS OF KNOWLEDGEABLE PRACTICE

# IN

# RADIATION THERAPY

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by

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A SOCIO-TECHNICAL ANALYSIS OF KNOWLEDGEABLE PRACTICE

IN

RADIATION THERAPY

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## ABSTRACT

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The role of the modern radiation therapist is directed and driven by the organizational system. Changes affecting their role are implemented as a response to changes in the industry. Operations of the modern cancer center, with new and changing treatment technologies bring questions regarding the learning process of radiation therapists at a time when optimal patient care requires informed radiation therapists with good independent judgment abilities. Radiation therapists monitor accuracy through a human interface with technology. It is through this interaction where levels of awareness and critical judgment are called upon to control the outcome. Problem recognition for the user is heavily dependent on foundations of knowledge to connect a screen display to the unseen treatment processes occurring within the treatment room. The purpose of this qualitative case study was to understand how staff radiation therapists learn new skills and build on existing knowledge within a highly technical environment. This study used a socio-technical frame providing structure to my research and data analysis according to the multi-layers of socio-technical systems. Three research questions focusing on the organization's infrastructure, info-structure, and info-culture guided this study to answer the broad research question, how do radiation therapists learn new skills to develop a "knowledgeable practice" in a highly technical environment? My interpretation of the data, based on Situated Learning Theory describes the growth and development of "Junior Rangers" within the organization. The same principles provide the framework to describe linkage between the removal of processes (participation), the loss of a practice for the profession linked with diminishing boundaries to develop maximum potential for the role of the radiation therapist. I correlate the loss of participation with the emergence of a treatment practice with a limited knowledgeable practice. Resting on modern socio-technical literature, reported behavioral patterns and perspectives of technical socialization, and a review of the literature across various industries, I conclude with the argument of the loss of foundational knowledge through a process of "knowledge appropriation." Foundational radiation therapy knowledge is appropriated by technology and replaced with the knowledge required to operate the new equipment and technology. Data from the case study; supporting literature; situated

learning perspectives; and findings from a workflow cross analysis of pre and post technology processes forms the argument of knowledge appropriation.

# CHAPTER ONE

# INTRODUCTION TO THE STUDY

## Statement of Problem

Operations of the modern cancer center, with new and changing treatment technologies, bring questions regarding the learning process of radiation therapists at a time when optimal patient care requires informed radiation therapists with good independent judgment abilities. The consequence of uninformed radiation therapists is an increasing risk of treatment errors. Treatment errors have gained the attention of the public in light of an increasing number of reported lethal treatment misadministrations. The role of the modern radiation therapist is directed and driven by the organizational system, and changes affecting their role are implemented as a response to changes in the industry.

There are two driving forces in the clinical workplace that propel this development, each working against the other. First, the practice of radiation therapists is changing involving fewer manual, hands-on operations with tasks more in line with machine programming, as an operator. Some educators perceive that the radiation therapist's role has become distant from the planning stages of treatment and is removed from information relevant to the patient's history and condition. The new role reduces the staff's ability to rehearse, practice and participate in applications that actively connect conceptual knowledge to their clinical work. For the professional practice, this represents a large step backward regarding the evolution of the credentialed "Radiation Therapist" and distinction of this title by the profession from the previous title of the "Radiation Technologist." The difference in title reflected the growing demands of the profession with the growing professional role of the radiation therapist.

Second, while benefits have been derived from finely tuned, narrow beams of radiation being used to destroy tumor cells, one must understand that the treatment delivery is the product of computers communicating with computers. Modern treatment delivery systems deliver a high dose of radiation in a very short period. Typical treatment volumes are small with fewer margins for error. Optimal care and safety demands comprehensive knowledge, and awareness based on the magnitude of radiation that may be delivered in a short period. Optimal care demands knowledge informed radiation therapists since errors regarding typical small fields have potentially crippling, and even fatal consequences. The actions of the radiation therapists must be rooted in knowledge, awareness, and information in order to recognize the potential for treatment error.

Although safety and check systems are in place one must realize their limitations. Treatment data including beam configuration and patient information are routed via a local network from a "treatment planning" system typically in a physics department to a "record and verify" system at the treatment unit. The professional literature warns that an enormous amount of data must be transferred from the treatment planning system to the treatment machine, much more data than that which can be transferred and checked manually. It has been reported that transferred data may be lost or altered due to incorrect default settings in some record and verify systems (Xia & Verhey, 2005). A recent occurrence of lost data having fatal consequences was traced to software system crashes that were described as "not uncommon" by hospital officials (Bogdanich, 2010). Though the user was prompted to save the file after each system crash, before closing the program, the file had become corrupt leading to a negative treatment outcome.

Textbooks emphasize that confidence issues include having to trust one computer to check another computer. A quality assurance program is highly stressed, as one author from the Memorial Sloan Kettering professional group states, "using the MLC control computer to monitor its own performance is akin to asking the fox to guard the chicken coop" (Amos, Ling, & Leibel, 2003).

## Purpose of the Study

The purpose of my study was to understand how staff radiation therapists learn new skills and build on existing knowledge within a highly technical environment. I have suggested that the actions of the radiation therapists must be rooted in knowledge, awareness, and information in order to recognize the potential for treatment error. I use the concept of "knowledgeable practice" from a study of technology in the printing industry. This term was established by The Council for Science and Society (CSS) as a definition of skill:

> Aptitude and its development through practice; 'knowledgeable practice' and the element of control; it is not just dexterity, but a response to unexpected circumstances; manual and mental involvement' (CSS, 1981, p. 41, as cited in Parnell, 2006).

## The Research Questions

**The broad research question of my study is:** How do radiation therapists learn new skills to develop a "knowledgeable practice" in a highly technical environment?

Research Question 1. The Infrastructure. How does the hardware and software system promote or inhibit learning of modern treatment delivery?

Research Question 2. The Info-structure. How does the layout and management of information facilitate or inhibit learning of modern treatment delivery?

Research Question 3. The Info-culture. How does the organizational culture encourage or discourage seeking and sharing information that supports learning?

## Research Design

The role of the modern radiation therapist is directed and driven by the organizational system (the whole), and changes effecting their role are implemented as a response to changes in the industry. In other words, the organization adapts internally to the pressures of external change; this in turn initiates the shifting of technologies within departments. My assumption is that the practice of the radiation therapist has been re-defined within the hierarchal system of other departments that direct their work and control access to information through changing information networks and changing technology. Learning activities, individual participation, limitations of their thinking capacity and even their professional identity (Handley, 2007) are interdependent on other parts of the organizational system.

This study used qualitative research based on an interpretive, emergent design (Patton, 2002). I conducted an exploratory case study, approaching the study from a critical perspective, and a constructivist epistemology. Constructivists study the multiple realities constructed by people and the implications of those constructions for their lives. This type of theory assumes that humans do not share one reality. Understanding is contextually embedded and any notion of "truth" becomes a matter of consensus among informed and sophisticated constructors (Patton, 2002). This concept supports group work and group discussions that involve discourse to establish new meaning. The aim of my study was to understand how radiation therapists learn in their daily work routine. I sought to understand the organizational and work-related influences, processes, and factors that promote or inhibit learning.

## Assumptions

Although my general research question attempted to explore how individual radiation therapists learn new skills within a highly technical environment, my causal propositions for this case study were "predicted" patterns to emerge from the data analysis (Tellis, 1997). Here I acknowledge my beliefs going into this study based on my experience as a radiation therapist, and an educator in that profession. My assumptions are:

1. The function and role of the radiation therapists are controlled by other sectors within the organization.
2. There exists decreased and marginal participation by the radiation therapists related to certain previous professional functions and roles in the clinical workplace.
3. Through fragmentation of work processes, the radiation therapists' on-task learning is highly weighted towards technological aspects with a high degree of operational skill leaning towards subsidiary awareness and less focal awareness.

## Significance of the Study

### *Implications for Policy*

Safe treatment outcomes rely heavily on "knowledgeable practices." My work brings information to decision makers to better understand the learning processes of new treatment technology. An analysis of the modern work flow processes, compared with a previous task analysis helps identify specific points where knowledge regarding technology operations overshadows and replaces foundations of radiation therapy knowledge. This may foster administrative attention to internal processes leading to change in policy and practice, or to encourage vigilance at the point of treatment delivery.

*Implications for Practice*

The rationale driving my study involves the modern role for radiation therapists, regarding aspects of deskilling, and safety. Gaps in skill develop over long periods of work activity without using and associating foundations of treatment concepts in daily operations. Using a supporting body of literature, I make the case that using newer technology bears the cost of deskilling. This is one effect of the fragmentation of processes through automation that I bring attention to. The increasing risk of error having potentially crippling, and even fatal consequences suggests that optimal care and safety demand comprehensive knowledge and awareness

This study provides an analysis of work processes to inform the existing body of knowledge and improve modern treatment delivery practices.

## Chapter Summary

Optimal care and safety demands comprehensive knowledge, and awareness based on the magnitude of radiation that may be delivered in a short period. Supervisors have described the demand to be able to "think on your feet" in a highly technical, fast paced environment.

Chapter one introduces the problem by summarizing two driving forces at play that have a consequence of increasing the risk of treatment errors in radiation therapy. This brings questions regarding the thinking skills, knowledge, and the independent judgment ability of the radiation therapist.

The purpose of my study was to understand how staff radiation therapists learn new skills within a highly technical environment.

The broad research question of my study was how do radiation therapists learn new skills to develop a “knowledgeable practice” in a highly technical environment?

This research should confirm assertions and bring light to current processes for future studies to seek improvement in patient care and to the practice of radiation therapy.

# CHAPTER TWO

# REVIEW OF THE LITERATURE

## Recent Media Coverage on Treatment Errors

The New York Times has reportedly examined patterns of accidents and spent months obtaining and analyzing records. The New York Times is currently a public source of several accounts of treatment errors, running a series of reports titled, "The Radiation Boom" (Bogdanich, 2010). One interview includes Dr. John J. Feldmeier, a radiation oncologist at the University of Toledo and a leading authority on the treatment of radiation injuries. Feldmeier estimates that 1 in 20 patients will suffer injuries. Most are normal complications from radiation, not mistakes. But in some cases the line between the two is uncertain and a source of continuing debate. According to the article, in 2009, the nation's largest wound care company treated 3,000 radiation injuries, most of them serious enough to require treatment in hyperbaric oxygen chambers, which use pure, pressurized oxygen to promote healing. Records described 621 mistakes from 2001 to 2008. The Times writes that while most were minor, causing no immediate injury, they nonetheless point to underlying problems.

To place this in the most accurate and unbiased context possible, I include a statement from the American Society of Therapeutic Radiation Oncologists (ASTRO) responding to the report. ASTRO writes (January 25, 2010) that 621 errors is misleading since during that time it is estimated that half a million New Yorkers received 13.6 million daily treatments meaning errors occurred only .0046 percent of the time.

The Times found that on 133 occasions, devices used to shape or modulate radiation beams were left out, wrongly positioned or otherwise misused. On 284 occasions, radiation missed all or part of its intended target or treated the wrong body part entirely. In one case, radioactive seeds intended for a man's cancerous prostate were instead implanted in the base of his penis. Another patient with stomach cancer was treated for prostate cancer. Fifty patients received radiation intended for someone else, including one brain cancer patient who received radiation intended for breast cancer. The Times reported that New York health officials became so alarmed about mistakes and the underreporting of accidents that they issued a special alert in December 2004, asking hospitals to be more vigilant.

Dr. Eric Hall, known to most radiation therapy educators for his Radiation Biology textbook, stated in his interview that "even accurate intensity modulated radiation therapy (IMRT) treatments, when compared with less technically advanced linear accelerators, may nearly double the risk of secondary cancers later in life (20 years or later) due to exposure of radiation leakage. When therapeutic errors enter the picture, the risk multiplies."

## Statistics from State Agencies of Radiation Medical Misadministrations

A more credible source of data comes from state reports. The New York State Department of Health, Bureau of Environmental Radiation Protection-Inspections Unit reported 187 treatment misadministrations from 2001 to 2007 for that state alone, excluding New York City. Seventy-eight reported radiation medical misadministration events during the first study period and 109 reported medical events during the second study period. An error in radiation dose delivered that exceeds the prescribed dose by 10% is referred to as a *radiation (medical) misadministration event* and must be reported to the state agency within 24 hours after discovery. This information comes from a public presentation by the bureau. The statistics combine errors involving linear accelerators (external beam therapy) with those of isotope implant treatments (brachytherapy).

The Texas Department of State Health Services, Radiation Control Program, Environmental Monitoring Group Inspections Unit provided data indicating a 75% increase in treatment misadministrations from 2007 to 2008 (R. Freer, personal communication, December 8, 2009). Another statistic from a different type of source also indicating an increase in these types of errors comes from malpractice claims. The Physician Insurers Association of America, Claims Trend Analysis (2009) report that in 2008, radiation therapists were among the top ten of specialties in which claims were paid out. Radiation therapy topped all medical specialties for the highest average indemnity among medical specialties in 2008 closed claims within the country.

Radiation therapy claims even surpassed obstetrics and gynecology, pediatrics and neurosurgery in the US.

## Perspective on Modern Treatment Delivery

Significant advances in both hardware and software have contributed to innovations in computer-controlled treatment delivery. Proton radiation therapy is an example of a new type of treatment. The Midwest Proton Radiotherapy Institute reports that dose distributions in proton radiotherapy are more sensitive to positional errors than those in conventional radiotherapy due to the additional dimension – depth. Considering a geometric plane with X (width), Y (length) coordinates, the depth at which the highest percentage of radiation may be delivered is now considered the 3rd dimension used in modern treatment planning. Radiation volume can be made to conform to the tumor to produce a beam that varies in shape as much as the targeted tissue or tumor area in three dimensions. With a specialized, computer-controlled jaw opening on the machine known as multileaf collimation (MLC), very specific beam shapes consistent with the 3-D volume of the tumor may be produced. The high precision of beam shaping is reflected in the term, "beam sculpting" (Bewes, Suchowerska, Jackson, Zhang, & McKenzi, 2008). With this very specific sculpted beam, treatment plans involve a very high dose using smaller, stringent target volume borders. The intended level of accuracy is such that the concentration of positional error has shifted from positioning the patient’s body to a more precise focus on organ movement. This illustrates the high degree of intended accuracy, where only the targeted tumor is exposed to a very high dose, leaving other normal tissues unexposed to radiation.

To appreciate how a difference of only two millimeters results in rapid escalation of radiation dose, one must understand that treatment deviations with small field size settings have a large impact in the resulting dose output. The impact of the resulting output intensifies with smaller field sizes and higher energies, measured in Mega Volts (1MV = 1 volt x 1 million). A two millimeter deviation changes the resulting dose per monitor unit by 2% and 3% for a 2 x 2 centimeter treatment area for 6 MV and 18 MV energies respectively. These are typical treatment energies. The same 2 millimeter deviation for a 1 x 1 centimeter area changes the resulting dose per monitor unit by 15% and 16% for 6 MV and 18MV respectively (Sharp, Miller, Yan, & Wong, 2000).

## The Impact of Technology on the Element of Knowing and Awareness

High levels of efficient automation and computer networks have replaced manual, step-by-step processes that once allowed a greater degree of tactile practice with rich opportunities for observing and connecting conceptual to applied relationships in the clinic. History shows that automation and certain healthcare management serves to divide and limit knowledge, eliminating learning opportunities and teaching moments (Bravermann, 1974; Donahue, 1995; Fitzgerald, 1993; Hollis, 2009; Rinard, 1996).

As a result of the change in treatment practice due to new technology, staff as well as students are seeing, doing, and understanding less of the foundational concepts of radiation therapy. Staff, and consequentially, students may be less able to demonstrate, practice, or rehearse the ability to connect treatment practices with higher-level thought processes and critical thinking applications regarding treatment rationale. This trend has been described in historical publications showing that the clinical setting is increasingly characterized as incorporating fragmented operational knowledge through simplified tasks (Donahue, 1995; Gordon, 1994; Hughes, 1964; Kranzberg, 1972; Nobel, 1984; Rinard, 1996; Ritzer, 1993; Singerist, 1961; Smith, 1961).

With generations of no conceptual recall and failure to rehearse simple application of concepts, I assume a reduction in foundational knowledge develops with "know how" but less and less "know why" knowledge. My assertion draws from the work of Michael Polanyi (Polanyi, 1958, as cited in Grant, 2007), notable as being one of the most cited sources in three major knowledge management journals through 2003. Many theories of knowledge management begin with Polanyi's views of tacit and explicit knowledge. Polanyi was a leading chemist who became disenchanted with the scientists' view of knowledge, building a post-modern view of how individuals gain knowledge and share it. In his work, *Personal Knowledge: Towards a Post-Critical Philosophy* (1958), *and*, *The Tacit Dimension* (1966), Polanyi makes the following points that apply to my conjecture of the problem described. According to Polanyi's work on knowledge:

- Knowledge includes the element of *knowing* shared by communication. While language is a vital tool we can use to share knowledge, we can often know how to do things without either knowing or being able to articulate to others why what we do works.

- *We can know more than we can tell*, expresses a breakdown in peer-to-peer teaching between a speaker and listener with the false assumption by the speaker that we all share the same history and work experiences. The listener gets only a limited version.
- There are two kinds of awareness, subsidiary awareness and focal awareness. Using some tool or device to achieve some objective, skillful, more experienced individuals with a rich knowledge inventory can focus on the "overall objective" of using that device (focal awareness) focusing on optimal treatment of the patient. Less skilled individuals pay more attention to the "proximate" device, the mechanics (subsidiary awareness) with less focus on the full objective – the patient.

Modern radiation therapists may learn new treatments by the "see one – do one" method only. New knowledge in this manner is void of the "knowing" element described by Polanyi and restricts awareness to the subsidiary awareness level. Older generation radiation therapists with much experience have a richer stock of background knowledge and hold on to the foundations of knowledge gained from the previous "old school" years of application practiced through their work activities. **Foundational knowledge** includes the element of "knowing." Foundational knowledge includes "knowing why" as much as "knowing how." The notion of "button pushers," the degradation from "therapist" to "technician" results from this subsidiary awareness phenomenon where the scope of learning remains limited to the machine operation. From that phenomenon, knowledge sharing among peers remains restricted to tacit knowledge or “know how” with less “know why” articulation ability.

Chapter four includes findings that demonstrate a practice that relates to these two types of awareness leading to the loss of foundational knowledge. Two excerpts follow:

Joseph reflected,

“When you get used to treating with IMPAC you just look at the screen and it says “30 – Left” that pretty much tells you how to set the wedge. After treating that way for a long time you forget the concept of looking at the patient and the logic between the wedge heel and the contour of the breast. “

Dr. Anders reflected,

“…modern technology like IMPAC, and record and verify, etc. which takes away some of the human fallibility, but it does it by taking away them doing it day after day. So, no one argues with the desire to minimize the chance of human error, but I do think that you do lose some degree of human participatory learning when you do so…”

Even if older, manual procedures are no longer performed, radiation therapists should still maintain adequate knowledge of concepts with strong critical thinking skills and good independent judgment. Supporting this principle, in the introduction section of the 2009 Radiation Therapy Professional Curriculum, the ASRT Curriculum Revision Committee writes, *advances in radiation therapy and employer expectations demand* *more independent judgment by radiation therapists. Consequently, critical thinking skills must be fostered, developed and assessed in the educational process* (ASRT, 2009). The changes in the practice of radiation therapy bring questions regarding critical thinking and independent judgment and how these are fostered or inhibited among staff radiation therapists within a system of fragmented knowledge.

## Historical Views of the Impact of Technology on Skill and Knowledge Degradation

Concerns of the impact of technological change upon professional practices are not new. Views of the impact of technology and automation have been published by disciplines of industry and other health professions that have studied and described the degradation of skill sets and knowledge.

Hollis (2009) editor of the Southeast Farm Press described the subtle changes that occur whenever a technological advance drastically and permanently alters farmer's practices. In his editorial he refers to the social sciences as he defines deskilling as the process by which skilled labor within an industry is eliminated by the introduction of new technologies. His article describes the hybridization of corn. Farmers were persuaded to buy new hybrid seed each season, replacing the traditional practice of planting farm-saved seed. This dynamic and rapid switch from open-pollinated to hybrid corn seed eventually led to a deskilling of farmers. A historian who specializes in farm labor and economics, Deborah Fitzgerald describes this phenomenon in the farming industry (Fitzgerald, 1993). She points out that a certain skill set or knowledge was required of farmers to plant the appropriate open-pollinated corn seed. These farmers needed to know maturity rates, climatic conditions, soil quality, insect and disease prevention potential. The farmer had to keep consistent and accurate records to compare the performance of their own seed selection from year to year. The following excerpt describes her view:

But by 1945, this art or knowledge of seed selection had been almost totally replaced by hybridization, and the popularity of hybridization grew so that by 1945, hybrid corn constituted 90% of the corn grown in the US. Quietly, quickly, a type of knowledge, specifically a type of user knowledge was gone, transferred and transformed in historically the blink of an eye. Farmers who had earlier been able to select corn, whether from the field or from the seed dealer according to visual characteristics now had no concept of what to look for (Hollis, 2009).

Rinard (1996) forms her conceptual framework of technology and deskilling making her claim that changes in healthcare lead to less skilled, less trained, and less well paid workers to accomplish the nurse's tasks drawing from the work and perspectives of previous researchers (Gordon, 1994; Hughes, 1964; Kranzberg, 1972; Nobel, 1984; Singerist, 1961; Smith, 1961). Her resources described historical explanations of changes due to technology as systems of tasks driven by *a crude technological determinism and an internal dynamic that when unleashed, explains social changes* (Rinard, 1996, p. 61).

Rinard's study on technology and the deskilling of nurses (1996) involved a content analysis of the American Journal of Nursing, in five year increments since World War II. Changes included new medical techniques and new drugs (1950 – 1960); new electronic machinery and specialized care units (1965-1981); and the introduction of new technologies to control, streamline, and predict care (1980 – 1996). Most relevant views include the nurses recorded responses to the technological changes. The separation of tasks entailed by the changes made many fear that the hospital was turning into a factory and the nurse into a "technician." The following excerpt expresses this concern, "As nursing moved into higher education, differentiation between a 'technical' nurse and a 'professional' one depended on the ability to discuss tacit skills in a social scientific jargon."

Rinard writes in 1996 that the daily routines of nursing continue to be radically altered. Nursing is being transformed by the introduction of new machines, equipment, specialized care units, electronic monitoring devices, and information systems. The author describes changes in nursing as a deskilling in the *Bravermannian* sense making nursing *all hands, little head, and hardly any heart* (p. 63).

Bravermann, in *Labor and Monopoly Capital: The Degradation of Work in the 20th Century* (1974) wrote that the introduction of mechanization and automation in combination with modern management has led to a deskilling of work. Using efficiency studies of Taylorism, job components were shown to be increasingly separated. The eventual result was a separation of the conception of the full range of a job from its execution in parts. The traditional skill content of jobs was destroyed and a homogenous, degraded working population created.

Donahue's work in 1995 and her findings in the field of radiology echoed the work of Ritzer (1993) who in 1993 wrote that the skills needed by physicians and others involved in diagnosis were being degraded by technology. Ritzer wrote that technology contributes to skill degradation in the practice of medicine with its laboratory procedures and machines that aid in the diagnostic process (Ritzer, 1993).

Donahue's dissertation on the deskilling of radiologic technologists (1995) pointed out that while technological advancements may initially be appreciated by employees, the overall effect can be one of degrading skills of the worker, and to alienate the worker from the work process in the long term. In this respect the worker loses connections with the product of his or her labor. She describes the increased division of labor in radiology stemming from separate licensing for different machines. Some technologists can work x-ray machines for mammography, some may work only on computed axial tomography (CT scanner) and magnetic resonance imaging (MRI) while others are not allowed to do those procedures or use those machines. She claims that along with machine technologies contributing to the division of labor, new machines like MRI and CT scanners have reduced the skills of technologists in that they are no longer involved in positioning patients, in calculating how much radiation is required to produce a clear image of the anatomy.

Today, adjustment knobs and dials for setting and metering proper voltage and amperage have been replaced with symbols of skulls, spines, arms, etc. New buttons include small, medium, and large anatomy figures so that measurements and calculations are not required to acquire the correct machine settings. These types of tasks are meant to be automatic by simply pressing the button that closely matches what you see on the table. This system has removed many forms of thinking and awareness from the practice, leaving tacit knowledge with subsidiary awareness as the functions to match the correct size anatomy.

Parnell’s (2006) study of changes in the printing industry includes these findings that parallel my study and offer some explanation of what I refer to as (de-constructive) knowledge appropriation in chapter five. In this case, the co-evolution of user and technology offers greater benefits to the new technology as the artists and printers learn about new computers, “operational” knowledge only. She makes the point that “for many printers the ‘art’, or essentially human aspect of the skilled work, has been lost as their knowledge has been codified and installed in the computer (Parnell, 2006, p.101). The point she makes, based on her enquiries among the staff printers themselves, is that the new skills could be learnt in a very short time, and were very limited compared with those they had lost.

Parnell makes the following distinctions between modern skill and that of apprentice skill. “Many jobs which are classified as skilled take only a matter of a few weeks to learn, rather than a four to seven year apprenticeship which is what ‘skilled’ formerly meant.” Parnell’s most significant point for my study follows; she describes the superficial nature of the new skills acquired for the participant as compared that lost:

> This has led to the concept of skill being transient and limited, associated with a specific task using a specific machine, for a specific employer, rather than acquired through the long apprenticeship which was the norm in pre-industrial and during early industrialization and which equipped a worker for mastery of all

> the tasks associated with his or her trade. Thus, in such circumstances, the 'skill' acquired belongs only to the current 'job', not to the worker his or herself.

Parnell's study (2006) uses the following definitions and applications of skill and knowledge taken from The Council for Science and Society (CSS).

> The CSS is a research group with charitable status, set up in 1973 to promote the understanding of the effects of technology upon society. A report by CSS provided the following definition of skill: aptitude and its development through practice; they stress 'knowledgeable practice' and the element of control; it is not just dexterity, but a response to unexpected circumstances; manual and mental involvement. The close relationship between intelligent thinking and practical craftsmanship was the basis for much industrial and scientific advancement; and 'there can, at the more personal level, be no doubt at all that to deny the experience of interaction between theory and practice is damaging to the development of the individual' (CSS, 1981, p. 41).

The CSS suggests a long term consequence of a practice that depends on technology for maintaining a "knowledgeable practice," manual and mental involvement under control of technology.

> …the pool of skilled knowledge from which the program was drawn will dry up. Future advance will have to come from specialized research devoted to improving the program, and the number of skilled observers alert to new developments will

> be much smaller. Ultimately the machine will out-perform every human ability, and the development will therefore be self-justifying. To reverse it will be nearly impossible (CSS, 1981, p. 74).

Parnell's interpretation was that this seems to indicate a dangerous reliance upon technology which, initially, leaves the fallible skilled human behind, but ultimately as skills are not passed on to new generations of humans the ability to develop further will be lost. She points out that, "this is a similar effect to that in the description of 'technological determinism' (Parnell, 2006, p. 98).

## Theoretical Perspective

Situated learning theory (Brown & Duguid, 2001; Handley, et al., 2007; Lave & Wenger, 1991) provides a framework that supports my supposition in the clinical workplace relating decreased and marginal participation through the separation of tasks in treatment planning, treatment simulation, and other forms of treatment preparation. These characteristics influence a changing identity and practice for the radiation therapist. As work processes are separated into tasks, participation is greatly decreased and limited to a subunit or a piece of the entire process.

Cases of similar phenomena have described the separation of tasks within a job role that induces a perception of diminished knowledge and skill (Donahue, 1995; Fitzgerald, 1993; Hollis, 2009; Rinard, 1996). Main points presented in the previous section describing this same phenomenon include,

- Nursing responses to technological changes. The separation of tasks entailed by the changes made many fear that the hospital was turning into a factory and the nurse into a "technician."
- Distinguishing the nurse "Professional" from the "Technical" nurse based on ability to discuss tacit skills demonstrating conceptual knowledge.
- In nursing, the main point is that due to mechanization and automation in combination with modern management techniques, job components were increasingly separated. The eventual result was a separation of the conception of a job from its execution. The traditional skill content of jobs was destroyed.
- The study of radiology described the increased division of labor in x-ray. This stems from separate licensing for different machines. The overall effect of new technology can be one of degrading skills of the worker, and to alienate the worker from the work process in the long term.

The situated learning construct builds a conceptual framework of learning through the development of **identity** and **practice** achieved through **participation** in communities of practice. My perspective of the problem is that the radiation therapist is well on the way to becoming "radiation machine operator" as a result of diminished, fragmented modern job duties loosing status and credentials based on a decreased job role. The situated learning conceptual model illustrated in figure 1 shows that participation plays a mediating role in the process of the development of identity and practice. It is through participation that identity and practice develop. Handley, et al., (2007); Brown and Duguid, (2001); Lave and Wenger, (1991) agree that:

(1) Participation enables or may constrain opportunities to develop identities and practice;

(2) The ability of individuals to participate, and the forms which that might take, may be constrained or enabled by dynamics relevant to the setting;

(3) Changes in an individual's identity and practice may influence the search for new participatory opportunities (i.e., after a promotion, change in position).

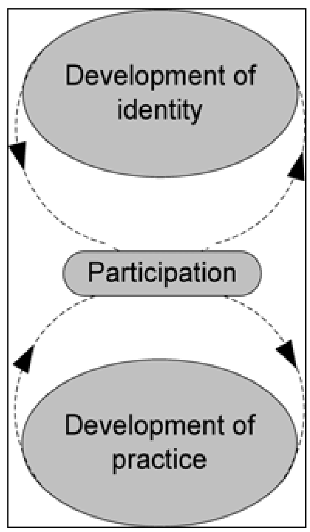



*Figure 1*. Participation as a Mediating Factor to Identity and Practice.
Reprinted from "Researching Situated Learning: Participation, Identity, and Practices in Client-Consultant Relationships," by K. Handley, T. Clark, and A. Sturdy, 2007, *Management Learning, 38*, p. 175.

The Constructs of Situated Learning Theory

Situated learning theory considers learning to be an integral part of everyday work, family, or other social settings. This places an emphasis on context, setting, and relevant tasks.

The core constructs of situated learning theory are (1) participation, (2) identity, and (3) practice. Lave and Wenger (1991) view learning within social relationships – situations of co-participation. As stated in the introduction of their book, "rather than asking what kind of cognitive processes and conceptual structures are involved, they ask what kinds of social engagements provide the proper context for learning to take place" (p. 14).

*Participation*

Participation is central to situated learning since individuals develop their identities and practices according to the participatory opportunities available to them. Participation involves the way individuals understand, take part in and subscribe to the social norms, behaviors and values of the communities in which they participate. Communities of practice refer to skilled groups that model an apprentice-to-master working and learning relationship. Groups may be formally recognized groups such as plumbers, or Lave describes a community and culture of a Mayan midwife, as a young girl takes on a greater role as she grows within her culture. It is within these communities where an individual may observe, and progress from limited tasks or "peripheral" participation, to full participation. In this manner an individual progresses from a "newcomer" to an "old timer" or from an apprentice to a master plumber or master electrician. Lave writes that "newcomers develop a changing understanding of practice over time from improvised opportunities to participate peripherally in ongoing activities of the community. "Knowledgeable skill" is encompassed in the process of assuming the identity of a practitioner, of becoming a full participant, an old timer" (p. 68). I bring emphasis to this process described as forming "knowledgeable skill" by Lave and "knowledgeable practice" the term used in in my research question (see figure 2).

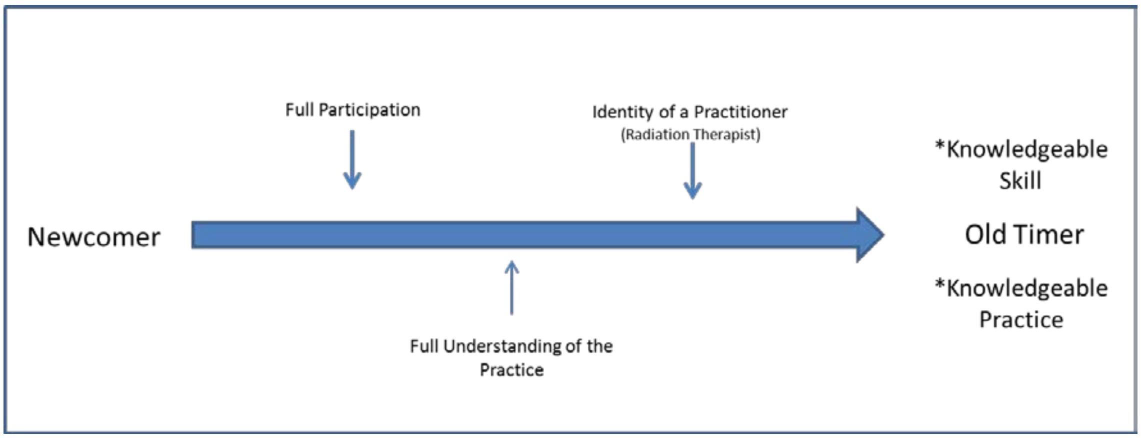



*Figure 2.* The progression from Newcomer to Old Timer encompassing Knowledgeable Skill and Knowledgeable Practice.

*Identity*

Learning involves understanding who we are, as well as understanding our maximum potential (Lave, 2004). Situated learning theory holds that identities are continually evolving through, but bounded by, participation within communities of practice. It is framed by the possibilities available in the community of practice. One must learn to speak and act in ways that make sense in this community. This implies a relationship between "self" concerning "the whole person acting in the world" (Lave & Wenger, 1991, p. 49).

An individual's sense of self plays a role in practitioner identity; however, Lave refers to a collective recognition and validation of an individual by other participants. Community members share views of the changing practice of newcomers to “old timers.” This is a form by which persons and communities of practice constitute themselves, construct their identity, through the activity of its practitioners. This happens as an individual – as self, but is influenced by the community.

*Practice*

Wenger refers to “social” practice in the context of situated learning (Wenger, 1998, p. 47). Describing situated learning from the social learning perspective, Ibarra (1999) explains that individuals may try out new roles and identities by experimenting with practices typically associated with the identities they aspire to. These practices relate to role definition, depending on the situated influences. Individuals may adopt or transform new practices based on the social context that provides structure and meaning to what we do. Through participation, “new comers” gradually assemble an idea of what constitutes the practices of the community (Lave & Wenger, 1991). Participatory opportunities include observing, experimenting, and adapting as influences on the development of practice.

Within the definitions of situated learning are embedded some of Schön's concepts. The concept is described using terms such as “knowing in action” and “knowing in practice.” Schön (1983, 1987) uses "knowing in action" to mean achieving familiarity with processes so as to be able to carry out their daily work without having to think about each step of the process. These concepts build from experiential learning theory as it relates to reflective processes or "reflection on action." I make an association with the term "knowing, "Polanyi's (1958) concept of having an understanding of related processes with the ability to articulate "why" as well as "how" things work (see figure 3). For purposes of this study, I refer to "**knowledgeable practice**" in my research question as introduced in chapter one.

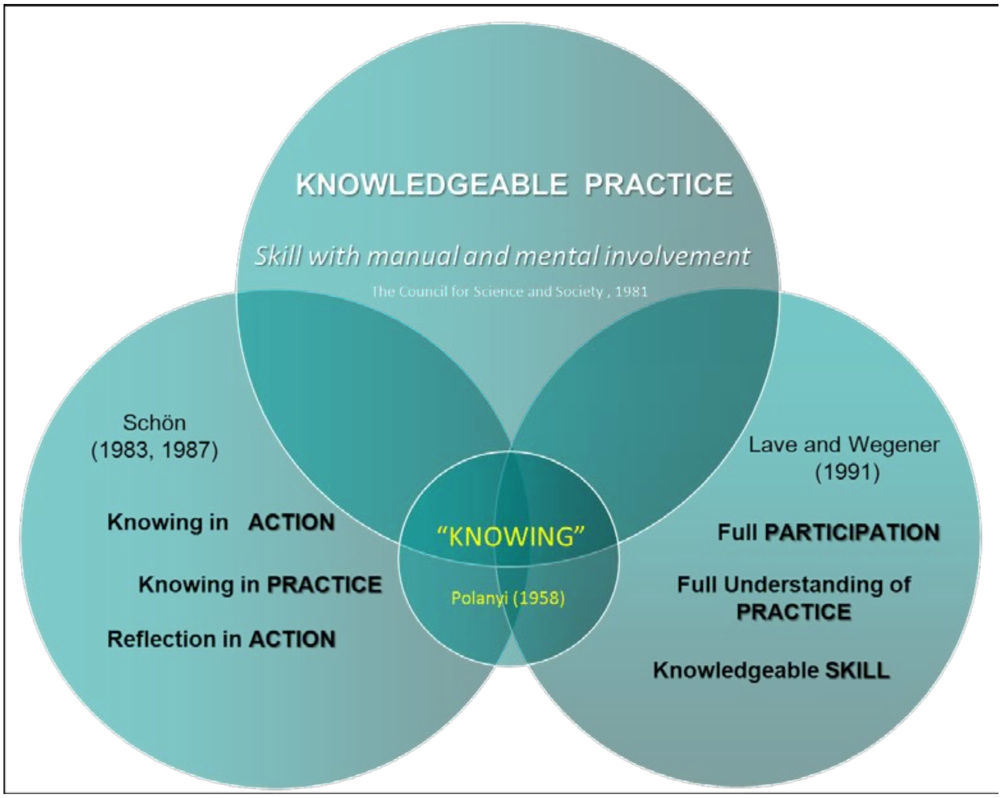



*Figure 3*. The principle elements of "Knowledgeable Practice."

Linking these views closer to my study, the learning context for the radiation therapist was referred to as training "in the trenches." This refers to hands-on, experiential learning. Working in the trenches implies working alongside a peer or colleague sharing experiences. An excerpt of my findings in chapter four follows as

Michael explained:

> Yes our training is very similar to how we do it on the job because our training is mostly job based.  I mean, your training is usually, for example, if you're training as a new therapist your training is while you're working under one of our more seasoned, experienced therapists.  Our training doesn't differ all that much from job performance or treatment in that, I mean, we're doing it, as we're training, we're doing it.  You know, certainly we like to have some little cheat sheets, here's how you do this, here's  how you do that, that we hand folks early on, "OK here's where this is and here's where that is," but, their training is, most of the time, "in the trenches" training so to speak.

Another excerpt from of a response by Michael who has 25 years' experience as a radiation therapist associates the term "old school" with his identity and refers to characteristics of his practice.

> "I'm "old school" enough that when I treat, I look through the chart so, for example, the last time I read about patient staging was last week."

For some radiation therapists who consider themselves to be "old school" the preference is to "know" more about the patient's background before treatment.  This follows the views of Polanyi (1958) that distinguish between subsidiary awareness and focal awareness. Skillful, more experienced individuals with a rich knowledge inventory can focus on an overall objective, such as the optimal treatment of a patient, when using a tool (focal awareness) to achieve the objective. Less skilled individuals pay more attention to the tool and its mechanics (subsidiary awareness), focusing less on the overall objective. I feel what is most revealing of this response is the nature of the radiation therapist, referring to himself – his identity, as “old school” with a meaning that suggests a “practice” that is better informed than the modern radiation therapist– a knowledgeable practice.

Another source from my findings demonstrated how learning in action may result in informing and changing the practice. My findings include descriptions by Gabriel and Dr. Anders who focused on their experiences facing unexpected responses by patients who did not fall into the typical pattern during treatment. The expressions pointed out that a means of informing the practice comes from unexpected situations with patients who respond differently to radiation treatment. I elaborate further in chapter four.

## The Socio-Technical Perspective

The constructs of the socio-technical system were established in the context of labor studies by the Tavistock Institute in London and the work of Trist, Emery and colleagues in the 1950s (Emery & Trist, 1960; Mumford, 2006; Trist & Bamforth, 1951; Trist, 1963, 1981). The term socio-technical was first suggested by Trist to describe a method of viewing organizations emphasizing the interrelatedness of the functioning of the social and technological subsystems of the organization, and the relation of the organization as a whole to the environment in which it operates (Emery & Trist, 1965; Pava, 1986; Scarbrough, 1995).

Pan and Leicester (1998) point out that according to Pasmore, Francis, and Shani (1982), "the socio-technical system view contends that organizations are made up of people that produce products or services using some technology," and that each "affects the operation and appropriateness of the technology as well as the actions of the people who operate it" (p. 1182).

Coiera (2007) recognizes a need in modern health care related to the socio-technical system. Because health care systems are so dependent on complex human organizational structures, they seem particularly suitable to socio-technical analysis (Berg, 2004). In his work, he writes that Information technologies (IT) seem crucial to the development of sustainable health services, but every IT intervention seems to generate an unanticipated consequence. It is with some concern that many now are recognizing that the unanticipated consequences of IT use in health care include mishaps and errors that may have negative consequences on patient care (Ash, Berg, & Coiera, 2004).

The concept of the socio-technical system was established to stress the reciprocal interrelationship between humans and machines and to foster the program of shaping both the technical and the social conditions of work, in such a way that efficiency and humanity would not contradict each other any longer. The idea of socio-technical systems was designed to cope with the theoretical and practical problems of working conditions in industry. It uses the systems model to describe both social and technical phenomena - persons and machines; the *technization* of society and the *socialization* of technology (Ropohl, 1982, 1999).

## The Organizational Layers of Socio-Technical Analysis

Knowledge management systems summarize the socio-technical analysis in terms of the three major layers listed below. The levels are:

**1. Infrastructure:** the hardware/software which enables the contact between network members (Bressand & Distler, 1995, as cited in Pan & Leicester, 1998). The focus at this level is the physical hardware and software that allows the transmission of communication. Examples include devices such as computers, fax machines, television, telephones.

**2. Info-structure:** An info-structure is similar to infrastructure, except that it does not refer to any physical device or facilities. A simple contrast between the terms may be illustrated as follows: the info-structure may be delivered seamlessly as water through a faucet. The faucet and plumbing may be referred to as the infrastructure while the water flow is information that is highly dynamic, bi-directional, and requires a transmission mechanism to distribute and meter the flow. The info-structure, or information structure, is the layout of information that may be navigated and organized in a useful manner. The focus at this level is the information itself that may be in the form of video programming or scientific and business databases. While there is a link between technological infrastructure and informational infrastructure (info-structure) information professionals think of information management not just records management in solving strategic issues (Meagher, 2002).

**3. Info-culture:** Exploring aspects of the info-culture, informs the major research question by examining influences of the organizational culture upon the use of information. Understanding the organizational culture, defines constraints on knowledge and information sharing (Bressand & Distler, 1995, as cited in Pan & Leicester, 1998).

## Organizational Culture

Schein (1992) identifies ten major categories of overt phenomena associated with organizational culture that may be applied to information sharing. They are (1) observed behavioral regularities when people interact (language, customs and traditions, rituals); (2) group norms; (3) espoused values; (4) formal philosophy; (5) rules of the games; (6) climate; (7) embedded skills; (8) habits of thinking, mental models and/or linguistic paradigms; (9) shared meanings; (10) "root metaphors" or integrating symbols. Schein's definition of group culture fits within the context of my study of technology adaptation through group learning within a socio-technical perspective. He defines organizational culture as "A pattern of shared basic assumptions that the group has learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think and feel in relation to those problems" (Schein, 1984, p. 3).

His model defines organizational culture at three levels: Artifacts including technologies, the visible organizational structures and processes; Values, the social principles, goals and standards held within the culture to have intrinsic worth. This level defines what the members of the organization care about; and Basic Assumptions, the invisible level of the model, assumptions taken for granted, beliefs and habits of perception, thought and feeling, see figure 4.

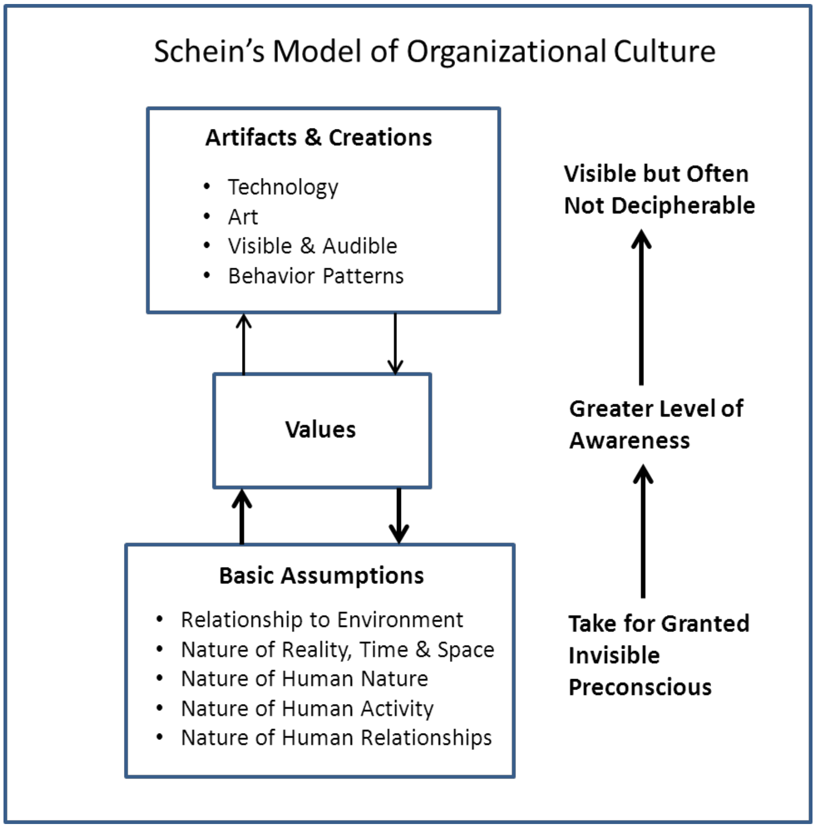



*Figure 4.* Schein's Model of Organizational Culture
Reprinted from "Coming to a New Awareness of Organizational Culture," by E.H. Schein, 1984, Sloan Management Review, 25, 2, p. 4.

## Chapter Summary

This chapter presents current literature documenting investigations and reports of recent treatment errors including levels of analysis that bring attention to current practices of modern radiation therapy. The material includes reports and statistics from contemporary media as well as state agencies and insurance claim records. The chapter provides a technical perspective of modern treatment delivery with its intended goal for very narrow beams customized to the exact fit of a defined tumor volume referred to as "beam sculpting." With the degree of intended accuracy I include technical information regarding resulting doses of radiation with only a difference of two millimeters to emphasize that a large amount of radiation may be delivered in a very small time period.

The chapter has accounts of several previous studies of the impact of technology on skill and knowledge degradation as I attempt to present a comprehensive view across industries of deskilling by new technology and automation.

Using classic theory of Polanyi's *Personal Knowledge*, I introduce the difference between focal awareness and subsidiary awareness to distinguish and establish a firm definition of Foundational Knowledge. Foundational knowledge includes the element of "knowing." Foundational knowledge includes "knowing why" as much as "knowing how." With this background, I make the assertion that modern radiation therapists may learn new treatments by the "see one – do one" method only. New knowledge in this manner is void of the "knowing" element described by Polanyi and restricts awareness to the subsidiary awareness level. Older generation radiation therapists with much experience have a richer stock of background knowledge and hold on to the foundations of knowledge gained from the previous "old school" years of application practiced through their work activities. The notion of "button pushers," the degradation from "therapist" to "technician" results from this subsidiary awareness phenomenon where the scope of learning remains limited to the machine operation. From that phenomenon, knowledge sharing among peers remains restricted to tacit knowledge or "know how" with less "know why" articulation ability.

The final section of the chapter introduces the two theoretical perspectives that guide this study. The constructs of Situated Learning are defined relating decreased and marginal participation through the separation of tasks in treatment planning, treatment simulation, and other forms of treatment preparation. These characteristics influence a changing identity and practice for the radiation therapist. As work processes are separated into tasks, participation is greatly decreased and limited to a subunit or a piece of the entire process. Using Situated Learning, I present my perspective that the radiation therapist is well on the way to becoming radiation machine operator as a result of diminished, fragmented modern job duties loosing status and credentials based on a decreased job role.

In this chapter I bring together terms from the body of literature of Adult Education that derive similar meaning. I have pulled together concepts of Lave and Wenger, (1991); Schön (1987, 1983) who uses "knowing in action;" the term “knowing” with Polanyi’s (1958) concept of having an understanding of related processes with the ability to articulate “why” as well as “how” things work. For purposes of this study, I refer to “knowledgeable practice” in my research question as introduced in chapter one and explained further in this chapter.

The organizational layers based on the socio-technical perspective are defined in this chapter. The Infra-Structure, the Info-structure, and the Info-culture are the organizational layers informing the three sub research questions to this study.

# CHAPTER THREE

# METHODOLOGY

This qualitative case study used a naturalistic approach (Patton, 2002) to study how staff radiation therapists learn new skills within a highly technical environment. I sought to engage in research attempting a deeper understanding rather than examining general hypotheses. The case on which this research focused was a radiation therapy organization with details of one particular center.

## Systems Thinking

In keeping with Lave and Wegner's views on situated learning, this study takes a "systems" perspective. Patton (2002) describes systems thinking as an understanding of the whole, by disaggregating, and explaining the parts. It does so by revealing the role of the parts and function in that whole. The layers making up the whole are pulled apart or deconstructed studying each function as related to the whole. A system cannot be divided into independent parts as discrete entities of inquiry because the role, function, and effects of the behavior of the parts are interdependent with the whole. The parts are so interconnected and interdependent that any simple cause-effect analysis distorts more than it illuminates (Patton, 2002, p. 120).

The role of the modern radiation therapist is directed and driven by the organizational system (the whole), and changes effecting their role are implemented as a response to changes in the industry. In other words, the organization adapts internally to the pressures of external change this in turn initiates the shifting of technologies within departments. My assumption is that the practice of the radiation therapist has been re-defined within the hierarchal system of other departments that direct their work and control access to information through changing information networks and changing technology. Learning activities, individual participation, limitations of their thinking capacity and even their professional identity (Handley, 2007) are interdependent on other parts of the organizational system.

As a multi-level study, taking a vertical path of inquiry within the organization, I sought to understand the different perspectives of participants. I attempted to see through the lens of participants, situated within their role. I followed the path of material, interactions, information and processes as treatment plans are prepared and developed at one level, to be implemented by staff radiation therapists at another. Spending time within the various departments, my observations consider not just the voice and perspective of the actors, but also of the relevant groups of participants and the interactions within and between them.

## Context of the Study

*The Cancer Center*

I chose a specific cancer center for this study for several reasons. The two most important reasons I chose this organization were (1) the cancer center has characteristics of a high performance radiation treatment center that incorporates various forms and specialties of treatment modalities and techniques. This is an important site characteristic for my study because it exemplifies a center with a rapid rate of change that demands continuous learning to keep up with the elite, state-of-the-art treatment equipment. The staffing structure and physical space at the site consists of the typical chain of command with the typical departments. (2) The demands on the staff to learn new processes have been described as a constant inflow of change by the supervisor. This is an important site characteristic for my study because with the flow of change, is a high demand for continuous learning.

Other reasons for choosing this site were (3) I worked side-by-side with the radiation oncologist while employed at another facility from 1986 to 1991. I feel that I have a good relationship with this physician who also serves as the CEO and owner. This is an important site characteristic for my study because it makes use of contacts that can help remove barriers to entrance and access; it puts our relationship at ease based on our background, past working relationship and mutual employment history at the main site (4) The CEO has been a member of the Advisory Board for the Texas State University Radiation Therapy Program since 2004 and remains supportive of educational endeavors. He is a major employer of our graduates. This is an important site characteristic for my study knowing we share the same values of education and staff competence. This reduces issues of trust and questionable intent for my study.

Trustworthiness or research validity is essential. Validity was a concern throughout the inquiry because of this relationship. During my data collection, I made an effort to triangulate data provided by Dr. Anders specifically through individual and group interviews, as well as during my document review and field observations. I was also aware of certain researcher biases I have pointed out as assumptions. These were not favorable, but critical of the modern cancer center as I pointed out previously. Data were transcribed, and then inserted into matrices based on subject category, without regard to the participant. The data was subjected to several iterations of groupings during the analysis process directed by coding and emerging themes. This helped to ensure an objective interpretation of data without regard to the participant. Feedback from Dr. Ann Brooks, whom I met with regularly and who reviewed and checked my biases was helpful in adding new perspectives in my research design.

*Description of the Study Site and Participants*

The Cancer Center is one of seven facilities of the multi-site organization. All have similar technology for treatment delivery except for one site housing older equipment. Although staff and physicians may rotate among the sites, the staffing structure remains consistent. The core staff for each site consists of one physician, one nurse, one dosimetrist, one radiation therapist supervisor, and two staff radiation therapists. The cancer center is a freestanding ambulatory care center where patients walk in for their daily appointments. A treatment typically lasts fifteen to twenty minutes. The center is open five days a week Monday through Friday holding normal eight to five working hours.

*Administration*

The organization is directed by one Chief Executive Officer and two co-administrators. Questions for the administrator, at this level of the organization sought to understand perceptions of ways of learning throughout the organization in a holistic view; sources of learning; positive and negative factors affecting learning; influence of superiors and colleagues; organizational culture and working climate, philosophy, mission, goals, values and their interpretation and practice by the whole organization; division of labor; image of organization; social and communication abilities; learning experiences in the organization; and learning expectations for radiation therapists.

*Physicians (Radiation Oncologists)*

The facilities share four radiation oncologists, with one doctor assigned to a center at any one time. I interviewed one doctor. Questions for the radiation oncologist sought to understand perceptions of the learning processes as the physicians see it; the utilization of new training and equipment; the commitment to learning by radiation therapists; team relationships; degree of expectations being met; processes of information networking systems; processes of knowledge sharing among peers; mentoring; and supervisory support and involvement in learning. Additional elements I sought to understand included aspects of positive and negative factors to learning; influence of superiors and colleagues; organizational culture; working climate and learning expectations for radiation therapists.

*Medical Physicists*

Physicists also have a rotation schedule for each cancer center. I interviewed one physicist. Questions for this level targeted perceptions of similar elements to those of the physician group. I sought to understand perceptions of the learning processes as the physicists see it; the utilization of new training and equipment; the commitment to learning; team relationships; degree of expectations being met; processes of information networking systems; processes of knowledge sharing among peers; mentoring; and supervisory support and involvement in learning. Other elements of inquiry included aspects of positive and negative factors to learning; influence of superiors and colleagues; organizational culture and working climate and learning expectations for radiation therapists.

*Staff Radiation Therapists*

A core staff of one chief therapist and two staff radiation therapists are typically assigned at each cancer center. I interviewed three radiation therapists with another radiation therapist joining us during the focus group interview. Questions for this group sought to understand perceptions of elements that are listed above for the Physics group.

## Participant Selection

The purposeful sample consisted of selected individuals from participant groups of a cancer treatment center located in central Texas that typify a progressive center with characteristics of a high rate of change. Participants were selected according to the following criteria:

- Active involvement with treatment planning or delivery
- At least three years full time experience with the organization
- Regular contact with staff radiation therapists
- A role as a radiation therapist, dosimetrist, physicist, radiation oncologists, or administrator.
- Planned number of participants per cancer center included:
  - Administrator – one
  - Physician – one
  - Physicist – one
  - Medical Dosimetrist – one
  - Radiation Therapists – three

## Data Collection

Data collection, as a research design component, enhances construct, internal and external validity, or trustworthiness. The importance of multiple sources of data to the trustworthiness of the study has been well established by qualitative case study researchers (Patton, 2002; Stake, 1995; Yin, 1994).

Methods of data collection included personal interviews, focus group interviews, document examination, and direct field observation. In this section I describe the type of information and data I acquired by each data collection method. In addition, I have linked the specific research questions I am addressing with each method.

Gaining access to the cancer center and participants that ranged from the chief physician / CEO, two co-administrators, the chief physicist, and four radiation therapists required travel to three locations. Several recorded interviews were conducted off site in a private and quiet setting, two interviews were conducted in a private conference room at one cancer center, and a focus group interview was conducted at another cancer center during a working lunch arrangement.

*Interviews*

I developed a table linking the interview questions to categories within each of the infra-structure, info-structure, and info-culture domains to ensure linkage between response and corresponding question being addressed. I refer to the table as the Research Question - Data Collection Matrix (Appendix A). During the data analysis these same categories were used to assist with my data analysis.

Recorded, semi-structured, one-to-one interviews were conducted with selected individuals in every department representing every level of the corporate hierarchy to understand their personal experience of learning in the organization. The participants included a range of different actors – staff on the floor, and management level participants – physician and above, to cover a complete scope in the development and implementation processes. This was the main field work carried out with the most knowledgeable managers and staff as informants. I encouraged participants to express themselves in their own terminology and experiences to provide a managerial perspective as well as a more holistic organizational view. I listened for implicit statements of need to reveal the strengths and weaknesses of existing processes and systems.

This provided data for all research questions with insight of personal perspectives, individual characteristics, how knowledge is interpreted and valued addressing research question number three within the Info-culture level. This provided information regarding the routing and flow of information, adaptation and development processes of treatment technologies spanning from questions one through three addressing – The infrastructure as well as the info-structure, and info-culture levels within the organization.

*Focus Group Interviews*

Focus group interviews were one form of triangulation. A recorded focus group interview was conducted with a group consisting of the entire workgroup of staff radiation therapists. As a semi-structured group discussion, I followed the same interview guide used for personal interviews to investigate various learning factors, information flow processes and schemes of adaptation of new treatment technologies. This provided data for all three research questions.

*Document Examination*

I conducted a document examination to gain perspective on the whole experience of the organization on administrative structure, policy and processes. Types of charts (electronic charts) were examined limited to treatment instructions and information relevant to the treatment delivery as routed from other departments. I sought to learn and understand the organization's mission and goals; how they wish to be seen by stakeholders; the types of things communicated among organization members; the frequency of communication; the typical tone of communications.

Organizational documents and publications included brochures, business cards, the organization's website, a patient information portfolio, as well as a video recorded production of patient interviews reflecting on their experiences during treatment. Documents provided access to secondary data on the organization's key processes and mechanisms that shape the way Q1: Infrastructure, Q2: Info-structure, and the Q3: Info-culture levels within each tier of the organization interact, research questions of all three levels are addressed. These data also linked the interrelationship between the levels of the administration, physician, the physic, dosimetry departments that foster support for learning at the radiation therapy staff level.

*Field Observation*

Comprehensive observations were recorded of staff radiation therapists as they functioned in their day-to-day activities; i.e., their work behaviors and informal interactions were documented. This lies at the heart of this naturalistic approach as the means of understanding and experiencing what occurs in and among the staff of the organization under study in their real-life context.

My intent as an observer was to maintain a passive presence, being as unobtrusive as possible and not interacting with participants during this time except in a limited sense in order to gain clarification of actions and events as they occur. This provided data for all research questions and especially helped in gaining insight of personal perspectives, individual characteristics, how knowledge is interpreted and valued addressing research question number three within the Info-culture level.

## Data Management

All data material was maintained in a secured media device or system. Two major sets of data material were created and stored. These included (1) Raw Data files; (2) Data analysis files that consist of tables, matrices, figures and model illustrations. The materials were stored in my personal computer and in the Teaching, Research, and Collaboration System (TRACS) system that requires log-in and password for access.

Categories based on types of data collection were organized within each general category. Data management consisted of the following computerized folders:

- Interview Transcripts. Transcribed recorded interviews and digital audio files. Transcripts in Word were filed in separate computer folders appropriately titled and dated according to the selected participant and position.
- Document Examination and Field Observation - field notes.

- Coding and Analysis
- Chapters

## Data Analysis

The following describes my approach to data analysis. I describe (1) the perspective or lens from which I conduct my analysis; (2) how I proceeded, (3) what I expected to find in data comparisons, and (4) how I expected differences in group and individual perspectives contributing to my research questions.

*The Case Study*

1. Systems Frame Analysis – I analyzed the data from a systems perspective. Patton (2002, p. 120) tells us that in systems theory, the parts are so interconnected and interdependent that any simple cause-effect analysis distorts more than it illuminates. I understand that to mean that findings will involve multiple interpretations from sources at different levels that see things through a different lens.
2. Situated Learning Frame Analysis –From this frame, I sought to understand the impact of environmental and contextual influences that foster or inhibit learning.
3. Socio-technical Frame Analysis – The organizational layers based on the socio-technical perspective, the Infra-Structure, the Info-structure, and the Info-culture are the organizational layers informing the three sub research questions to this study and provided structure for my data analysis.

*Cross Analysis of Workflow Processes for Pre and Post Technology Treatment*

Data from the case study provided rich information that informed how radiation therapists use information to support learning in a highly technical environment. The data provided descriptions of the organization's infrastructure, info-structure and info-culture that encourages and discourages seeking and sharing information. Participants shared their experiences and provided important insight about the preparedness to return to work with older equipment after working in a technology-centered facility. These personal experiences described a direct impact on maintaining and holding on to a knowledgeable practice. Regarding the practices of treatment delivery, this case study also triangulated the recognition of a trend towards deskilling among staff within the organization which I attempted to bring a specific, deeper focus to.

A task analysis for radiation therapy treatment procedures was published in the 2010 edition textbook, Principles and Practice of Radiation Therapy (Washington and Leaver, 2010). Informed with data of my study, I conducted a cross analysis with previously documented work flow processes and procedures. The original listing of processes provided excellent material for a pre and post -modern technology cross analysis. The analysis identified processes that are no longer suited for modern practices. The cross analysis also helped to identify specific factors that lead to the loss of a knowledgeable practice that I use for my argument in chapter five. The cross analysis may be found with the appendices, appendix G.

## Development of Codes and Themes

Selected data from the transcripts were coded using a matrix construction with Microsoft Excel. The matrix format provided much of the organization and structure I sought to maintain while allowing freedom for creativity in a systematic framework. This arrangement allowed me to sort and re-sort small units or chunks of rich information following a constant comparison method as I proceeded through interviews and the field work to further my data collection. My intent was to maintain the linkage between specific interview questions, research questions, and the level of the organization being explored. In this manner, through a trial and error process that I became more comfortable with as I proceeded, I constructed and grouped responses according to a structural coding strategy. In many cases I disassembled elements of a very long response aimed at answering one interview question, but also addressing another critical topic. The process was not a clean and direct maneuvering of bits of information. The constant comparison method of analysis checked current responses with previous responses to determine consistencies or inconsistencies. In this manner my analysis was recursive because new data directed my attention to a previous writing. These type of findings facilitated new questions consistent with a semi-structured interview. Some questions served to triangulate previous responses and perspectives. I developed three numbered small binders with the coded material as I progressed and as my data grew. The binders refer to the number of cross analysis, the first, second, and third pass. For final stages of my analysis, I printed the tables allowing me to work directly with the printouts by making notes, drawing lines to connect data segments, crossing segments out, literally going page by page with thoughts and scribbles to study the material. The table was modified electronically as my work progressed. I kept the collection showing how my findings are derived as the binders actually map and chart out my process.

My initial coding scheme involved grouping data by descriptors taken from studies of knowledge transfer. I attempted to use these as structural codes for my data. Well into the process, I learned that much of my data did not fit any of the descriptors. I changed my strategy during the data analysis process deciding to follow where the data seemed to be going instead of forcing it to fit *a priori* codes. My initial coding scheme and process reflects this natural process leading to my findings. This does not change the essence of my research, but maintains a clearer alignment that strengthens my process. It is also reflective of the emerging nature of qualitative research. I performed several passes of the raw data beginning with broad coding and characteristics. Through each successive pass of the data I coded down into finer sub codes until the present coding schema developed. The following are the research questions. For elaboration of the basis for each question see chapter two, The Organizational Layers of Socio-Technical Analysis of this dissertation.

**The broad research question of my study was:** How do radiation therapists learn new skills to develop a "knowledgeable practice" in a highly technical environment?

Research Question 1. The Infrastructure. How does the hardware and software system promote or inhibit learning of modern treatment delivery?

Research Question 2. The Info-structure. How does the layout and management of information facilitate or inhibit learning of modern treatment delivery?

Research Question 3. The Info-culture. How does the organizational culture encourage or discourage seeking and sharing information that supports learning?

*Trustworthiness*

Characteristics of trustworthiness in qualitative research include four criteria used to judge the soundness of the research. Lincoln and Guba (1986) use credibility, transferability, dependability, and confirmability as measures of trustworthiness. Trustworthiness is the qualitative equivalent to reliability and validity in quantitative research. I address these aspects of validity concerns as my attempt to show rigor and trustworthiness in my study.

*Credibility*

Credibility in qualitative research is an equivalent term to internal validity (Lincoln & Guba, 1986). It lies in establishing phenomena in a credible way, asking if the research is accurate. The goal in conducting credible research is to ensure that the participant was accurately described in the data and interpretations. Ways to ensure this included member checks. I shared written transcripts and thoughts with participants at different times and during different visits to the cancer center asking for additional notes and comments to guide my work. This helped with clarifications, interpretations and spurred new ideas not included during interviews. After writing chapter four, the report of findings, I mailed the chapter to participants. I have included an excerpt of a response by the CEO in the appendix section, appendix F.

This research describes (1) what organization has been chosen and why clearly; (2) I have attempted to establish findings that are internally coherent and systematically related by category and to my research questions and the stated purpose; (3) My research includes a detailed description of the case study analysis process. As the process I have already described, I developed several numbered small binders with the coded material as I progressed and as my data grew. For my analysis I printed the tables allowing me to work directly with the printouts by making notes, drawing lines to connect data segments, crossing segments out, literally going page by page with thoughts and scribbles to study the material. The table was modified electronically as my work progressed. I keep the collection showing how my findings are derived as they actually map that charts out my process. I performed several passes of the raw data beginning with broad coding and characteristics. Through each successive pass of the data I coded down into finer sub until the present coding schema developed.

*Transferability*

Transferabilityinquires whether the research can be applied to other groups experiencing the same situation. It is an equivalent qualitative term to external validity (Lincoln & Guba, 1986). A thick description can aid the transferability of findings. Rich, thick description is writing that allows the reader to enter the research context (Glesne, 1998), and the voices, feelings, actions, and meanings of interacting individuals are heard. An interesting report with sufficient description allows the reader to understand description (Patton, 2002). In order to provide rich, detailed writing, as the researcher, I dedicated myself to the transcription of every interview making sure I alone held discernment between what was important and what was not. In this way I was able to catch inflection in voice, emotion, excitement, or phrases and comments that may have been made "tongue in cheek." Hearing recorded responses repeatedly and personally transcribing all interviews helped me to study and reflect, taking me closer to the data and allowing much detail in my writing.

The thick description in the report of findings (chapter four) and interpretation (chapter five), as well as in the description of methodology of this study permits the reader to make his or her own interpretations making possible applications in their own settings.

*Dependability*

Lincoln and Guba (1986) use dependability as the qualitative equivalent to reliability. According to Patton (2002) qualitative researchers must maintain detailed records on interviews, observations and the process of analysis to ensure retest reliability of research analysis. Internal auditors may provide input ensuring dependability with these processes. Dependability is also monitored by external auditors who may also verify the data generation, the analysis, and the logic used for interpretation throughout the study (Lincoln & Guba, 1986). Input from Dr. Ann Brooks during various stages of data collection and analysis provided this role. Dr. Brooks reviewed my study at various stages reading material, questioning my interpretations, at times checking meaning and understanding and bringing up points of validity concerns. Although Dr. Brooks played a primary role as auditor for dependability, reviews by the dissertation committee may also be seen as an external audit checking for dependability and ensuring an acceptable level of rigor in my study.

*Confirmability*

Confirmability addresses how the researcher remains objective throughout the qualitative study (Lincoln & Guba, 1986). Validity concerns address the threat of personal bias in data collection, analysis, and interpretation. Steps are taken during stages of the inquiry and reporting to identify and even highlight personal bias and to monitor objectivity through methods of linkage of interpretation with data. In the section that follows, I describe processes to minimize the influence of my personal biases.

*Role of Researcher*

Qualitative studies should include information regarding the researcher who is considered the instrument of the study (Patton, 2002, p. 566). As the researcher, I was aware of my biases before and during data collection and analysis. For this reason, I have included the section of assumptions in the previous chapter. This serves to highlight this for the readership as well as to recognize them in written form for my own purposes. My personal experience as a radiation therapist allowed me to “speak the language” understanding key terms, typical acronyms and their use to describe treatment delivery. My current credentials as a registered radiation therapist provided experience and knowledge of the topic being addressed. It provided a baseline from which to understand the general organizational layout of cancer centers with typical settings and processes. This provided a basis from which to explore the changes in technology and related workflow patterns as compared to twenty years ago.

As the researcher with this background, I attempted to set aside my own definitions, meanings, and perceptions during interviews in my effort to obtain accurate information without bias or presupposition in responses. It is essential for good qualitative research to separate the interviewer's own perceptions, experiences and biases from the interview and analytical process as much as possible (Denzin & Lincoln, 2005; Patton, 2002).

Methods to minimize the influence of my own personal biases during data collection and analysis included making notes on my printed transcripts as I completed one interview and planned the next. As I proceeded to analyze data, grouping data in several different iterations, I literally proceeded page by page with thoughts and scribbles to study the material. Making personal side notes helped to reflect as I read responses and to monitor my own biases. These tables show how my findings are derived as they actually map out my process and maintain a traceable linkage. This process helped track and separate my responses against those of the participants (Patton, 2002).

*Triangulation*

Notes, comments, scribbles of thoughts and phrases heard were written on each transcript as I repeated this form of documentation after having conducted interviews. This served as my form of documenting observations that added to interview data as I completed other stages of my study, such as the document review for example. The time period during document review also provided ample opportunity to observe Mary, James, and Joseph, three radiation therapists in their natural work setting. My observations also included their interaction with the administrator, Michael. Reflections at the end of the day were hand written in the appropriate sections adding to a particular topic on the interview transcript. This also aided during the process of grouping data for coding and thematic analysis. This process of reflexive entries as the research progressed being added onto the documents of previous types of inquiries helped triangulate the data and strengthen the rigor of the study. This describes the triangulation of sources, comparing the consistency of information derived at different times and by different means (Denzin & Lincoln, 2005; Patton, 2002; Stauss & Corbin, 1998).

## Ethics

The following are potential ethical issues of this study using Patton's (2002) Ethical issues checklist as my guide (p. 408).

1. Explaining purpose. I explained the purpose of my study and methods of data collection using clear language that will make sense, with sufficient detail to foster good understanding by all participants.

2. Risk Assessment. Risk to radiation therapy and other staff – Could my research harm the staff or have repercussion? To make staff comfortable being honest with me I assured the staff confidentiality and interviewed them in a neutral location away from their normal working department. I also reported findings from a composite perspective.
3. Confidentiality. I assured participants that data were stored in a secured location and data were maintained until the study and report is completed and approved after which it were destroyed.
4. Informed Consent. I developed an appropriate consent form according to IRB guidelines. The consent form was approved by the IRB. (See Appendix B: Consent Form, Appendix C: Certificate of Approval)
5. Data access and ownership. As the researcher I am considered the owner of all data. Dissertation committee members and organizational administrative officials have access to the data, they have right of review of the entire report.
6. Advice. All dissertation committee members were considered the researcher's confidant and counselor on issues of ethics during the study.
7. Data Collection. I used a reasonable means as modeled by documented qualitative research methods in my data collection. I followed an interview guide using a semi-structured interview method (Appendix A).

## University Institutional Review Board

The research proposal was approved by the Texas State University-San Marcos Institutional Review Board (2010E306). (Appendix C) All participants were informed of their rights and asked to read and sign an informed consent form in accordance with IRB requirements.

## Chapter Summary

The strategy of inquiry was that of an exploratory case study, approaching the study from a critical perspective, and a constructivist epistemology. Constructivists study the multiple realities constructed by people and the implications of those constructions for their lives. This type of theory assumes that humans do not share one reality. Understanding is contextually embedded and any notion of “truth” becomes a matter of consensus among informed and sophisticated constructors (Patton, 2002). This concept supports group work and group discussions that involve discourse to establish new meaning.

The aim of my study was to understand how radiation therapists learn in their daily work routine. I sought to understand the organizational and work-related influences, processes, and factors that promote or minimize opportunity for learning. As a multi-level study, taking a vertical path of inquiry within the organization, I attempted to understand the different perspectives of participants. I attempted to see through the lens of participants, situated within their role. I then followed the path of material, interactions, information and processes as treatment plans were prepared and developed at one level, to be implemented by staff radiation therapists at another.

I chose two corresponding theories to guide my study. The situated learning perspective considers learning to be an integral part of everyday work, family, or other social settings. This places an emphasis on context, setting, and relevant tasks. The core constructs of situated learning theory are (1) participation, (2) identity, and (3) practice. Lave and Wenger (1991) view learning within social relationships – situations of co-participation. It is through participation that identity and practice develop. I used this frame to understand the impact of environmental and contextual influences that foster or inhibit learning.

I chose the socio-technical frame using the following organizational layers, the Infra-Structure, the Info-structure, and the Info-culture to structure my three sub research questions.

The purposeful sample consisted of selected individuals from participant groups of a cancer treatment center located in central Texas that typify a progressive center with characteristics of a high rate of change. Recorded semi-structured one-to-one interviews were conducted with selected individuals in every department representing every level of the corporate hierarchy to understand their personal experience of learning in the organization. A recorded focus group interview was conducted with groups consisting of the entire workgroup of staff radiation therapists. Data collection also included field observation and document review.

# CHAPTER FOUR

# REPORT OF FINDINGS

## Introduction

This chapter begins with an overview of the context of the study and participants. The chapter continues in meaningful segments of coded data for the three research questions. The questions explore factors that impact learning of modern treatment delivery within the three socio-technical categories used by Pan and Scarbrough (1998, 1999); Bressand and Distler (1995), the infrastructure, the info-structure, and the infra-culture of the organization. **The broad research question of my study was:** How do radiation therapists learn new skills to develop a "knowledgeable practice" in a highly technical environment?

Research Question 1. The Infrastructure. How does the hardware and software system promote or inhibit learning of modern treatment delivery?

Research Question 2. The Info-structure. How does the layout and management of information facilitate or inhibit learning of modern treatment delivery?

Research Question 3. The Info-culture. How does the organizational culture encourage or discourage seeking and sharing information that supports learning?

Findings regarding these questions are reported in separate sections; each section contains a table with relevant codes and themes. An overview of the findings and a narrative that presents the experiences of each participant follows. I have presented my analysis and interpretation in relevant sections closely linked to supporting data. Each section ends with a brief summary. Interpretation and discussion of the results are found in chapter five.

## Background

Operations of the modern cancer center, with new and changing treatment technologies, bring questions regarding the learning process of radiation therapists at a time when optimal patient care requires informed radiation therapists with good independent judgment abilities. Some educators perceive that the radiation therapist's role has become distant from the planning stages of treatment and is removed from information relevant to the patient's history and condition. The new role reduces the staff's ability to rehearse, practice and participate in applications that actively connect conceptual knowledge to their clinical work. Optimal care and safety demands comprehensive knowledge, and awareness based on the magnitude of radiation that may be delivered in a short period, to a small area. Errors regarding typical small fields have potentially crippling, and even fatal consequences. Treatment errors have gained the attention of the public in light of an increasing number of reported lethal treatment misadministrations. The actions of the radiation therapists must be rooted to a firm bed of knowledge, awareness, and information in order to recognize the potential for treatment error.

The purpose of my study was to understand how staff radiation therapists learn new skills and build on existing knowledge within the context of a highly technical environment.

## Overview of Context and Participants

With a multi-level study, I set out to understand the different perspectives of participants situated within their role in the organization. The ambulatory facilities are staffed with one supervising radiation therapist, and one or two Junior radiation therapists depending on patient load.

The participant criteria included:

- Active involvement with treatment planning or delivery
- At least three years full time experience with the organization
- Regular contact with staff radiation therapists
- A role as a radiation therapist, dosimetrist, physicist, radiation oncologists, or administrator.

I acquired the perspectives of three senior radiation therapists and one junior radiation therapist. Both co-administrators who participated in my study also have over 25 years of experience as a radiation therapist.

## Participant Profiles

To maintain confidentiality, respondents have been given pseudonyms. Each participant was an experienced practitioner meeting the criteria of working at least three years. The full time experience of the radiation therapists ranged from 3 to 10 years. All of these staff radiation therapists have worked only at this organization. The co-administrators have over 20 years' experience as radiation therapists with an extended range of experience. Abram has 10 years' experience as a medical physicist, and Dr. Anders has been a Board Certified Radiation Oncologist for over 25 years. Table 1 depicts elements of individual data and general profiles.

Table 1

*Participant General Profile*

| Participant | Role | Years Experience | Gender |
|---|---|---|---|
| Dr. Anders | CEO/Rad. Onc. | 25 | Male |
| Abram | Physicist | 10 | Male |
| Michael | Co-Admin | 25 | Male |
| Peter | Co-Admin | 25 | Male |
| Mary | Rad. Therapist | 10 | Female |
| Joseph | Rad. Therapist | 8 | Male |
| Gabriel | Rad. Therapist | 5 | Male |
| James | Rad. Therapist | 3 | Male |
| Julia | Marketing Dir. | 5 | Female |

## Description of Environment

The Centers for Cancer Care include the Wonder World Center in San Marcos, The Lost Pines Center in Bastrop, the Hill Country Center in Kerrville, the Sundance

Center in New Braunfels, the Hilltop Center in Kyle, and two new centers under construction in Uvalde and Fredericksburg. The Lost Pines Center for Cancer Care in Bastrop, Texas, is about 32 miles east of Austin. The property is a wide open area with many tall Pine trees. The building has windows that overlook a large pond with close parking nearby. The main entrance opens to a medium sized, decorated lobby with patients seated waiting to be called back for their treatment. Music, snacks, cookies, and coffee are set on a dark wood antique style side table reflecting the motto of the organization which was to have an environment unlike a medical facility. All staff dress in casual clothes with males in a company polo shirt and slacks unlike your typical medical whites, scrubs, and lab coats. This includes the physician and co-administrator. Headed towards the treatment area, stopping by the staff lounge, one finds the remains of baking pans on a small oven as evidence that cookies are baked fresh every day. The facility has a second floor with plans for a future chemotherapy suite with comfortable recliners facing a large windowed wall looking out onto the large pond. Although the entire building is nicely decorated projecting a welcoming environment, the path to the treatment room becomes increasingly more technical with computers and equipment as you enter the treatment room onto the humming of the treatment unit.

Great effort has resulted in transforming a highly technical treatment room referred to as a “treatment vault” due to the thickness of concrete used in wall construction as to attenuate the beam of radiation exiting the patient. This is best described with Julia’s words:

> When we decorate in our offices, we try to bring hope. There are words of hope everywhere you look. We strive to take the patient out of the clinical environment. We want them to experience as homey of an environment as possible, we would ideally like them to not be scared and not be releasing freakish endorphins. We use soft wood floors that are actually a rubber product, yet that is indistinguishable, it appears to be large plank wood. The floors look warm and they don't "click" as you walk. We employ couches and living room chairs instead of "doctors' office" chairs. All our artwork was to be light and happy; no foreboding colors, nothing that speaks fall ...like the end of a season.... just life. In our vaults we go as far as to put cloud gel covers, (sometimes they have hot air balloons in the sky screens incorporated into the gels) over our florescent lights above the treatment table to let the person on-beam look at something other than scary ceiling. The happier the patient, the more relaxed the patient, the better the patient. If all doctors are smart, and all equipment is fairly equal, then the difference is patient care and love.

I observed a great deal of symbolism. My conversations with staff also included a high sense of symbolism. Patton (2002) tells us that people create shared meanings through their interactions, and those meanings becomes their reality. Citing Blumer (1969), Patton writes, “human beings act toward things on the basis of the meanings that the things have for them” (p. 112). The importance of symbolic interactionism in qualitative inquiry resides in studying the original meaning and influence of symbols and shared meanings that can shed light on what is most important to people. I asked Julia what the tree means that I keep seeing throughout signs, business cards, logos, and repeated throughout the organization's website.  Julia explained:

> The tree symbolizes life; life flourishing. The tree was a symbol used long before I came; I just stylized it. The light beaming through the tree is also symbolic of hope and a new beginning, like a new day dawning.

As an individual involved in continuous accreditation reviews and site visits, I looked for the classic mission statement hanging on the wall.  There is none to be found. The Centers for Cancer Care demonstrate the holistic patient focus that runs through the veins of literally everyone I have spent time with.  The grand prize of this deeply rooted value came to me when I viewed patient interviews.  My review included a video testimonial and interviews found on the organization's website.  The video celebrates cancer survivors at their Hill Country Survivor's Picnic with interviews by ex-patients. One statement that demonstrates the organization's mission in practice comes from a senior male patient who says:

> I have never in my life seen so many good people in one place.  They are over friendly and helpful.  You really look forward to receiving your treatment.  If you enjoy going to take these treatments, instead of hating that, it is real good.

The patient testimony was so much more powerful than a written statement on the wall.  A document examination served as triangulation regarding the organization's mission and goals as stated by participants; how they wish to be seen by stakeholders; the desired public's image of the organization; the types of things communicated among organization members, and stated methods of communication. Organizational documents included a patient education folder that includes material ranging from the organization's goals, doctor's curriculum vitas, description of treatments, to aspects of care. Other items included brochures, and maps to locations. Still other types of useful information existed on the organization's website. These included archived newsletters that included stories and information regarding staff members, their hobbies, and their families.

My request to review other forms of communication such as inter-departmental memos, announcements to departments, and even written policies initiated a tour of the organization's electronic medical record systems that manage such things as the physician's transcriptions and notes, provides distribution lists for ease of communication after reviewing, editing, and approving certain material.

Peter pulled out his smart phone to scroll down a distribution list and explained that simple email has replaced the antiquated inter-department memo. As an example he showed me an electronic request sent to physicians to register for an upcoming webinar workshop on treatment planning. A record of such forms of communication are no longer normally in print form, but in his computer's hard drive, and other portable communication devices such as his smart phone.

Shortly after demonstrating his electronic messages to physicians and staff, Peter held in his hand a stack of regular post mail. Mailings such as professional newsletters, simple bills, service documents, and other forms of mail had "post-it" notes attached with messages from Dr. Anders. Peter explained that Dr. Anders gets mail at his home that he reads then sends to certain staff with personal notes. These may be in regards to a specific facility, a workshop, or other business. Peter and Scott, the co-administrators regularly sort normal mail for all facilities and manage that aspect of communication through mail routing.

## The Infrastructure

Research Question 1. The Infrastructure. How Does the Hardware and Software System Promote or Inhibit Learning of Modern Treatment Delivery?

The infrastructure includes the hardware/software which enables the contact between network members (Bressand & Distler, 1995, as cited in Pan, 1998). In exploring aspects of the infrastructure, sub question number one informed the broad research question by providing the layout of types of hardware and software, the network systems that promote or inhibit learning. **The broad research question of my study was:** How do radiation therapists learn new skills to develop a "knowledgeable practice" in a highly technical environment?

The aim of the analysis for sub question number one was to determine aspects of the hardware and software that promote and inhibit learning of modern treatment delivery. An overview of the findings and a narrative that presents the experiences of participants follow. This section ends with a summary of the promoters of learning and the inhibitors of learning separated by hardware and software.

## An Overview of the Organizational Infrastructure

The five cancer centers currently in operation are interconnected for communication and data transfer allowing all centers to access patient records electronically. Every time a patient checks in at any facility, the receptionist brings them up on the IMPAC system. What they are doing is communicating with the New Braunfels facility database to retrieve that information. When the therapists get ready to treat that patient in Bastrop for example, they also pull the patient file up from the IMPAC system. The therapists treat the patient; the file is updated and saved in the New Braunfels database. To streamline communication within groups at various facilities, each new center is set up with the same basic hardware.

An important aspect of knowledge sharing that is facilitated through this type of technology involves obtaining medical records and images from other facilities and referring physicians. An electronic network also facilitates this function. In another role, some senior radiation therapists are also managers of their facility. In this role, the radiation therapist is involved in floor level management for operations including housekeeping, building and ground maintenance. The infrastructure provides the tools from which the radiation therapists are expected to address facility issues. Our discussions have included issues ranging from technical breakdowns of the treatment machines and computer glitches, to contacting a service technician for the air conditioning system, and maintaining lighting both in and outside the cancer center.

Support for learning modern treatment delivery comes in both forms at this cancer center, electronic and well as in written forms. Radiation therapists create the chart, electronically with hard copy parts in file. The centers are equipped with networks allowing staff access to all information needed to perform duties related to treatment delivery and patient care as well as other type of duties related to the management of the facilities. Michael, an administrator, Abram, the chief physicist, and Gabriel, a senior radiation therapist commented on the ease of the network systems and their usefulness. What I observed is that the utilization of these systems enhances the amount of information and the type of information that may be captured, and then shared. In this way, support for enhanced knowledge of several aspects of the patient is improved.

## Systems of Communication

The following section describes the infrastructure across all facilities to support communication, flow of information, patient flow, and knowledge sharing.

### *The IMPAC System*

The five cancer centers currently in operation are interconnected through fiber optics for communication and data transfer allowing all centers to access patient records electronically. According to Joseph, who has worked his way up the organization with his very first exposure to radiation therapy as a patient himself, the two most significant technical factors making an impact on communication and information flow are the internet and fiber optics. Joseph explained that:

> Every time a patient checks in at a facility, the receptionist brings them up on the IMPAC system. What they are doing is communicating with the New Braunfels

database to retrieve that information. When the therapists get ready to treat that patient in Bastrop, they also pull the patient file up from the IMPAC system. The therapists treat the patient; the file is updated and saved in the New Braunfels database.

IMPAC is an electronic medical record system as well as a record and verify system for treatment delivery, also used for patient scheduling and billing. The IMPAC medical records system provides accurate documentation related to treatment delivery with computer work stations *hard wired* to the treatment machine, in direct communication with the unit. This is the electronic treatment record, or treatment chart that may be seen next to the operator's treatment console that programs the treatment machine. IMPAC is integrated with the Mosaiq medical record system that manages other types of documents such as transcription, and other types of information normally found in a paper medical chart such as history and physical, pathology reports, surgical reports, radiology reports, follow-up documentation by the physicians. Both systems allow communication and messaging with all staff using a distribution list for electronic communication.

Michael referred to the New Braunfels Center as the IMPAC hub for all facilities, "our day to day operations are intimately tied to using IMPAC as our record and verify system to make sure we're not making any treatment errors. Everything essentially flows through that."

To streamline communication and sharing of information within groups at various facilities, each new center is set up with the same basic hardware. Joseph, who plays several roles in the organization describes, "I set up the basic package each time at each facility, the hardware, the machine and systems communications and networks. I set up the processes that we've used before at other centers." A major characteristic identified is that all cancer centers are interconnected allowing a flow of communication for all personnel without regards to time or place. The same basic hardware setup was to be found at each center for the ease of staff operations.

*Replacing the "Sticky Pad" with Electronic Systems*

Michael, one of the two co-administrators, described the use of the electronic medical record installed in all facilities. He provided one account of system utilization for the sharing of information fostering knowledge sharing between departments.

Demographic information, nursing and other medical record information is found in the Mosaiq electronic medical record (EMR) system. Both systems are integrated and may be referred to as the EMR by staff. Michael elaborated on differences from older times:

> The technology kinda changed everything in our field hasn't it? All of our forward planning and scheduling like, you know, things we used to write on a sticky pad and have to remember. They are all in the EMR now and they just (clicking his fingers) pop up before your face when you're working. You know when it's time to get the simulation done. All those types of things, so really, we almost exclusively use the EMR for the day to day operations of the facility.

Access to information for any staff member may be immediate throughout the facilities. Joseph is a radiation therapist who has seen both sides of the table due to his own treatment at this cancer center. He expressed the following:

> Every computer in our company has access to IMPAC which means it has access to our database. You can find any patient information. If it was created and if it was uploaded, then it is accessible from any center, at any time.

All facilities operate on computer based platforms to complete tasks at every department level. When the patients arrive the receptionist calls up the patient in the system notifying everyone having a procedure scheduled that the patient has arrived. The computer treatment plans are prepared by the physics department using one system, uploaded to the IMPAC system where therapists acquire the information needed to implement a treatment. The information within the IMPAC system informs therapists of details and information regarding room setup, patient positioning, as well as required positioning devices. Other information includes treatment parameters such as number of treatment fields, field size, collimation information, shielding information and specific machine programming details regarding settings for treatment delivery. The same system records the treatment, maintains accumulated treatment doses, and may be used for billing purposes. These are only a few of this system’s functions.

*Obtaining Medical Records from other Facilities*

Another important aspect of knowledge sharing that is facilitated through this type of technology involves obtaining medical records and images from other facilities outside the organization and referring physicians. Gabriel has worked his way up in the organization from starting out as maintenance assistant and a technical aide. He provided details of how radiation therapists deal with this:

> This is currently one of the biggest frustrations during new patient consults. From our standpoint the therapist has to make sure we are getting everything we need from our colleagues. Since radiation oncology is always referral based, we depend on getting original records and reports from another party. The doctors refer to one another, but the staff is in charge of getting the proper material and information by the time of the consult. We often have to hold the hand of the other office to make sure we get everything. Whereas with a click of a button we tap into that source and not depend on another human being to remember to follow through. This makes things much easier.

Gabriel described an aspect of how the new system allows quick access to patient information. This extends the network as a knowledge sharing tool outside the organization.

*An Easy and Useful System*

An important characteristic for any system is ease of use and acceptance by personnel. Abram is a physicist who has worked with the group for ten years. He expressed:

> All the documents that are used for the treatment process are collected according to a unique patient ID number. As long as that number is known it is easy to find.

Expressing the same tone of satisfaction, Gabriel, a radiation therapist responded in the following manner:

> It is very easy. Using a paper chart you would find the index tab and find the report there. From an electronic perspective, I do think that you do have a couple extra steps, but once again, the flow of everything becomes more natural electronically just as it does with the paper chart. Very similar to the paper chart system though it's simply moving from one tab to the next tab. There is an electronic medical records navigation system. Once you get into a patient file, you can pull up the navigation box and move through that fairly quickly. Everything from doctor notes, nursing notes, therapy notes, to history and physical, to pathology and weekly TSDs that are recorded [target to skin distance (TSD) measurements that have been recorded by radiation therapists].

The system was described as being user friendly and similar to using a paper chart moving from tab to tab to find important information.

*The "Share Drive"*

From the administrative perspective, the IMPAC and Mosaiq medical record (EMR) systems effectively share information across facilities, the systems function as a tool to foster continued learning in the midst of solving problems. Some senior radiation therapists are also managers of their facility. In this role, the radiation therapist is involved in floor level management for operations including housekeeping, building and ground maintenance. Our discussions have included issues ranging from technical breakdowns of the treatment machines and computer glitches, to contacting a service technician for the air conditioning system, and maintaining lighting both in and outside the cancer center. The supervisors are equipped with a collection of contracted sources through an electronic database referred to as the "share drive." Michael, co-administrator, spoke about the share drive:

> It's available in our master folder; we call it our "share drive." Our master contact list so if we need anything from a guy to wash our windows to somebody to help us find staff for if we're short in an emergency situation for whatever, if someone is out for maternity leave; all those contacts are saved in a master list to call them right away. It's accessible to everybody.

The "Share Drive" is a resource for personnel designed to allow them to take matters in their own hands. As such I consider this aspect of the system a tool for continued learning and sharing knowledge. More material is presented in other sections regarding administration's expectations of problem solving and the impact on learning.

Differences among Cancer Centers

Differences exist among cancer centers despite setting up the same basic hardware and sharing the same network. Having learned one system, staff is expected to anticipate being asked to assist at other centers periodically. Several radiation therapists spoke of the differences and provided some detail of the type of differences seen as they are re-assigned from center to center. This calls for learning and working with these differences. The discussions also provided some information regarding the evolution of the changes. Mary is a radiation therapist with over ten years with the group. She felt that:

> The technology is a little bit different at each site. Makes filling in a challenge. For example, we have Portal Vision in New Braunfels whereas here, we have an on-board imager. I would just have to learn the differences between those two because I have not worked with Portal Vision. For the most part, within our organization, we try to make it to where all of our electronic charts are the same; a lot of the day to day things are the same. But you run into differences.

Joseph also commented that centers differ after he reproduces a clone of a previous center:

> I set up the basic package each time at each facility, the hardware, the machine and systems communications and networks. I set up the processes that we've used before at other centers. As each facility evolves, they make changes to work as they want it to be, as it works best for them. Work processes differ greatly

> sometimes like how they do shifts. [Note: a shift in this context is an adjustment to the treatment area, a slight move to correct drifting of the target.]

Exploring further, I asked, what frequently must be adjusted and how. Michael elaborated on how these differences occur:

> Given that the clinics are geographically separate, we know there were minor differences because one doctor wants to do this, and another doctor wants to do that a little bit different so there were minor differences. But we really truly want each staff member at each facility to talk to their counterpart at the opposite facilities so that, when someone comes up with a great idea, everyone gets it.

My understanding was that a large factor influencing differences among centers was related to the physician. Gabriel spoke of how these differences by the physician begin and he described how they are adopted by the radiation therapists, “When doctors coming back from seminars and they say, ‘I saw this new incredible thing, let's try it’.”

Five participants, including Michael the administrator, provided a description of changes of the infrastructure between facilities. I spoke with radiation therapists, James, Gabriel, Joseph, and Mary who find it difficult to learn different systems as they are re-assigned to different locations. Details of their learning experiences are included in addressing aspects of the info-structure, research question number two.

Summary of Findings for Research Question Number One

**Research Question 1. The Infrastructure. How Does the Hardware and Software System Promote or Inhibit Learning of Modern Treatment Delivery?**

The organization sets up all facilities using the same general layout of equipment and software. Network programs are used for medical records management, patient flow, treatment records, and as a record and verify system for treatment delivery. The two systems used by this organization are the IMPAC medical system and the Mosaiq medical system. Despite an effort to implement universal procedures and constructing sites with similar infrastructures, differences that are driven by the preferences of the physician as well as certain equipment characteristics exist. This is a source of perpetual demand to keep learning something new as radiation therapists are expected to substitute when needed. Traveling to different facilities, radiation therapists are required to learn new equipment and technology, or to re-visit older equipment from a previous generation. Differences that exist among facilities create the demand to learn, but also serves to make learning difficult. The goal of cloning the setup at each facility is to facilitate learning and to reduce the learning curve as radiation therapists transfer from one site to another. The learning curve is extended when therapists face changes prolonging adaptation periods. The organization is very progressive in its equipment and technology. For this reason, treatment equipment manufacturers have selected them occasionally to beta test new products before marketing. The experiences described were of very stressful periods where staff must troubleshoot imperfect software during active treatment times. Staff must address problems without much technical assistance as the system is being used as part of the development and research phase. Although this positions the radiation therapists at the very center of problem based learning, it produces frustration levels that made work unpleasant and exhausting also causing delays for patient treatments. I see this as one aspect of how new systems are used that does not promote learning as Mary expressed just trying to make it through the day.

*The Promoters of Learning*

The following lists aspects of the hardware and software that promote the learning of modern treatment delivery.

(A) Hardware

1. Computers and equipment are setup identically at each facility. This supports information flow and connectivity. The goal is to minimize the learning curve by keeping similar environments at each facility.
2. Working within the same environment with the same equipment for an extended period creates stale and stagnant staff. In this respect, facilities that are geographically separated using varying types of equipment and different levels of technology encourage learning. Although the learning curve in this instance is extended, radiation therapists are required to learn new equipment and technology, or to re-visit older equipment from a previous generation upon reassignment.
3. Fiber optics keeps all facilities connected. This is the fiber cable that physically transmits data and information. This connectivity allows the crossover and immediate sharing of information.

(B) Software

1. The IMPAC medical record and treatment record and verify system. The systems information includes treatment parameters such as number of treatment fields, field size, collimation information, shielding information and specific machine programming details regarding settings for treatment delivery. The same system records the treatment, maintains accumulated treatment doses, and may be used for billing purposes. The system uses a systems quality assurance program to communicate with all departments of pending checks and assessment procedures. This aspect of the system provides connectivity between departments and the sharing of information through communication.

2. The Mosaiq medical record management system. The system is a network program for managing many types of patient reports including surgery reports, history and pathology reports, digital medical images, and other relevant patient records. This system also allows the connectivity among all departments providing access to patient records.

3. An electronic folder referred to as the “share drive” was created to facilitate the sharing of information for everyone to find contractors, vendors, repair service technicians, technical support and other resources used in the management of each facility. This is a useful resource used during times of problem solving and is instrumental in providing managers technical assistance.

*The Inhibitors of Learning*

The following lists aspects of the hardware and software that inhibit the learning of modern treatment delivery.

(A) Hardware

1. Differences that exist among facilities create the demand to learn, but also serves to make learning difficult. The goal of cloning the setup at each facility is to facilitate learning and to reduce the learning curve as radiation therapists transfer from one site to another. The learning curve is extended when therapists face changes prolonging adaptation periods.

(B) Software

1. Implementing the new “on board imaging” software was said to have many “bugs” causing delays in treatment delivery. However, the site was beta testing the software for the company. Cancer centers are often asked to be a beta test site to make certain a product is ready for market prior to release. This is true, especially if the center has already purchased several other types of equipment from the company showing interest in newer technology. During beta testing of a new product, the center agrees to work with the company as staff identify and work through glitches in the new product. This caused much discomfort and increased stress levels for the staff. Mary elaborated:

> We were a beta test site for that and that was not fun. Just getting through the software was very stressful. There were a lot of software glitches. We

spent a lot of time on the phone with them, “Theraview”. But a lot of it now is just day to day work since we’re past all of that.

2. As a beta test site for new “on board imaging” software some technical issues were expected. However, staff expected to have technical support from the company in times of trouble. Since the imaging system was new even for the vendor’s technical support, they were not knowledgeable and were not able to assist the radiation therapist and in fact depended on the radiation therapist to trouble shoot the system to inform them.

## The Info-structure

Research Question 2: The Info-structure. How does the layout and management of information facilitate or inhibit learning of modern treatment delivery?

The info-structure is similar to infrastructure, except that it does not refer to any physical device or facilities. A simple contrast between the terms may be illustrated as follows; the info-structure may be delivered seamlessly as water through a faucet. The faucet and plumbing may be referred to as the infrastructure while the water flow is information that is highly dynamic, bi-directional, and requires a transmission mechanism to distribute and meter the flow. The info-structure, or information structure, is the layout of information that may be navigated and organized in a useful manner. The focus at this level is the information itself that may be in the form of video programming or databases. While there is a link between technological infrastructure and informational infrastructure (info-structure) information professionals think of information management not just records management in solving strategic issues (Meagher, 2002). **The broad research question of my study was:** How do radiation therapists learn new skills to develop a "knowledgeable practice" in a highly technical environment?

Exploring aspects of the info-structure, how information is structured and may be navigated in a useful manner, informed the broad research question by identifying patterns of communication and information sharing. Interactions and mechanisms of the information flow also described how information is gathered by problem solvers, and how such processes provide feedback. This also informed the purpose of my study since optimal care and safety demands comprehensive knowledge, and awareness that depends on the seeking and sharing of information.

An overview of the findings and a narrative that presents the experiences of participants follow. I describe how the info-structure of the organization facilitates or inhibits learning as I attempt to bring insight into my analysis. Further interpretation based on theory of my findings is presented in chapter five. The findings are organized according to four themes.

**Theme Number 1**: Peer Teaching: Teaching the "ins and outs"

**Theme Number 2**: Rotation Assignments: We don't let staff stagnate.

**Theme Number 3**: Signing Off: Routing the Treatment Plan.

**Theme Number 4**: Working Memory: Not "in mind" Lost Over Time

## Peer Teaching: *Teaching the "ins and outs"*

### *An Overview*

Peer teaching is one of the contexts where information is exchanged to facilitate learning. In general, theme number one describes the exchanges and interactions occurring during on-the- job peer teaching that provides encouragement, feedback, and direct, immediate communication. Radiation Therapists work side by side with peer to peer learning as the prevalent method of new employee training. The radiation therapists I interviewed expressed themselves in very personal terms. They explained the reason and rational for this process with personal detail, less in terms of policy, but because of something they deeply cared for. Dr. Anders; Mary, Gabriel, and Joseph, the three senior radiation therapists as well as Abram, the chief physicist, and Michael, the administrator described the on-the-job type of learning most characteristic of the workplace learning that occurs in radiation therapy. The subthemes to Peer Teaching were (1) Teaching the "ins and outs in the Trenches", (2) "Being Brutally Honest" as a Form of Feedback, (3) Cross Training: "Walk in Their Shoes".

### *Teaching the "ins and outs in the trenches"*

This refers to on the job, hands-on training in the form of peer teaching. This is the essence of comments such as learning is "on the job" and learning is "patient by patient" as colleagues work with one another treating patients. Radiation therapists share information sometimes using personal "cheat sheets" as was described by Michael to cover step by step processes. Michael explained:

> Yes our training is very similar to how we do it on the job because our training is mostly job based. I mean, your training is usually, for example, if you're training as a new therapist your training is while you're working under one of our more seasoned, experienced therapists. Our training doesn't differ all that much from job performance or treatment in that, I mean, we're doing it, as we're training, we're doing it. You know, certainly we like to have some little cheat sheets, here's how you do this, here's how you do that, that we hand folks early on, "OK here's where this is and here's where that is," but, their training is, most of the time, "in the trenches" training so to speak.

Gabriel has only five years experience as a registered radiation therapist, but he has worked as an aide for Dr. Anders in previous roles. Gabriel shared his perspective about teaching peers:

> I try my very best to cover all the bases when I teach a new therapist. In order for them to flourish and in order for you to work as a great team, as a fluid team, they need to know the "ins and outs" and that's going to take someone being a "teacher" and the other party being "teachable." I mean it's really very involved if you teach this right. If you really look at it, when you are doing something that comes across as something that is very simple like a simulation, there is 500 steps from start to finish and if they miss 7 steps in between there is going to be a whole lot of frustration in people like other therapists to dosimetry because they didn't get the plan, or the doctor were mad because he does the plan contour and is

> asking where his images are. When you do not get the right borders for the field, you have to get the patient back into the simulation and repeat the procedure. So I think that teaching all the "ins and outs" down to the nitty gritty, even things that seem simple and stupid that a new person would have no idea unless they go through it all.

Gabriel recalled his experience upon his hire also describing the hands-on approach to training:

> I am a fairly new therapist, a few years out. I depended on my co-workers to take me under their wing and to really explain things in and out and not to leave out the small details. Very much hands-on and I think that's how a lot of therapy works.

The responses provided insight to the process of learning among radiation therapists. In terms of the info-structure, the mention of "cheat sheets" shows the extent of the depth and breadth of information that is referred to and shared among colleagues. This involves a sequential listing of procedures to learn completely. One point demonstrated here is the completeness of information that must be shared during the tasks.

*Being Brutally Honest As a Form of Feedback*

Peers provide feedback directly and immediately as the more experienced radiation therapist works with their new partner.  New therapists depend on "more seasoned" therapists to take them under their wing as they share what was referred to as "brutally honest" feedback.

Gabriel reflected the same type of peer to peer interaction the other radiation therapists described occurring as one radiation therapist takes another under his or her wing:

> When working alongside someone who is new you let them know what they do well, but you also are brutally honest. You may say 'you do this and this perfect, but when you do this, make sure you do this,' making sure that they are on top of everything.  'This new technique is working great, but you have to make sure you also do this and that, you also missed this one step.'"

This described two characteristics of the info-structure.  It described the frequency and nature of information received by new, junior radiation therapists; feedback is immediate and honest – regardless of feelings - is one characteristic.  Another characteristic this described is the direction of flow, moving down the chain of command. A comment of being "brutally honest" makes me think of the law of military protocol of communication, the belief that communication of superiors is more important than those from subordinates.  This one response does not support my previous view that the info-structure is multi-directional although a larger view and study of other responses do support that.

*Cross Training: Walk in Their Shoes*

Concentrating on developing an overall higher level of awareness in the organization, administration schedules observation visits by all new members of the team referring to that as cross-training. This is a structured process to increase awareness within the organization. From an organizational perspective the participants work closely sharing information, ideas and working across department borders following initiatives fostered by administration to learn as much as possible about your neighbor. In terms of the info-structure this demonstrates the sharing of information across department borders with a lateral flow of communication among different staff. This study identified that information flow may also flow vertically, passing through barriers of professional levels as radiation therapists may spend time with the doctor, physicists, or administration.

In his response, Dr. Anders expressed the organizational priority to promote and encourage awareness between departments. Dr. Anders' views follow:

> One of the learning tools we like is the "walk in their shoes" approach. We like to take non-technical front office person and have them shadow a therapist in the vault. Then we take a therapist and let them sit up there in the front so they can get phone calls, be asked questions, deal with the Fed-X guy simultaneously, while scheduling an appointment. Both the parties gain a new sense of respect for what the other had to deal with… all of our staff are formally rotated through every area. Through dosimetry, simulation, treatment checks with the doctor where staff merely sits in there while the doctor does treatment checks, or during a new patient consult just so at least once, they see what's involved.

*Summary for Peer Teaching: Teaching the "ins and outs"*

In this context, peer teaching is a form of mentoring where an experienced radiation therapist takes a new person "under his or her wing." This is an informal approach to teaching and learning during real life work situations that builds knowledge as radiation therapists exchange information "on the job."

## Rotation Assignments: We don't let staff stagnate

*An Overview*

The re-assignment of clinical rotations mixes staff, changes equipment, and the work place environment. I found that for this organization, aspects of the info-structure that facilitate learning of modern treatment delivery is fostered and utilized greatly through the rotation assignment. The rotation assignment mixes staff having learned treatment delivery using one type of equipment, under the practice of one physician with another group. I relate this to the info-structure because it directly influences the flow of information by people.

Participants also described how administration informs staff of pending rotation schedules to the San Marcos facility (requires manual, pen and paper operations) to foster motivation within staff to maintain a broad range of skills. My findings are based on five participants who described their perspectives of transitional periods. A transitional period may be a time where the radiation therapist is learning a new method of treatment or learning new equipment.

The subthemes to Rotation Assignments were (1) Addressing Gaps in Foundational Skills; (2) Working With New People and New Setups; and (3) Perspectives on Transitioning from Old to New Equipment.

*Addressing Gaps in Foundational Skills*

The mere fact that supervisors and administration recognize and acknowledge a trend of deskilling is a positive attribute of this organization. Their proactive involvement to maintain the desired skill level for the organization takes on the characteristics of a learning organization. Administration has taken responsibility to ensure that staff is prepared with the required skill set to do a good job. The perspectives that follow begin with merely recognizing the concern; I then present the CEO's solution.

Gabriel recognized and expressed the importance of keeping their minds and skills sharpened. Gabriel, spoke of some of the struggles:

> I know that I don't want to become stale and stagnant. This is one thing that staff continuously talks about among each other. We want to make sure we are staying fresh and on top of everything. This is a huge issue right now for radiation therapists. With either a new therapist joining the facility or even with an old therapist who has been working in one facility for a while and is used to one way for the majority of their career, then has to move to a different facility.

I consider this as an aspect of the utilization of information that facilitates learning because as a supervisor, Gabriel reflected that staff talks about their concern. He referred to their concern as "a huge issue" and acknowledged to administration that an issue in learning exists. Steps were taken by administration to utilize the diversity within their facilities as a "natural training ground" as Dr. Anders put it during his interview.

For Dr. Anders, a solution for staying fresh and on top of things is keeping the staff from becoming stagnant and too comfortable. He uses the circuit of various centers as a training ground:

> We don't let staff stagnate on one piece of equipment or in one setting. We try to move them around from machine to machine, from a center to another for a short period of time just to make sure they stay fresh on something and don't end up back at square one. We also have degrees of technology and levels of different skill sets at various centers making the circuit a natural training ground.

Supervisors inform staff of their pending rotation to the San Marcos facility encouraging staff to remain diligent in maintaining their skills. The large difference between facilities fosters motivation within staff to maintain a broad range of skills as much as possible. Modern facilities are fully equipped with informational systems (IMPAC and Mosaiq); the San Marcos facility requires manual, pen and paper operations.

*Working With New People and New Setups*

The perspectives provided insight regarding learning in three different contexts. One context referred to the rotation assignments among facilities; another context referred to working with people during informal planning sessions in the treatment room as difficult patient situations bring people from different departments together; in another context multiple parties come together as they strive to fix equipment and/or software, or as they resolve facility issues.

Participants provided multiple accounts describing the interaction and exchange of information within these contexts. What follows is a brief summary of views of learning within the context of the rotation assignment.

The following are Gabriel and Joseph's perspective where working with new people brings new learning as the radiation therapist leaves behind certain treatment techniques under the direction of one doctor to work under another. Gabriel, a radiation therapist with five years' experience described the challenge radiation therapists face as they are assigned to a new center. Gabriel explained:

> Procedures for everything can look totally different when you move from center to center… working with one group, then having to leave and start all over again... That's where "new" therapists can bring very new and different perspectives. That's the whole reason I think that seasoned therapist can learn from new therapists.

The two elements being described include the crossover of information due to the rotation schedule as already identified previously. A new focus here is on new radiation therapists bringing new ideas into the organization. This suggests that experienced radiation therapists may learn from the new radiation therapists whom they have taken under their wing. This is a reversal from the usual expectation of the seasoned radiation therapist being the teacher. The flow of information, the type of information, and the source of information describes aspects of the info-structure that facilitates learning of modern treatment delivery. I have expressed that the flow of information is multi-directional. This form of peer to peer training describes a lateral flow of information among radiation therapists, but also a bi-directional flow between experienced and new radiation therapists.

Joseph, a radiation therapist with eight year experience who also helps with the startup of new centers also related to the learning opportunities found by working with different people and places:

> That is what my job has become. Going to new centers and learning… So I learn from therapists who are working at a particular facility and I also learn from students who already know the ropes there. I have to take the lead from who's ever there.

A source of information that facilitates learning from Joseph's perspective comes from his contacts as he works in new centers. He takes his direction from whomever he may be working with. This shows that information flow is receptive at senior levels flowing from bottom up in the case of this experienced radiation therapist taking direction from students. This demonstrates a bi-directional flow of information that is not the typical top – down flow based on the administrative hierarchical levels of the organization.

*Perspectives on Transitioning from Old to New Equipment*

Three experienced radiation therapists and one co-administrator provided perspectives as I explored their experiences of moving to various facilities within the organization. Joseph; Gabriel, a radiation therapist with five years experience; Mary, a radiation therapist with ten years experience; Michael, a co-administrator, with 25 years experience as a radiation therapist elaborated on their experiences and observations regarding working through transitional periods. The common thread among responses was about the struggle to adjust.

Mary remembered her transitional period recalling the biggest factor that kept her motivated to keep learning the new technology:

> For me it was really hard to transition. Obviously Joseph and James were newer, out of school, more comfortable with computers to begin with. It was a big change for me. But you are forced to learn it. You have to step in with open arms. There is no question that if I want to keep my job I have to learn everything, so bring it on! And I have always felt that it is better treatment and care for the patient so I've been driven to learn all this.

Asking Mary what it is that she remembers as causing the most trouble, she related,

> You can say that this is very stressful, maybe even negative at first. It becomes inundation with a whole lot of information. It's not really negative, but it's just very stressful. After you get through the hurdles of acquiring the correct training,

> you get training from any of the vendors, but sometimes they don't have answers to half the questions that you ask them.

Information overload is not supportive of true knowledge sharing as it makes navigating through a flood of data difficult. Under these conditions the channels of communication become distorted and cluttered where the receiver is not able to decode and draw meaning from the information. The recipient at times like this is not processing information adequately. Adding to this negative learning experience, Mary is also unable to get useful information from the vendor's technical support service.

Asking Gabriel how he handles the transitional periods, he claimed:

> I've always been a person that practices perfection. And the more you get to know your equipment; I mean getting into manuals and really get to know your equipment as a therapist is extremely important. Not to just come on and say I know how to push "auto setup" but to really get down to the depth of how the equipment runs. A lot of therapy now involves CT planning systems which is 10 to 15 years in the making but still fairly new to the field. Considering therapists are not usually CT certified, this is a big learning curve, for me personally. Just getting into the user manuals is what it comes down to with that.

A therapist may seek answers to questions by personally reviewing operation manuals of equipment. Larger organizations may have other sources that may include more staff, an in-house engineer, or a physicist at the site who may be called for help.

Although calling someone is an option, the philosophy instilled within staff is always to attempt to solve your own problem before calling someone. This is demonstrated in Gabriel's comments as he described searching through operation manuals.

*Summary for Rotation Assignments*

In general participants described working with different groups; working with other staff and doctors to consider all aspects of a new treatment method; and learning through various forms of problem solving. Radiation therapists are assigned new facilities and work with new people. This increases the circle of influence as it facilitates the sharing of new information. Accounts related to problem solving demonstrated a context in which a need for immediate information arises. Multiple parties come together as they strive to fix equipment and/or software, or as they resolve facility issues. Working in this context draws people closer in contact with vendors, service technicians, engineers, physicists, as well as their counter-parts in other facilities. Learning from each other and sharing that information was described in terms of "constantly flowing," "free flowing" and "using everything you know." The responses described many forms of unstructured, informal processes that keep communication alive throughout the organization during periods of learning new methods and ideas.

From an infrastructure perspective, the electronic medical record network provides the transmission of information from facility to facility; from a perspective the info-structure, work rotations provide interpersonal, face-to-face communication allowing people of the organization to share information as they work together.

## Signing Off: Routing the Treatment Plan

*An Overview*

Signing off the computer plan was the strongest form of communication that linked departments and people together as they focused on a common goal. Types of information delivered to the radiation therapists such as the computer treatment plan are reviewed and checked for accuracy in sequence as the material is sent from department to department electronically. The completion of each check may send the information forward prompting the next check in a sequential path leading to the treatment delivery. The flow of information may be stopped and reversed for material that is not approved at a particular "node" of this pathway. The flow may be bi-directional and repeating until all participants are fully satisfied with the accuracy of information. Upon review and approval by all departments the treatment plan becomes the "blue print" for the patient's treatment. The departments are physics where the computer treatment plan originates; the physician who prescribes and directs the treatment; and the radiation therapist who delivers the treatment. Through this review process, personnel in these departments remain linked in communication. Questions regarding aspects of the treatment plan or some other related material continue to keep these three major groups in contact and in communication. The subtheme to *Signing Off* was, Better Tools Means Better Knowledge.

*Better Tools Means Better Knowledge*

The physicist, Abram, described the flow and process involving double checks and multiple sets of eyes on the treatment plan as it moves from department to department when it is completed ensuring accuracy and simultaneously providing the radiation therapist staff useful knowledge.

Abram explained the procedure:

> So basically that means that when the physician starts his portion and it's done, dosimetry jumps in, physics jumps in, therapy comes in the end, whoever comes next, checks the work of the previous person. So everything in that order gets checked twice. And in this way, yes you have technical influence on a daily treatment or it brings your technical skills to a higher level. Because you have better tools, you have better knowledge, you can save time, you can do things better when it comes to patient quality. If something is written in a way that you should follow, sometimes it brings perfect results, sometimes it needs revisions. If it's the first case, then overall you say that influence brings benefit to the whole process.

What Abram emphasized and referred to as "tools" is knowledge. The radiation therapists with greater knowledge of the treatment plan - that includes rationale for beam placement, beam angle, size, etc. - is better equipped with informed treatment readiness contributing towards a "knowledgeable practice." This process is directly related to information flow and management (info-structure). The sequence of signing off the computer plan clearly demonstrates the flow and sharing of information to facilitate learning.

Joseph also spoke of double checking, triangulating, what Abram referred to as a basis of communications between departments, and a process that fosters the sharing of knowledge since radiation therapists always “know what’s going on” through this process.  Joseph elaborated:

> The therapists have to sign off on everything, each and every piece of the approvals.  It’s good for them because they know exactly what is going on with the patient, but they also take complete responsibility.....if anything at all comes up that they do not understand or agree with they are supposed to communicate with dosimetry, the doctor, or physics to make sure they understand and agree with the plan. They definitely do not sign off on any treatment until they understand and confirm that it is correct.

*Summary for Signing Off:  Routing the Treatment Plan*

The sequence of signing off the computer plan clearly demonstrates the flow and sharing of information to facilitate learning.  By “signing off,” the radiation therapist attests in writing that they have not only reviewed the treatment plan, but understand it, has no concerns, and will carry out the treatment delivery.  The process also documents the process recording information as individuals agree to carry forward, or return the plan with questions or concerns.  I note that these are two very different forms of information that may facilitate learning. One encourages the radiation therapist to review the treatment plan before treatment delivery (Individual Learning); another informs the review process for the organization (Organizational Learning). The radiation therapists with greater knowledge of the treatment plan - understanding rationale for beam placement, beam angle, beam size, etc. - are better equipped with information contributing towards a “knowledgeable practice.” This process highlights a very important dynamic of information flow and management, the info-structure.

## Working Memory: Not “in mind” Lost Over Time

### *An Overview*

Aspects of new treatment technology remove the radiation therapist from intimate involvement in the treatment delivery process reducing opportunities for learning.

Situated learning theory holds that *identities* are continually evolving through, but bounded by, participation within communities of practice. This perspective of reduced learning opportunities with a modern practice of treatment delivery parallels the Situated Learning frame since it is contextual and based on participation. In this context limitations are imposed on the practicing radiation therapist although they may be considered as efficient practices. Repeat use of information keeps information as working memory where it can be assessed as part of comprehension and problem-solving. Information not used repeatedly, or not kept “in mind” is lost over time. As a result learners may seem disorganized and unprepared when facing demands that require the information that has been lost.

In terms of knowledge utilization, interview data suggests that a modern practice that includes record and verify systems inhibit critical thinking and therefore learning. It is described as a substitute for thinking as radiation therapists use this type system more and more to direct their actions as opposed to using it as a second check to verify correct treatment machine settings. The subthemes to Working Memory: Not “in mind” Lost Over Time were, (1) You Forget the Concept of Looking at the Patient; (2) A State of Awareness: You Really Have to Understand What’s Going On; (3) Deskilling: The Impact of Long Term Use of New Technology.

*You Forget the Concept of Looking at the Patient*

Within the context of working with new technology, one factor that came up repeatedly involved how the record and verify system is used, different from its intended design. The concept of the record and verify system was to “check” the actions of the radiation therapist who was to utilize charted information as well as their own reasoning and discernment for treatment delivery. However, staff tends to use that information system more and more to direct their actions, leaving out reasoning and concepts behind treatment rationale. Staff simply set what is seen on a screen taking that as absolute, following its lead. This system when used this way inhibits thinking. Joseph reflected on his experience upon his return to the San Marcos site:

> The San Marcos center is completely manual. You have to go into the treatment room for every field to set the jaws, set the gantry, set the collimator, put the block and compensator in. And I mean you’re doing this really fast to keep up the

schedule so it is a real wake up call. As an example of treating with and without IMPAC say you are treating a breast. We always learn how a wedge is typically set for the breast tangential field. [Note: Radiation therapists learn the proper placement of the wedge onto the machine by seeing how it is oriented in relation to the patient lying on the table. It is possible to place it in a reversed position decreasing and increasing intensity to the wrong part of the patient's body].

When you get used to treating with IMPAC you just look at the screen and it says "30 – Left" that pretty much tells you how to set the wedge. After treating that way for a long time <u>you forget the concept of looking at the patient</u> and the logic between the wedge heel and the contour of the breast. Going back to San Marcos, all you have is a chart with "30 wedge" noted. Now you have to look at the patient and pay attention because you don't have IMPAC telling you how to put in the wedge. <u>You have to think</u> to put it in the machine correctly.

Working at the newer centers, you are working with IMPAC and a new treatment machine. As soon as you are asked to go back to cover in San Marcos, it's like, whoo. What am I doing? It takes a while to catch up. IMPAC is a wonderful tool to help make sure that treatment is always delivered correctly. But it also lessens your skills because <u>you are not thinking</u> as much for every field as to what needs to me done. Just by having San Marcos in our company, it keeps people on their toes. Everyone has either come from working in San Marcos or has treated there enough, even our newest therapist, Marissa has covered enough in San

> Marcos to know that she better not lose those skills because as soon as someone goes on vacation, she could go right back to cover.

*A State of Awareness: You Really Have to Understand What's Going On*

Gabriel perceives that reliance on new technology as a check for your work weakens radiation therapy skills. Repeatedly seeing the patient on the table in the treatment position keeps the radiation therapist "knowing" what the setup should look like. I may also suggest as related to my previous comment, that this keeps relevant knowledge in memory, or "in mind." An automated shielding block moving in or out of the radiation beam may be depicted by a graphic on a computer monitor outside the room by the control console. This is another aspect of technology that removes the radiation therapist from intimate involvement in the treatment delivery process. In terms of the info-structure, information is received or observed only as the radiation therapists continue to enter the treatment room to set the wedge, the verification film, or the shielding block manually. These are processes that are automated in modern treatment machines. Like Joseph, Gabriel described the focus and degree of awareness required when working on older equipment:

> You really have to know and understand what's going on with older equipment; you can really hurt somebody, or do something critically wrong if you don't know what you're looking at. I really believe that my therapy skills have increased significantly mainly because of what I have had to learn working with old equipment. I feel that my therapy skills are at a higher level because I do work

> with older equipment. I have to really know what I am doing without systems checking behind me. I have to recognize the red flags myself, I have to see the setups with my own eyes and know what they should look like on the patient. Having to work with the older equipment has kept those skills sharper.

*Deskilling: The Impact of Long Term Use of New Technology*

Two senior radiation therapists, Joseph and Gabriel, described their experiences going from old, to new, working with new technology for several months, then returning to the older equipment, repeating this sequence several times. These types of experiences provided important insight about the preparedness to return to work with older equipment after working in a technology-centered facility.

Repeating these experiences allowed the participants to reflect on more than one time, more than one experience forming rich perspectives to share. The perspectives are personal accounts of stepping into a different simpler treatment environment and realizing their lack of preparedness and a loss in retention of foundational concepts. This struggle to recall and to re-learn aspects of treatment during re-assignments may be viewed as a normal process of adapting to a different setting. Through inductive reasoning, these personal experiences provide patterns and regularities suggestive of the impact of long-term use of newer technology and equipment. Through inductive reasoning these observations suggest a direct impact on maintaining a knowledgeable practice. Triangulating the views of Gabriel and Joseph, Dr. Anders elaborated about effects of using newer equipment for long periods of time. He spoke of the cost involved in using the newer technologies:

> I think that they probably over a long period of time reduce errors or give more consistency, but I think that to some degree they do so at the cost of not having the individual staff people intimately involved in writing down monitor units and making entries in the chart, keeping track of a written chart and having to actually check data by hand. ...if you want to learn how to throw a baseball you can't just watch films entirely or just think about it. At some point, you have to throw a baseball over and over. I think that even something as basic as just tactile, just the sense of physically entering angles and putting blocks in trays and turning the gantry yourself over the years gave perhaps therapists in particular just a more solid gut feeling for what a setup was like, than a therapist who is using all the modern technology like IMPAC, and record and verify, etc. which takes away some of the human fallibility, but it does it by taking away them doing it day after day. So, no one argues with the desire to minimize the chance of human error, but I do think that you do lose some degree of human participatory learning when you do so.

Dr. Anders described his observations of radiation therapists who no longer personally record information of treatment delivery. This process is done automatically by modern treatment systems. This is one aspect of information management that brings distance between the user and processes within the treatment room. This demonstrates one way modern technology brings distance between the user and treatment processes adding to the complexity of safety issues in radiation therapy. Dr. Anders proceeded to describe other aspects of automation that remove the radiation therapist from intimate involvement in treatment delivery reducing opportunities for learning.

*Summary for Working Memory: Not "in mind" Lost Over Time*

Removing processes (removing participation) that use and keep foundations of radiation therapy in working memory has the effect of removing elements from practice. Technology serves to reduce the paths radiation therapists take having the effect of reducing the established Knowledgeable Practice. Drawing from the principles of Situated Learning Theory, <u>if</u> it is true that full participation is a mediator for development of identity and practice, <u>then</u>, removing participation has the opposite outcome. I bring a deeper focus of this phenomenon through inductive analysis in chapter five.

## Summary of Findings for Research Question Number Two

**Research Question 2: The Info-structure. How does the layout and management of information facilitate or inhibit learning of modern treatment delivery?**

The aim of the analysis for sub question number two was to identify how the layout of information facilitates or inhibits learning of modern treatment delivery. The layout of information refers to how information exists, how it is used, and how it is shared. Radiation therapists exchange information as teaching moments present themselves when peers work together during real life work situations. Generally, the senior radiation therapist takes someone "under their wing." Processes that foster the flow of information to facilitate learning include cross training across departments and continuous rotation assignments to various facilities. Participants expressed a genuine desire to teach fully and completely while providing immediate, honest feedback citing serious consequences for the failure to teach fully. Double checking the computer treatment plan is the principle means of chain linking information and knowledge to all departments as a new treatment plan is routed for review and acceptance to all parties involved in the patient's treatment.

Aspects of new technology were viewed as introducing efficient processes, but eliminating certain practices that substitute thinking with automation. Through inductive reasoning, I suggest a long-term consequence of forming a practice that lacks foundational knowledge. Chapter five includes a detailed analysis of the decreased role of the practicing radiation therapist and of this knowledge appropriation by technology.

I did not identify any specific aspects of communication patterns inhibiting the sharing of information. However, I suggest that as respondents expressed that they depended on their co-worker to take them under their wing to really explain things in detail, the extent of learning for a new radiation therapist is depended on the willingness and desire of their colleague to teach fully – every time. Data obtained by the participants who are all senior radiation therapists expressed specific motivations to teach fully. This may vary greatly among staff based on personal motivations. Although my data is limited offering no clear evidence of this, this may be an inhibitor of information sharing not expressed by the participants interviewed.

Another possible factor to sharing information depends on the workload of the facility since all respondents reported that learning and training is mostly "on the job." As Michael expressed that, "training doesn't differ that much from treatment in that, we're doing it." I suggest that a new radiation therapist working at a busy facility treating many patients will have much more interaction with their seasoned partner and glean more from many experiences as compared to someone at a slow facility. This may also be a factor inhibiting sharing information that was not expressed by the participants interviewed. Activity and participation in treatment delivery is depended on patient load therefore staff at different facilities will have different learning experiences that include greater or less degrees of knowledge sharing among staff.

## The Info-culture

### Research Question 3: The Info-culture Level: How Does the Organizational Culture Encourage or Discourage Seeking and Sharing Information that Supports Learning?

**The broad research question of my study was:** How do radiation therapists learn new skills to develop a "knowledgeable practice" in a context of a highly technical environment?

Exploring aspects of the info-culture, informed the major research question by examining influences of the organizational culture upon the use of information. Understanding the organizational culture, defines constraints on knowledge and information sharing (Bressand & Distler, 1995, as cited in Pan, 1998). Schein defines organizational culture as "A pattern of shared basic assumptions that the group has learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think and feel in relation to those problems" (Schein, 1984, p. 3). In my analysis of the info-culture, I focused on the espoused values and beliefs of staff that motivated seeking and sharing information, or discouraged it.

The common statement regarding a strong value typically began with "Dr. Anders is really big on….." An important value regarded the holistic approach to patient treatment and taking a very personal interest in each patient; another was in regards to taking an ownership philosophy of the facility and operations. These values foster a motivation to learn expanding much wider than what a typical job description requires for a radiation therapist.

The "cross-over" among staff in this organization is action oriented, and driven by a philosophy of facility ownership. During interviews staff used terms that suggest ideals such as taking care of one's workplace like home; staff and patients are like family, and work is part of one's life and purpose. Gabriel even used the term "disciples" in regards to carrying out the vision of this organization. There are strong signs of self-determination among the staff that is action oriented and driven by these types of values. An overview of the findings and supporting data follow. Further interpretation based on theory is presented in chapter five. The findings are organized according to the following themes.

Theme Number 1: Taking Ownership: We Don't Do Just Radiation Therapy Here

Theme Number 2: Climate of Open Communication: They Will Answer You if You Question Them

Theme 3: Knowing Your Patient: The First Priority

Theme 4: Relationships and Trust

## Taking Ownership: We Don't Do Just Radiation Therapy Here

*An Overview*

The greatest motivation to learn grew from the personal agency the individual develops being required to manage an entire facility. This increases self-determination and also greatly extends the boundaries for experiential and participatory learning. Administrators in this study clearly had high expectations for staff to remain diligent in learning as much as possible on their own.

The sub themes in this section cluster around the aspects of taking responsibility, taking problems in your own hands as facility managers are expected to use all resources available. This was a significant factor for the personal agency I observed throughout our interviews. The sub themes were, (1) Don't Just Throw a Problem on Somebody's Feet and Walk Away; (2) We Don't Do Just Radiation Therapy Here; and (3) Taking Personal Responsibility. It was clear that radiation therapists try to work out their own problems, call upon their peers for assistance. It was also expressed by both the CEO and co-administrators that they welcome any concerns, but do expect staff to have proposed solutions in an attempt to work together towards solutions.

*Don't Just Throw a Problem on Somebody's Feet and Walk Away*

The expectation for all staff is that you work through a problem using the resources provided before approaching administration. During my conversation with Michael, co-administrator, he explained:

> If they're everyday occurrences, we want staff to just be able to fix things. If it's something simple like, "we're out of copy paper" I don't need to know that, just order the copy paper. We want people to take ownership, we really do…. we ask them, if you have a problem in this hand, when we talk, we really want you to have a proposed solution in this one. Don't just throw a problem in somebody's feet and walk away….And we want everyone, when they are in that feedback moment that you're talking about right now to give their best appraisals. Alright, don't just tell me what it is; tell me what you are doing to fix it.

Certain questions I asked radiation therapists were to triangulate the administrator's views and to see if they shared the same perspectives regarding taking ownership and "fixing things" as Michael expressed. Mary provided similar responses:

> We try to keep it pretty open. If there is a problem, we try to work it out ourselves, if that doesn't work we just go to the next step… Dr. Jones has always been very big expecting problem solvers. If you have a problem, he expects you will have possible solutions also. They are usually good about, "let's try that and if that doesn't work let's talk about something else.

Mary and James work at the Lost Pines facility in Bastrop. She has eleven years experience, James has only three. Mary expressed that:

> If we have machine problems we call an engineer. We go directly to the source to solve the problem…If I or James cannot handle something; I know there is someone I can go to. There is always someone in the infrastructure we can call for anything. There are very informal ways to solve problems. I usually simply email Michael, or call him and tell him that this is not working; it's not going to work. This is usually resolved very quickly.
>
> I feel blessed to learn from other people. I just said a moment ago, I think you should always continue to learn. I learn from patients, I learn from their spouses, I learn from colleagues, I learn from physicians, I learn from everybody. I learn from my kids and implement what I learn from them. I mean, I learn every day with an open mind and I enjoy that.

Dr. Anders expressed this expectation:

> The caveat that I'm known for is summarized as, I strongly encourage that you should always feel free to bring me your concerns. However, I do request that if you bring me a problem, that you also have with you, at least your best effort at a proposed solution. I have no patience for any staff member who brings me a problem and just stands there expectantly, with clearly no wheels turning in their mind because they are just idling, waiting for a solution to be handed to them. ....when you come to me with a problem, it's simply unacceptable for you not to

> give this enough thought, and have struggled with this just a bit and give me your shot at a solution.

The CEO and administrators expressed the clear message that staff is expected to utilize all resources addressing an issue on their own before taking it to the top. My interviews with Mary, Gabriel, Joseph, and Abram confirmed those expectations set down by administration as I triangulated interview responses.

*We Don't Do Just Radiation Therapy Here*

An organizational characteristic that extends the role of radiation therapists beyond the classic boundary of the treatment room provides unique opportunities for learning. Mary reported, "We don't do just radiation therapy here. This is a company-wide characteristic. We manage the entire facility."

Gabriel also linked his role with expectations across other departments expressing a larger view of his role than just being a radiation therapist in charge of treatment delivery only.

> We try to be more than therapists, or doctors, or nurses, or receptionists. We like our staff to be well rounded throughout the entire facility... if our nurse is unable to find something she can come to the therapist who should know exactly where to refer the nurse to, or simply take care of it. ... It might be as simple as sending them to somebody else.

When the radiation therapists spoke about their expanded role with limitless job duties they shared the same positive tone with a definite enthusiastic voice. I asked, “How can you be so positive about job demands with no limits?”

“I would be bored to tears if all we did was treating patients. This is a positive attribute to our job,” responded Mary. Similarly, Joseph related that, “the positive attribute comes from not depending on anyone to fix the problem.”

These types of responses revealed a motivating influence the radiation therapists held as they worked through the challenges of learning from their changing roles. Gabriel expressed,

> The job requires this because they want us to be incredible therapists and excel and we want to stand apart from other facilities. So, absolutely, the therapists should learn the ins and outs of every part of the facility from the treatment plan to the reception area.

When asking James, a radiation therapist who has only three years experience, the question, “how can you be so positive about job demands with no limitations?” he compared notes with the job duties of his recent fellow graduates reflecting on strength and personal values the job brings:

> I think it really helps us develop to be stronger. Our skills are not just limited to treatment. I talk with people who have graduated from my class who have a simulation tech, in-house engineers; they have aides, someone else to do this and that for them. All they do is treat all day and go home. Whereas, we’re putting

light bulbs in machines, and calling and talking to service reps ourselves about the machine, and doing all this other stuff. I think we are much more well-rounded learning simply by questions the service techs ask us and making us learn that which is usually outside the role of the radiation therapist. I figure that if we ever go somewhere else we have all this background and experience to work with.

The radiation therapists Mary, Gabriel, and Joseph as well as Abram, the chief physicist, expressed feelings of good will and personal acceptance to job duties beyond a typical job description for a radiation therapist. Abram gave his perspective of the radiation therapy group with the same sentiment that expressed personal agency more than meeting policy motivating action for carrying out many of the tasks not related to treatment delivery.

The responses I include in this section expressed personal enrichment and growth as a positive attribute to the responsibilities of their job. Gabriel's comment that, "they want us to be incredible therapists" and Mary's "I would be bored to tears if all we did was treating patients" expressed the goodness of fit between this group and the organizational philosophy of "ownership."

*Taking Personal Responsibility*

Mary related to this sense of ownership that included her sense of responsibility:

I think that in a way we have more ownership in our job. It is our job, but we take a lot of pride in it, we take personal care of it. It's your center and you want it

> to look nice, you want it to flow so you can't say, "oh that's not my job, I'm not doing that."

Comments from students who rotate through several other cancer centers also question the large difference observed in job duties as Mary explained:

> This is something that I hear students comment on all the time. They say that therapists never do these things in other centers. To this I say, "Well why wouldn't you? Do you want your patients to come to a dirty place? Would you bring your guests to a dirty home? I mean seriously, don't you want your center to look nice and clean? Would you leave dirt all over the front floor and walk right past it? I guess that this is something that we all take on as our own.

Also speaking of the very personal demeanor and sense of caretaking that goes beyond the typical staff of a cancer center, Abram commented that:

> Everyone here works to create their own environment. In your area you can control that where you can perform the best. We all have our own areas. The four facilities are a little different, but each place is set up by that group in their own style and where they can perform their best. All facilities have a personal, family feeling and the patients can tell that. No one forces staff or tells them that they have to have coffee that is fresh, or fresh baked cookies, but they themselves want that type of environment for their patients.

Data describing basic values hold the sense that this is “more than a job” and taking personal responsibility as Mary expressed taking a lot of pride and taking personal care of the facility comparing it to the condition of her home. Triangulating this from a member outside the radiation therapist group, Abram in physics referred to the autonomy among radiation therapists to create their own environment.

*Summary for Taking Ownership*

The ideals expressed in this section include having a partnership with Dr. Anders that includes ownership and much autonomy; developing strength through the experiences and changing roles that also serve as motivators to keep learning. My analysis begins with the view of administration who defines expectations of staff to remain diligent in learning as they take care of problems on their own. In terms of the characteristics defining the info-culture, addressing why and how expectations and values held by these individuals encourage seeking and sharing information to support learning, the global term used was “ownership.” Working with this image places the radiation therapists in a position accountable for all successes as well as failures. This provides great motivation for learning as they are the “first responders” to issues that occur within a facility. Analyzing further, this sense of ownership instills responsibility, charting new paths through problem solving, the need for more knowledge from which to draw from and utilize as participants resolve new issues both in and outside the realm of treatment delivery. Ultimately, this espoused value expands the accepted role and identity of the radiation therapist. I elaborate further in chapter five.

## Climate of Open Communication: They Will Answer You if You Question Them

### *An Overview*

Senior radiation therapists encourage peers to ask questions any time doubts arise from any treatment plan. For radiation therapists, this typically involves talking with a physician or a member of the physics department seeking clarification of a treatment plan. Radiation therapists are encouraged to ask questions without regard to status within the organization. There were two subthemes that expresses how staff feel about questioning others; (1) They want me to fix something or they want to bounce something off me; and (2) You need to explain this better to me. Why is this plan better than that plan?

### *They Want Me to Fix Something or They Want to Bounce Something Off Me*

During his interview, Michael, an administrator and respected radiation therapist took phone calls from staff, and he watched his email grow on his phone from several staff members. He made reference to them towards the end of the interview. These are some of the signs that demonstrated how members from different levels of the organization stay in touch with each other. During a visit at a different facility I observed personal interactions at a meeting to be "round table" type forums where everyone present had a voice as he conducted the meeting. During treatments, I observed casual discussions among radiation therapists standing by the operating console of the treatment machine during treatments. A radiation therapist occasionally stepped across the hall to spend a few minutes with Michael who was thumbing through mail, and then returned to the operating console.

Questions may be posed to administrators without concern when seeking improvements or to fix a problem. Michael shared his view that conveyed a comfort level in seeking his help or opinion.

> Because I'm their boss, most of the, almost all the time you know, they're usually just talking to me because they want me to fix something or they want to bounce something off me, or approval for something. I would say probably 80% of the time.

In a similar vein, Dr. Anders described a friendly environment expressing, "we like keeping fresh inquisitive younger people who haven't figured out you're not supposed to say this or that, or show this enthusiasm because it keeps everybody else on their toes."

Triangulating the views of the administrative levels, Abram, the physicist and radiation therapists expressed their ability to communicate freely with others. Mary recognizes the support at each level of the organization encouraging open communication:

> A big factor is the comfort level we have in each department as we are learning new things we continuously talk to each other, of the pros and cons. So, encouragement becomes as part of that as we hear the benefits of this new technique or product. We always want what's better for the patient. And when

> you do seriously question what you're doing, you know that here, you do have support to go to in any department.

These type responses conveyed and centered on simple, direct, face-to-face discussions that occur during the course of the work day.

*You Need To Explain This Better To Me. Why Is This Plan Better Than That Plan?*

Mary informs new hires of the open environment encouraging peers to question anything they do not understand or feel comfortable with:

> I'm talking about the physicians, the physicists, Dosimetry, everybody. Ask them to explain it to you, why are you doing this? I think this is very good that we are able to question things. I feel and I tell James, just being out of school not to be scared of those things. If you have a question, just go find out. They will answer you if you question them… ...because we have that comfort to be able to walk up to anyone; I think within our organization, I feel that this has helped our learning a lot. This has made us much stronger therapists.

Mary recalled that she frequently questioned the physics staff during a time of change and adjustment:

> As we got new dosimetry and physics staff; there were some changes in what we received, in the treatment plans. We were asking questions, things on planning like, "why is this a better plan?" We wanted them to explain it to us. I guess because we are not nervous in our departments at all, we know we're not there

> just to bring problems, but to try to understand better. We would freely go to them and say, "You need to explain this better to me, why is this plan better than that plan?"…. he will say something that I will not understand and I have to say, "You're going to have to change that, say it differently." So that was a little bit tough initially, but it's gotten a lot better.

Mary was comfortable with the freedom to cross departments and question staff. She was reassured that she could go back and continue asking until she understood the answer. Of special importance is her stern approach in repeatedly seeking an answer until she really understood.

*Summary for Open Communication*

Administrator, Michael described how staff tends to call him to get his opinion, or to fix something. I perceived that he was expressing that staff feel comfortable in calling him. Mary provided her views of the support she has experienced while questioning staff at various levels. The comments and views in this section describe a culture where staff is encouraged to ask questions of anyone regardless of position. In terms of the info-culture, this conveys a very encouraging environment for staff to seek information in their effort to learn.

## Knowing your Patient: The First Priority

*An Overview*

I report perspectives beginning with the views of the CEO, Dr. Anders who sets the expectation that radiation therapists will learn as much of the “soft data” as possible regarding the patient’s personal and family life. Radiation therapists as well as administrators provided their stories, observations, and pictures related to the philosophy of learning more of their patient in order to share celebrations as well as a few tears with them. According to Dr. Anders, this is to be rated as “the highest rating of importance and put a star by it.”

In terms of the info-culture, this demonstrated how radiation therapists accept and share the philosophy of “getting to know your patient” that instills motivation among them to spend time with patients, to record extra information, and to understand differences in their treatment plans. Mary claimed she would do this regardless of the organizational philosophy; she emphasized how learning more about her patients make them a bigger part of her own life. The subthemes for Knowing Your Patient were, (1) *Knowing the Soft Data; (2) Knowing the Treatment Plan.*

*Knowing the Soft Data*

Administration seeks qualities in candidates that may resonate with the organization’s values. It was expressed that good treatment skills are expected in candidates for hire, most candidates are equipped with such skills, but these special qualities of compassion are more difficult to find. “Knowing your patient” includes knowing aspects of the differences between patients, how and why the plans are designed a certain way, an understanding of differences of dose, and most importantly, a deep, personal understanding of the holistic patient and their family. This was reflected in Joseph's comments,

> Our company is very proactive coming from the top down. Dr. Anders' message is that we do everything. If you have down time, it's your job to go and talk to the family and learn more about them and the patient. He is very adamant about knowing the family. I think that there is a big social factor when it comes to therapy.
>
> That is something that our company asks a lot you know, what are their hobbies? What do they like to do? When is their birthday so we can celebrate their birthday with them? This part of care giving is something that is always reiterated repeatedly every time we have a staff meeting. Everyone in this family from the doctor, nurses, receptionist, to the therapists know that if you are not learning about your patient, about them as a person, you are not showing that you care about your patient at the level that we expect. You are probably not going to fit in this organization very well.

Gabriel, a radiation therapist, responded with similar feeling in his expressions:

> This is Dr. Anders' most important philosophy. His biggest thing is patient care. How can we make this a good experience for the family, the patient, and friends.... that's one thing that has always been embedded in us, "really know

> your patient before you meet them." I think that's a huge thing for the therapist to do, going into treatment knowing their history and physical, knowing that they are widowed and have seven great grandchildren is a key element in their daily treatment delivery. Too many therapists become immune and don't look into the patient and don't know who they are treating, why they are treating, what type of patient it is, or the things that the patient enjoys, the things that are really going to make a difference in these people's lives. For some, this becomes mostly a technical treatment and leaves out all personal approaches. The personal approach is what stands our clinic apart from the others. And I want the very best outcome for these patients and these families. I think figuring out how to deliver an absolutely incredible treatment, but at the same time make it the best experience for the family and the patient.

Knowing your patient is important to the "softer aspects of care" which is rated above all other jobs by administration. Dr. Anders, Joseph, Gabriel, and Mary all described this part of their job with deep commitment as a proverb that everyone works towards. While acknowledging that anyone who gets hired has good credentials for treatment delivery, but may lack other interpersonal skills, the focus in learning encourages taking a personal interest in your patient. As the quotes demonstrate this includes many aspects of the patient's life and family. Dr. Anders described the patient's "emotional world," the expectation for his radiation therapists is to share the patients' joys and celebrations, as well as the sharing of tears knowing the soft data. This describes part of the organization's culture that encourages radiation therapists to seek information as well as to share this information with one another. This supports learning the "softer data" of each patient.

*Knowing the Treatment Plan*

The treatment computer plan is a very detailed, report that includes patient anatomy, information of critical organs with their radiation dose, a graphic illustration of tumor volume, tables or charts such as histograms representing a distribution of radiation dose to certain organs and tissue. Knowledge of the report is rated highly by the organization which has taken steps to implement a procedure for "checking off' the plan as described in a previous section. This section reports the perspectives of three individual from top – down starting with the CEO of the value of this knowledge among radiation therapists. Triangulation of the data confirmed that this knowledge is highly valued knowledge for reasons described in this section. This organization-wide value motivates radiation therapists to seek this information before implementing the first treatment. A formal process for review serves to ensure "checking off" the plan.

Dr. Anders elaborated:

> I would rate the indirectly related learning like the learning about the treatment plan, or how it was created as high to the very next rung to the actual delivery of the treatment simply because, once again it's a bit like being able to teach something.

> The more you learn and the more knowledge you have about how the plan that you are implementing was created and what led to that, why was it done this way, and not that way, what was different about this patient versus that patient, why did the doctor choose to give this patient a higher dose, etc.
> None of this knowledge makes a bit a different regarding the activities on the machine like programming the console and setting the right angle, but the therapist that understands why that treatment is, what it is, will be superior to the therapist at the other facility who is simply doing it by rote with no deeper understanding than what button to press and what angle to set.

Mary also placed the highest priority in having knowledge of the treatment plan, in having a complete understanding of the treatment plan and why it was planned that way:

> When it comes to treatment delivery, I know that every patient is different, but once you learn the machine and equipment you don’t have to re-learn it again the next day, that’s like button pushing. Once you learn a treatment plan, you will then have to learn an entire new and different treatment plan with each patient and this is what directs how you treat, this aspect of treatment is very, very important. Unless you completely understand and know what you’re treating and why you’re treating it, do not beam on.

Knowing what button to press and how to program the treatment machine for each patient is an aspect of work for radiation therapists that is expected knowledge at minimum, but not sufficient as Dr. Anders, and all other participants explained during this and other aspects of this study that knowing the computer treatment plan is knowledge of the highest importance in caring for their patients.

### *Summary for Knowing your Patient*

The philosophy of making the patient the center of your professional existence in every respect echoed loudly and in many ways throughout the responses of the participants. A view from one perspective repeats throughout this study as Mary commented that the heavy focus on learning the new technology must not distract from the real purpose of learning this which is to provide good patient care.

Several responses led to a focus on the patient, so it is repeated in several sections from varying standpoints. It drives certain processes, personal motivations, as well as an organizational philosophy that is deeply embedded and expressed as a personal value among participants. Knowing your patient" includes knowing aspects of the differences between patients, how and why the plans are designed a certain way, an understanding of differences of dose, and most importantly, a deep, personal understanding of the holistic patient and their family.

## Relationships and Trust

### *An Overview*

This section provides the perspectives of trust while working with colleagues. Responses to several questions reflected a solid foundation of trust among the administrative group and the radiation therapists I interviewed. The four sub themes were, (1) You Have Your Disciples; (2) Administrators from the Ranks; (3) Hands-on People You Can Trust; (4) Partners Who Depend on You.

*You Have Your Disciples*

Gabriel provided insight of the core leadership within the organization from his perspective. He pointed out people working closely, who trust and believe in Dr. Anders. Gabriel expressed:

> In any organization you have your leadership. In this facility it is Dr. Anders to Gabriel, to Joseph, to Michael, to Dr. Lawson. He has key people on board with him who believe in his ideas, his dream, and his patient care. He looks to them to transfer his feelings to the rest of the staff so that his leadership truly reflects his character and philosophy of treatment. You have your disciples you know, your group that you trust, that you believe in, that believe in you and so I think that's the way he approaches it. He does like to have key people on board who he can talk to and communicate with who will then get it across to the entire staff.

Trust within this group seems to be built around very frequent communication with meetings lasting up to four hours at Dr. Anders' home or at a local coffee shop. Shared core values and characteristics run from the CEO, Dr. Anders from which these are rooted, through the co-administrators and shared with staff. Although I describe this path of communication, Dr. Anders often interacts with staff at all levels directly.

*Administrators from the Ranks*

Hiring administrative staff with strong radiation therapy backgrounds fosters good understanding between the technical and administrative views. Trust and confidence exists at the top level knowing that both co-administrators have a comprehensive understanding of issues and factors related to the operations within a radiation oncology department since both are radiation therapists with over twenty years' experience. This compares with other radiation oncology programs where top administrations have degrees in business administration with no background in radiation therapy. From the administrative perspective, Michael commented on the administrator's background that allows trustworthy decision making:

> The ownership, management, decision-making group in this corporation is made up of folks who have done it. And that makes a difference because people know they can't snow you, give you a lame explanation of something. If something needs to be addressed they need to give you the actual fact. The other side of that is that you truly understand if that really is a problem or not. Some things that an outside administrator would just say, "oh, just fix it just make it go away." We actually understand, "no that's really something that we need to address, that has to be taken care of" because we've actually done it before. And Dr. Anders saw that when he hired me three and a half years ago, and when we hired Peter last year. He knew that we needed hands-on people he could trust.

All administrative personnel from the CEO, physicians and administrators speak the same language having trained and been educated in radiation therapy. The core administrative group for the organization includes Dr. Anders, Michael, and Peter his co-administrators. Dr. Anders trusts the co-administrator's expertise. From Michael's perspective, their hire was based at least in part on their personal history and experience as radiation therapists working through the ranks toward s their current role in management.

*Hands-on People You Can Trust*

Close working relations are built on repeated interactions and communications to ensure understanding and treatment accuracy. The perspective of trust from the physics department comes from experience with radiation therapists who implement "their" treatment plan. With this in mind physics considers whether the radiation therapist is honestly working with the treatment plan seen as a product of the physics department.

Abram in physics provided his perspective of trusting the radiation therapists triangulating data provided by radiation therapists, Mary and Joseph:

> It's not that we have to wonder if we get an honest response, because what we feel, what they feel is just one right way to do it. Our job is very black and white, right or wrong. It works or it doesn't. And they feel good about it.
>
> We don't suggest a change in the way therapist do thing just to show that we are higher than they are. We know that's not our job. And they will suggest a change only after they look into it and bring much information including the benefit to the

> patient. We have to have trust in them and they have to have trust in you [the physics department]. And I think this is the best relationship we can achieve.

Joseph described a strong supportive relationship between the physics department and radiation therapists. This perspective of trust included phrases such as, “really protecting us,” “taking care of us,” “going up to bat” for us. Mary provided a similar perspective:

> In our company physics stay out of the treatment side of things. They’ve done the plans; they have checked the plans and know that plans are good. They then trust the therapist to follow the plan in the treatment delivery. They trust the therapists; they are not typically in the room telling therapists what to do. We continuously verify the treatment with port films and imaging, but dosimetry and physics are not usually in the room.

*Partners Who Depend on You*

Radiation Therapists described their job as, “working with your partners who depend on you,” they depend on each other, and patients depend on these partners for an accurate treatment.

Gabriel added to this by describing how partners must work closely with each other. He added, “From the patient’s perspective, the patient must work, and depend on both you.” Gabriel elaborated:

> This is a job that has multiple branches because you are not only dealing with the patient, but also with your partner. The patient deals with the two of you, or three or four on a daily basis. I think, first of all what's important is being an excellent therapist, being an excellent person. Coming to work and working very, very hard, but at the same time your team needs to be one and fluid and in the end this is a huge factor for the patient outcome.

I interpreted the perspectives as one with trust between partners, then one where the patient trusts the partners to do a good job.

*Summary for Relationships and Trust*

The core of administrators and supervisors referred to as "disciples" by one supervisor seem to share a level of trust based on their constant communication. The group maintains constant communication with Dr. Anders. It was expressed that these key people believe in his ideas, his dream, and his philosophy of patient care. He looks to their leadership to transfer his philosophy through the organization. A unique aspect of this organization stems from the administrative background growing from the ranks of radiation therapists. Radiation therapists who are administrators understand the issues and identify with staff. This fosters closer relations and trust from the heights of administration and doctors to the working staff. Stronger bonds were expressed between radiation therapists and the physics staff. It is perceived that good relations are built from repeated interactions and communication working towards understanding treatment plans and ensuring accurate treatment delivery. Both departments expressed high levels of trust in each other's work. Radiation therapists depend on each other as working partners to ensure an accurate treatment. Trust is of the utmost in regards to the exchange of information for treatment delivery.

## Summary of Findings for Research Question Number Three

**Research Question 3: The Info-culture Level: How Does the Organizational Culture Encourage or Discourage Seeking and Sharing Information that Supports Learning?**

The aim of the analysis for sub question number three was to examine influences of the organizational culture such as espoused values and beliefs of staff that motivate seeking and sharing information, or discourage it.

Administrators in this study clearly communicated high expectations for staff. This included aspects of knowing the differences between patients, how and why the plans are designed a certain way, an understanding of differences of dose, and most importantly, a deep, personal understanding of the holistic patient and their family. The radiation therapists expressed and demonstrated strong commitment to live up to administration's expectations, but self-determination and personally held philosophies were the true motivation expressed by them.

The climate of open communication facilitates questioning without regard to status and provides a degree of incentive to seek information any time questions and doubts arise regarding any aspect of treatment delivery. Radiation therapists expressed a strong level of trust towards administration, the physics department, and their peers regarding the exchange of information for treatment delivery. The first cancer center was founded on these principles working with a small core group. Today, these types of values and philosophies exist within facilities as most of the individuals of that small group work towards facilitating their future growth and development. The "disciples" as one participant put it, passed on deeply embedded values as the organization grew and expanded to the seven facilities of today. This was evident as participants frequently quoted Dr. Anders in their responses and referred back to a time when they worked as one team.

## Chapter Summary

The broad research question of my study was: How do radiation therapists learn new skills to develop a "knowledgeable practice" in a highly technical environment?

The chapter opens with an introduction and background information of the rationale for the study. The material then proceeds towards descriptions of the context and participants. Further description of the context and participants is found within responses for the sub questions in terms of three organizational levels for analysis; the infrastructure, the info-structure, and the info-culture.

The aim of the analysis for sub question number one was to determine aspects of the hardware and software that promote and inhibit learning of modern treatment delivery. The findings are organized according to two major themes with subthemes: (1) Systems of Communication: The IMPAC System. The sub themes were, (a) Replacing the "Sticky Pad" with Electronic Systems; (b) Obtaining Medical Records from other Facilities; (c) An Easy and Useful System; (d) The "Share Drive" and (2) Differences among Cancer Centers. Learning is promoted through using the same general layout of equipment and software at each facility. Network programs are used for medical records management, patient flow, treatment records, and as a record and verify system for treatment delivery. The two systems used by this organization are the IMPAC medical system and the Mosaiq medical system. Differences that exist among facilities create the demand to learn, but also serves to make learning difficult. The goal of cloning the setup at each facility is to facilitate learning and to reduce the learning curve as radiation therapists transfer from one site to another. However, the learning curve is extended when therapists face changes prolonging adaptation periods.

The aim of the analysis for sub question number two was to identify how the layout of information facilitates or inhibits learning of modern treatment delivery. The layout of information refers to how information exists, how it is used, and how it is shared. The findings are organized according to four major themes with subthemes: (1) Peer Teaching: Teaching the “ins and outs.” The subthemes were, (a) Teaching the “ins and outs in the Trenches”, (b) “Being Brutally Honest” as a Form of Feedback, (c) Cross Training: “Walk in Their Shoes.” (2) Rotation Assignments: We don’t let staff stagnate. The subthemes were, (a) Addressing Gaps in Foundational Skills; (b) Working with New People and New Setups; and (c) Perspectives on Transitioning from Old to New Equipment. (3) Signing Off: Routing the Treatment Plan. The subtheme was, Better Tools Means Better Knowledge. (4) Working Memory: Not “in mind” Lost Over Time. The subthemes were, (a) You Forget the Concept of Looking at the Patient; (b) A State of Awareness: You Really Have to Understand What’s Going On; (c) Deskilling: The

Impact of Long Term Use of New Technology. Exchanges and interactions occurring during on the job peer training provide encouragement, feedback, and direct, immediate communication. This was repeatedly described as the best way to teach and to learn radiation therapy. A formal aspect of the organization that fosters the sharing of information involves re-assigning radiation therapists to different facilities. Administration encourages staff to remain diligent with opportunities to work on different types of equipment. As a knowledge-sharing process of state of the art learning between staff at different skill levels, it cultivates a fertile environment for learning from each other, through mixing experiences and ideas.

The aim of the analysis for sub question number three was to examine influences of the organizational culture such as espoused values and beliefs of staff that motivate seeking and sharing information, or discourage it. The findings are organized according to four major themes with subthemes: (1) Taking Ownership: We Don't Do Just Radiation Therapy Here. The sub themes were, (a) Don't Just Throw a Problem on Somebody's Feet and Walk Away; (b) We Don't Do Just Radiation Therapy Here; and (c) Taking Personal Responsibility. (2) Climate of Open Communication: They Will Answer You if You Question Them. The subthemes were, (a) They want me to fix something or they want to bounce something off me; and (b) You need to explain this better to me. Why is this plan better than that plan? (3) Knowing Your Patient: The First Priority. The subthemes were, (a) Knowing the Soft Data; (b) Knowing the Treatment Plan,

(4) Relationships and Trust. The sub themes were, (a) You Have Your Disciples; (b) Administrators from the Ranks; (c) Hands-on People You Can Trust; (d) Partners Who Depend on You. Certain values and philosophies that are deeply embedded in staff at all levels within the organization are expressed repeatedly. One value is in regards to the holistic approach to patient treatment and taking a very personal interest in your patient. From the administrative perspective, responses clearly identified high expectations of comprehensive knowledge with depths that exceed the routine tasks of simply programming a treatment machine and delivering a treatment. This includes knowing aspects of the differences between patients, how and why the plans are designed a certain way, an understanding of differences of dose, and most importantly, a deep, personal understanding of the holistic patient and their family.

As respondents expressed that they depended on their co-worker to take them under their wing to really explain things in detail, the extent of learning for a new radiation therapist is depended on the willingness and desire of their colleague to teach fully – every time. This may vary greatly among staff based on personal motivations. Although my data is limited offering no clear evidence of this, this may be an inhibitor of information sharing not expressed by the participants interviewed.

Another possible factor to sharing information depends on the workload of the facility since all respondents reported that learning and training is mostly “on the job.” Activity and participation in treatment delivery is depended on patient load therefore staff at different facilities will have different learning experiences that include greater or less degrees of knowledge sharing among staff. A new radiation therapist working at a busy facility treating many patients will have much more interaction with their seasoned partner and glean more from many experiences as compared to someone at a slow facility. A last factor perceived to inhibit learning involves specific work processes that have become limited within the modern scope of practice. Aspects of new technology were viewed as introducing efficient processes, but eliminating certain practices that substitute thinking with automation. A more detailed analysis of this perspective is presented in chapter five.

# CHAPTER FIVE

# INTERPRETATION

## Introduction

Data in chapter four provide rich information that explains how radiation therapists use information to support learning in a highly technical environment. The chapter provides descriptions of the organization's infrastructure, info-structure and info-culture that encourages and discourages seeking and sharing information. Chapter five provides a specific focus to experiences, perspectives, and statements that were made by radiation therapists and the administrators in this study regarding situational influences that impact knowledgeable practice. In this chapter I attempt to show how contextual influences may work towards the long term loss of knowledge.

The perspectives include experiences described by Joseph, a radiation therapist with eight years of experience; Gabriel, a radiation therapist with five years of experience; and Dr. Anders, the radiation oncologist and CEO of the organization. These provided important insights about radiation therapists' preparedness to return to work with older equipment after working in a technology-centered facility. The perspectives are personal accounts of stepping into a different treatment environment and realizing their lack of preparedness and a loss in retention of foundational concepts. This struggle to recall and to re-learn aspects of treatment during re-assignments may be viewed as a normal process of adapting to a different setting. Related to this study, these personal experiences describe a direct impact on maintaining and holding on to a knowledgeable practice. Knowledgeable practice is the development of aptitude through practice with manual and mental involvement. The term was introduced in chapter one and defined fully in chapter two, and it will be described again as part of my argument later in this chapter.

The chapter begins with a brief summary of relevant literature providing a socio-technical perspective to build the construct of knowledge appropriation. I then provide direct parallels of study data with principles of situated learning that foster development and growth. Drawing from the principles of Situated Learning Theory, if it is true that full participation is a mediator for development of identity and practice, then, removing participation has the opposite outcome. The chapter proceeds with propositions to support this argument using data from the case study and findings from a workflow cross analysis from pre and post technology treatment delivery.

## Relevant Socio-Technical Perspectives

### *Technical Socialization*

The literature on socio-technical systems express that the characteristics of socio-technical relations evolve and change. Every invention is an *intervention* to nature and society. This is why technical development is equivalent to social change influencing group culture.

Technical products may incorporate functions which originally had been personal human abilities, knowledge and intentions. Types of functions and qualities from individual persons are externalized and *objectified* in the technical system, generalized beyond the individuals. In sociology, the term, *institutionalization* refers to this process of trans-individual generalization of value and behavior patterns into a community. Similarly, from a socio-technical view, a community using and learning more technological functions and gaining technical development incurs a process understood as *technical institutionalization* (Ropohl, 1999).

*Institutions*, in an abstract sense, channel and shape the behavior of the individuals, and integrate them into a common culture, an effect called *socialization*. Formerly, this happened mainly through human, group interaction and communication, but in today's organizations, such things as technical products, tools, and social network systems exhibit the same socialization ability. When viewed from the socio-technical system, technical products extend their institutional power to the individuals engaged in their use. This is referred to as *technical socialization*.

Common aspects where behavior patterns have been shaped by new technology creating a changed culture may be seen in our modern society. A common example is the use of one-touch calling cell phones, the development of texting from *smart* phones, and global positioning systems, along with other automated, one-step processes afforded by these types of mobile technology. In terms of radiation treatment delivery, the emergence of "auto setup" offers the automatic functionality of simultaneously setting the gantry angle, collimator setting, collimator angle, table setting, and automatic blocking with a single button.

*Knowledge Appropriation*

What may eventually become lost from the user's memory is what has been internalized within the technologies. This may include relevant phone numbers, physical mailing addresses, etc. The problem with technology is that you become dependent upon it and if it ever disappears for a reason as mundane as a lost mobile phone, or as serious as a corrupt computer file, or something as dramatic as a terrorist attack on the infrastructure of the internet, we are suddenly paralyzed as individuals or as a society.

What was transmitted by human communication before the *smart* phone is internalized through the appropriation of information and processes. From a socio-cultural point of view, appropriation is defined as the process of taking something that belongs to others and making it one's own (Morch, 2009, Wertsch, 1998). The *technical* subsystem does not risk any losses through the extension of its power; however an actual transfer of power occurs, in my view, from the *human* subsystem through a loss of conceptual knowledge over time. Although the human subsystem has incurred a technical socialization with enriched communication, collaboration and productivity, this view suggests that while benefiting from the technology, the human subsystem may incur a loss of original abilities.

As a very simple example, everyone who owns a calculator is able to extract the square root of any number, even if he or she has never learned the respective math. Even without the knowledge of the relations between sets of numerical functions and a clear understanding of the relation between square root and exponential functions, individuals can obtain an immediate answer without ever "knowing" the processes leading to that answer (Ropohl, 1999). This view fully supports Polanyi's philosophy as described previously in chapter two on subsidiary awareness. Less skilled individuals are not able to articulate to others why what we do works, but can explain how to operate the instrument or the machine fully (Polanyi, 1958, as cited by Grant, 2007).

*Knowledge Appropriation and the Loss of Foundations of Knowledge*

My synthesis of a new theory based on these concepts is applied to radiation therapy. What is significant to note is that appropriation has been defined as "the process of taking something that belongs to others and making it one's own" (Morch, 2009 and Wertsch, 1998). I argue in this chapter that knowledge appropriation is a process of deskilling, where foundations of knowledge are lost during long term use of new technologies without connecting foundational concepts. Based on the sociology concepts just presented, users incur a technical socialization with enriched productivity, benefiting from the technology. However, patterns of behavior and observations supported by the literature (Bravermann, 1974; Donahue, 1995; and Rinard, 1996) suggest that users also incur a loss of original abilities. In sections that follow, I draw parallels between my study data, and existing theory to build the argument that what is internalized within the automated process is lost from the user's memory. This is similar to using "speed dial" for phone numbers that were once dialed one key at a time. I build this conceptual framework as it applies to radiation therapy claiming that what is not maintained in working memory through manual and mental connections is lost.

Knowledge appropriation occurs as a gradual shift over a period of time where the radiation therapist uses new automation with inherent processes as replacements for tasks such as inserting the shielding block in the case with multi-leaf collimation. Through the elimination of that one process, other processes such as walking into the room between treatments to change blocks are forfeited. Also gone with this are practices to check and verify, or to communicate with the patient intermittently during a treatment. This also eliminates opportunities to personally visualize aspects of treatment such as beam orientation and collimator settings. The radiation therapist now views graphic animation of a collimator on a computer display on the control console.

## The Values of Ownership and Responsibility from a Situated Learning Perspective

Situated learning has three primary principles. The first two are (1) Levels of *participation* are motivated by personal values and beliefs and (2) Increased participation within a social community leads to acceptance of new and changing roles. These new roles lead to changing *identities* within the social setting. Lave and Wegener links this role definition with *Identity* as also defining who we are within a community.

The third principle is (3) New *Practices* are formed during problem solving, within situated influences and engaged in contexts of learning. New processes addressing the situated contexts are adopted as routine procedure, as *Practice* for the community or group. Chapter four includes themes from interview data that reflect growth and development as the radiation therapists for this organization assume the values of "Ownership" and "Responsibility" using these principles of situated learning.

These are positive attributes as so-called "Junior Rangers" in this organization are mentored to become "Facility Managers." Figures 5 – 7 depict how this relates specifically to "Junior Rangers" within this organization.

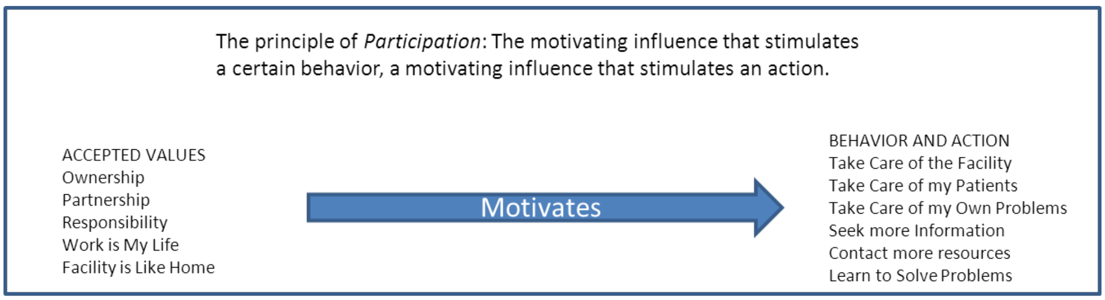



*Figure 5.* The relationship between values and action based response

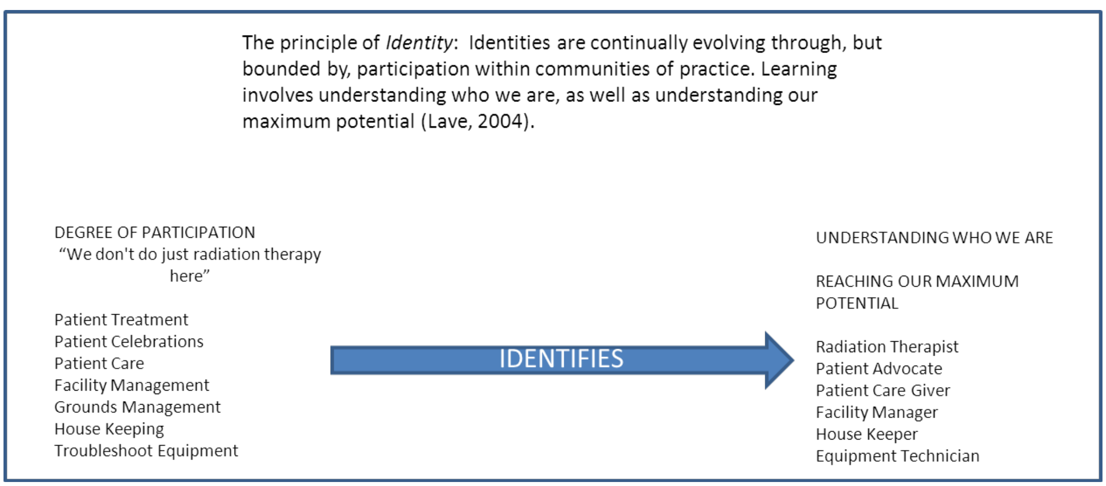



*Figure 6.* The relationship between participation and our maximum potential.

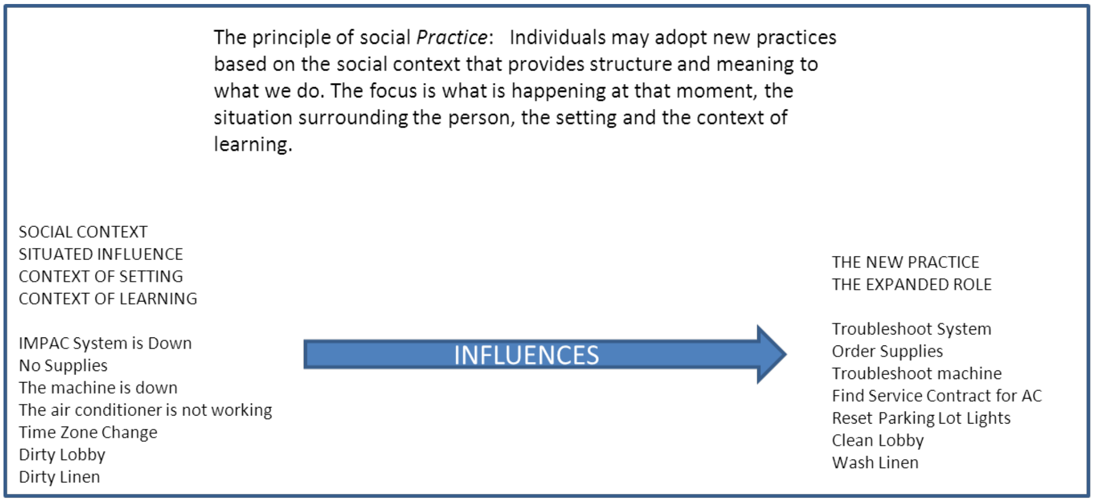


*Figure 7.* The relationship between situated influence and role expansion.

When the IMPAC system goes down this is addressed by the facility manager who is expected to be the "first responder." The facility manager holds a personal commitment to his or her role with expectations by his or her group to engage in some action as "facility manager" when required. His or her role is defined by both the situated context, what is happening at the time, as well as his or her social identity within the group. Lave and Wenger (1991) and Ibarra (1991) refer to role definition and identity based on social influences. Individuals may try out new roles and identities by experimenting with practices typically associated with the identities they aspire to. Wegener refers to "social" practice related to role, identity, and levels of participation from the social learning perspective. *Social* practice is one where individuals may adopt or transform new practices based on the social context that provides structure and meaning to what we do. Through participation, "new comers" gradually assemble an idea of what constitutes the practices of the community (Lave & Wenger, 1991). *Professional* practice is where one is required to extend knowledge and skills within a practical environment (The National Association of Colleges and Employers). As the radiation therapist troubleshoots the system based on his or her accepted role as "facility manager," they expand the practice of the radiation therapist / facility manager. The facility manager engages in action as called for by the social role; the manager seeks and establishes processes that address the situation; through repeated participation, the manager extends the knowledge and skills for the role of the radiation therapist; the manager adopts new processes as routine procedure, as *Practice* for the community. Figure 7 integrates the experiences expressed by participants in my study with the construct of *Practice*.

## Removing Participation: Shrinking Practices, Shrinking Role, Reduced Working Pathways, Reduced Working Memory

Drawing from the principles of Situated Learning Theory, if it is true that full participation is a mediator for development of identity and practice, then, removing participation has the opposite outcome. Guided by principles of Situated Learning Theory, I argue that situated learning within the context of modern technology for prolonged periods leads to deskilling. I argue that shrinking roles due to automation eventually shifts knowledge away from working memory.

Technology-centered treatment builds a new practice, void of the "knowing element" I described previously as "knowing why," as much as "knowing how" (Polanyi, 1958). This case study triangulated the recognition of deskilling within the organization through the perspectives and shared experiences of radiation therapists, as well as the

CEO, and supervisors as described in chapter four. Based on Situated Learning Theory, I argue that without administrative intervention to reinforce foundations of knowledge, this leads to diminished levels of a "knowledgeable practice." Removing processes (removing Participation) that use and keep foundations of radiation therapy in working memory has the effect of removing routine procedures that were once the norm within most departments (the Practice). Viewing an automated process through a display screen as an animation has the negative effect of establishing a new norm, a new practice with limited processes, procedures, or steps. In this way, technology serves to reduce the paths radiation therapists take, thereby having the effect of reducing knowledgeable practice as steps and processes dissipate.

Knowledgeable Practice refers to the development of aptitude through practice with manual and mental involvement. It is not just dexterity, but an appropriate response to unexpected circumstances and the element of control (CSS, 1981, p. 41, as cited in Parnell, 2006). Knowledgeable practice keeps foundational knowledge in "working memory" during manual and mental involvement.

Knowledge is appropriated by practices of modern treatment technology. As experiences using contemporary devices have shown, what has been internalized by technology becomes lost from the user's memory. The loss of conceptual knowledge is internalized through the appropriation of information and processes. I have attempted to identify specific points, facts and elements that contribute toward the loss of knowledgeable practice. This is important because it is within these practices where foundations of knowledge were rehearsed. Study data show that radiation therapists have experienced losses of working memory. Radiation therapy includes modern practices that remove or bring distance between radiation therapists and the treatment process. This further exacerbates potential loss of foundational treatment knowledge "in mind." Study data supports that as practices continue to shift toward automation, required skills focus more on "operator skills" and less on "therapy skills." Radiation therapists depend on control area displays representing internalized processes and information as they view treatment processes from outside the treatment room. Interview data identified that radiation therapists may depend on technology to direct their action as with record and verify systems replacing individual thinking. No stronger evidence has been documented as to the focus of attention migrating away from the treatment process than two recent fatal cases (Bogdanich, Radiation offers new cures and ways to do harm, *The New York Times*, January 24, 2010). If knowledgeable practice means development with mental and manual involvement, then, technology has gained these types of characteristics while radiation therapists have demonstrated a loss and dependence.

The data is consistent with the literature presented on deskilling observed in other professions and industries. What follows are propositions based on my study data and findings. A task analysis for radiation therapy treatment procedures was published in *Principles and Practice of Radiation Therapy* (Washington & Leaver, 2010). Informed with data of my study, I conducted a cross analysis of previously documented work flow processes and procedures. The original listing of processes provided excellent material for a pre and postmodern technology cross analysis. The cross analysis identified processes that are no longer suited for modern practices; it also helped to identify specific factors that I use for my argument. This can be found in appendix G. Figure 8 illustrates a comparison of original tasks performed during treatment delivery with new tasks reflecting the new treatment environment.

## Propositions Based on Study Data

### Radiation Therapists Incur a Reduction in Knowledgeable Practice

Proposition 1.0: Automation and technology impose limitations on working memory.

Proposition 2.0: Automation and technology reduce the radiation therapist's intimate involvement in treatment delivery thereby reducing pathways and processes.

Proposition 3.0: Foundations of knowledge are lost with decreasing practice; Mental and manual connections are overshadowed by technology.

Proposition 1.0: Automation and Technology impose limitations on working memory.

1.1 Upon returning to a manual environment, without computerized safeguards, the radiation therapist experienced a transitional period, realizing that gaps had developed within patterns of thinking. Changing patterns of thinking were described leading to reduced states of awareness and readiness.

1.2 I make the relation of this observation and the concept of working memory. Repeat use of information keeps information in working memory where it can be accessed as part of comprehension and problem-solving. Elements of information not used repeatedly, or not kept "in mind" are lost over time. As a result, radiation therapists may seem disorganized and unprepared upon demands that require the instant recall of information that has been lost.

1.3 Radiation therapists provided personal accounts of stepping into a different treatment environment and realizing their lack of preparedness and a loss in retention of foundational concepts. This struggle to recall and to re-learn aspects of treatment during re-assignments may be viewed as a normal process of adapting to a different setting. The personal experiences described issues of maintaining and holding on to a working memory contributing to loss of knowledgeable practice.

Proposition 2.0: Automation and technology reduce the radiation therapist's intimate involvement in treatment delivery by eliminating human processes related to treatment.

2.1 Dr. Anders described his observations of radiation therapists who no longer personally record information of treatment delivery. This process is done automatically by modern treatment systems. This demonstrates one way modern technology brings distance between the user and treatment processes adding to the complexity of safety issues in radiation therapy.

2.2 Comparing modern tasks and processes directly with previously documented tasks show areas where the radiation therapist has been removed from the actual treatment process, eliminating opportunity to visualize aspects of the treatment. The process also removes the radiation therapist from the room as compared to previous periods of walking in to check on the patient during treatment (between fields), to check patient alignment, and to provide reassurance. These aspects of involvement are not evident with conformal and IMRT radiation therapy treatment as they were with previous treatment delivery techniques.

2.3 Differences between pre and post technology treatment processes include the loss of steps in processes and other aspects that permit less human interaction with the patient on the table.

- Patients are highly immobilized with special devices. Moving and speaking is somewhat limited hindering communication as compared to previous processes.
- Conformal radiation therapy facilitates treatment delivery with a continuous, non-stop progression from the first to the last treatment field. Radiation therapists typically do not enter the room to verify visually once the treatments begin. This serves to further separate the user from the treatment process because the user never visually confirms by entering the treatment room therefore may not think about the connection between what is displayed on the control screen and what is actually occurring with the patient in the room.
- Conformal radiation therapy and IMRT may involve dynamic therapy with moving collimator leaves as the beam travels around the patient. Radiation therapists may observe animation of the "fluence patterns" of leaves on the treatment console display outside the treatment room. Originally, the task required setting each beam angle by rotating the gantry and collimator manually for each prescribed beam position.

- The pre-modern process required staff to position the “beam shaping accessories,” to insert the blocks and to personally check each “field.” It included taking the appropriate “portal verification procedure” or the port film for each field being treated. Modern treatment machines use automated multi-leaf collimators for conformal radiation therapy and for IMRT. An electronic imaging device has replaced walking into the room to take the verification film. All fields may be treated without the radiation therapist entering the room between treatment fields.
- Another example where a new process replaces the radiation therapist specifically to reduce error involves the use of bar-code readers on the treatment control console to call up the correct patient record for treatment. A reduction in treatment error due to calling up the wrong patient record was achieved by requiring the patient to scan his own patient ID card across a bar-code reader instead of allowing the radiation therapist to search and call up the correct patient chart on the machine computer (Ford, 2009).

2.4 Removing processes (removing *Participation*) that use and keep foundations of radiation therapy in working memory has the effect of removing elements from *Practice*. Viewing an animated process through a display screen outside the treatment room instead of carrying out that process personally; shielding blocks forming automatically; patients calling up their own record remove processes from the scope of practice for the radiation therapist. Technology serves to reduce the paths taken by eliminating processes for radiation therapists thereby having the effect of reducing the knowledge related to that practice.

<u>Proposition 3.0</u>: Foundations of knowledge are lost with decreasing practice; Mental and manual connections are overshadowed by technology.

3.1 Foundational knowledge for radiation therapy includes the basic principles for treatment delivery. One may view these as beginning with the simple, but critically important task of positioning the patient appropriately for the intended treatment and using correct devices and machine settings for a particular patient. These include principles that form the fundamental steps in delivering an accurate treatment. These are very "tactile" processes for the practice of radiation therapy requiring a degree of cognitive thought processes, and the ability to make mental connections drawn from the foundations of treatment knowledge. Joseph referred to, "the concept of looking at the patient and the logic between the wedge heel and the contour of the breast."

Appropriation of this foundational knowledge begins with the loss of this heightened sense of "focal" awareness. Blocking and collimator settings with modern multi-leaf collimation technology are designed to be set by the machine when the user calls up the appropriate page on the computer for that patient. One may have to press "auto setup" to also set the gantry angle, and couch angle if necessary. This removes the user from having to set the jaw size (collimator size) then insert a customized shielding block. Repeatedly removing this as an "on-task" part of the treatment eventually removes other associated concepts and principles linked to the treatment rationale. Having to set the correct machine settings from within the room and viewing the setup from the patient's perspective allows conceptualization of the treatment scheme and treatment design rehearsing these important concepts of why the beam is angled to the right for instance or why the heel on the wedge is placed up in reference to the patient's breast. Long periods of no recall results in diminishing thought processes and eventually remove elements from working memory. With those elements, important related foundational concepts are lost.

3.2 Figure 7 of my cross analysis in appendix G emphasizes the multiple human interfaces competing for the radiation therapist's attention. Documented cases has shown that it is in this type environment where radiation therapists have failed to read critical messages being displayed regarding wedge orientation; they have also failed to recognize and act upon a graphic illustration alerting of totally open collimators yielding fatal doses of radiation. The two errors had fatal consequences for patients. For the Jn-Charles case, the message, "Wedge Out" was missed for twenty eight treatments resulting in irreparable injuries leading to her death. Mr. Jerome-Parks also incurred fatal injuries (Bogdanich, Radiation offers new cures and ways to do harm, *The New York Times*, January 24, 2010). I emphasize that in some cases, despite the magnitude of information in sight, the focus of attention migrates away from the patient, or the treatment process. This case documented the manifestation of a "subsidiary" awareness, with a diminished manual and mental involvement.

3.3 IMPAC is a system designed to record each treatment and to verify that the radiation therapist set the machine properly. The concept of the record and verify system was to “check” the actions of the radiation therapist who was to utilize charted information as well as their own reasoning and discernment for treatment delivery. Staff tends to use that information system more and more to direct their actions, leaving out reasoning and concepts behind treatment rationale. Staff simply set what is seen on a screen, taking that as absolute, following its lead. This system, when used this way, inhibits thinking and recall of foundational information. One participant’s response confirms my argument as he stated, “IMPAC is a wonderful tool to help make sure that treatment is always delivered correctly. But it also lessens your skills because you are not thinking as much for every field as to what needs to be done.” Another participant spoke of suddenly working without the system, “[When not using a record and verify system] I have to really know what I am doing without systems checking behind me. I have to recognize the red flags myself…”

3.4 The study data suggest that practices as described result in using dissipating levels of foundational knowledge. Radiation therapists use less of their own personal discernment and allow technology to direct action.

Task Analysis of Treatment Procedure

1. Review the chart (paper or e chart)
2. Prepare the room. Position immobilization devices on the treatment table and place treatment accessories within reach.
3. Greet and identify the patient.
4. Assist the patient onto the treatment table and into **the prescribed position.**
5. **Locate the surface landmarks.**
6. **Raise the couch, bringing the area to be treated to the beam area.**
7. Refine the patient position relative to the isocenter using lasers, field light, and surface landmarks. Perform setup verification procedures if required for treatment technique.
8. **Rotate gantry and collimator to prescribed positions.**
9. **Position beam shaping accessories (blocks) and visually verify using the light field.** Perform portal verification procedures if required by treatment technique.
10. Position beam modifiers (wedge, compensator, bolus).
11. **Inform patient that you are leaving and treatment will begin.**
12. **Monitor the patient (room camera, audio system).**
13. Set appropriate machine controls and review correspondence with prescribed values in the record and verification system.
14. Initiate beam-on. Monitor the patient and equipment function. When multiple fields are to be treated, do the following:
15. Validate parameters downloaded to accelerator and enable accelerator motion, **or enter the room and check the patient, field position, and beam modifiers.**
16. **Repeat steps 8 through 14 for all fields until the completion of treatment.**
17. Assist the patient from the couch and room.
18. Complete the treatment record.

Coleman, A. (2010). Chapter 33 Treatment Procedures. In C.M. Washington, & D.T. Leaver (Eds.), Principles and practice of radiation therapy: Practical applications 3rd edition. St. Louis, Mo: Mosby-Year Book Inc.

Task Analysis of Treatment Procedure Based on Multi-Leaf Collimation and Automation of Technology

1. Review the chart (paper or e chart)
2. Prepare the room. Position immobilization devices on the treatment table and place treatment accessories within reach.
3. Greet and identify the patient.
4. ***Adjust appropriate immobilization device base frame to table. Match the positioning indexing data recorded on the e-chart and device for proper placement to achieve coincidence of the base frame / table coordinates. This ensures proper placement of the immobilization base frame upon the table.***
5. Assist the patient onto the treatment table and into the prescribed position ***using immobilization device(s).***
6. ***Locate the reference indexing data on immobilization device. Match the positioning indexing data recorded on the e-chart and device for proper placement to achieve coincidence of the device / table coordinates. This ensures proper placement of the patient within the immobilization device now connected to the table.***
7. Raise the table, to ***the level of the isocenter referencing the lateral and vertical digital readouts of the record and verify system viewed on the computer screen inside the treatment room. Verify proper table rotational angle or set at "zero".***
8. ***Verify*** the patient position relative to the isocenter using lasers, field light, and surface landmarks ***and other data if possible***. Perform ***other*** setup verification procedures if required for treatment technique ***QA policy***.
9. Rotate gantry and collimator to prescribed ***position for initial beam entrance from which the machine gantry will travel to deliver multiple beams for planned angles for IMRT or press "auto setup".***
10. Inform patient that you are leaving and treatment will begin.
11. Monitor the patient ***(room camera, audio system).***
12. Set appropriate machine controls and review correspondence with prescribed values in the record and verification system.
13. Validate parameters downloaded to accelerator ***for multiple fields according to treatment technique QA policy*** and enable accelerator motion.
14. Initiate beam-on. Monitor the patient and equipment function
15. ***Visually verify the "fluence patterns" of the mulit-leaf collimators on the machine console computer screen.*** Perform portal verification procedures ***with the Electronic Portal Imaging Device (EPID)*** if required by treatment technique ***"send" to doctor for electronic approval as per department policy.***
16. Position beam modifiers (wedge, compensator, bolus) ***between treatment fields and/or visually verify the (dynamic) wedge orientation with the graphics or text on the machine console computer screen.***
17. Assist the patient from the couch and room.
18. Complete the treatment record.

Revised from: Coleman, A. (2010). Chapter 33 Treatment Procedures. In C.M. Washington, & D.T. Leaver (Eds.), Principles and practice of radiation therapy: Practical applications 3rd edition. St. Louis, Mo: Mosby-Year Book Inc.

*Figure 8.* New Task Analysis for Treatment Procedure Based on Automated Technology.

## Chapter Summary

A new premise of knowledge appropriation as a theory of deskilling is presented. I build a conceptual framework as it applies to radiation therapy claiming that what is not maintained in working memory through manual and mental connections is lost.

The chapter presents relevant literature to support and build the construct of knowledge appropriation. Appropriation occurs as a gradual shift over a period of time where the radiation therapist uses technology, adopting new automation with inherent processes that replace tasks such as inserting the shielding block. Through the elimination of one process, other processes such as walking into the room between treatments to change blocks are forfeited. I proceed with an interpretation of the situated contexts of the study participants that led to an expansion of their role and the practice within the organization. Conversely, I articulated the perspective of deskilling due to reduced participation; a shrinking role, reduced working pathways and a shrinking practice in relation to modern treatment practices. Having defined "knowledgeable practice," the rest of the chapter is dedicated to propositions building the argument that the practice of modern treatment technology leads to a reduction of knowledgeable practice.

Removing processes that use and keep foundations of radiation therapy in working memory has the effect of removing elements from practices. Technology serves to reduce the paths radiation therapists take thereby having the effect of reducing the established knowledgeable practice. Shrinking levels of foundational knowledge are a result of modern treatment practice, as it is replaced by operating skill over time as a result of technology integration.

# CHAPTER SIX

# CONCLUSION

## Introduction

The goal for this study was to examine how radiation therapists learn new skills as they adopt new technologies for treatment delivery. I attempt to inform the problem of treatment error using a supporting body of literature and by making the case that aspects of practice using newer technology bears the cost of deskilling. I use the concept of "knowledgeable practice" established by The Council for Science and Society. Knowledgeable Practice refers to the development of aptitude through practice with manual and mental involvement. It is not just dexterity, but an appropriate response to unexpected circumstances and the element of control (CSS, 1981, p. 41, as cited in Parnell, 2006). Knowledgeable practice keeps foundational knowledge in "working memory" during manual and mental involvement.

This study used a socio-technical frame providing structure to my research and data analysis according to the multi-layers of socio-technical systems. Using qualitative research, the strategy of inquiry was that of an exploratory case study, approaching the study from a critical perspective, and a constructivist epistemology. The case on which this research focused was a radiation therapy organization with details of one particular center. The responses reported in chapter four offer an in-depth examination of the infrastructure, relating to hardware and software; the info-structure relating to the flow and management of information; and the info-culture relating to the cultural influences upon seeking and providing information to support learning. My interpretation of the data, based on Situated Learning Theory describes the growth and development of "Junior Rangers" within the organization. The same principles provide the framework to describe linkage between the removal of processes (participation), the loss of a practice for the profession linked with diminishing boundaries to develop maximum potential for the role of the radiation therapist. I compare the loss of participation with the emergence of a treatment delivery with a limited knowledgeable practice. Resting on modern socio-technical literature describing perspectives of technical socialization, and a review of the literature across various industries, I conclude with the argument of the loss of foundational knowledge through a process of "knowledge appropriation." Foundational radiation therapy knowledge is appropriated by technology and replaced with the knowledge required to operate the new equipment and technology.

## Summary of Findings

The organization sets up all facilities using the same general layout of equipment and software. Network programs are used for medical records management, patient flow, treatment records, and as a record and verify system for treatment delivery. The two systems used by this organization are the IMPAC medical system and the Mosaiq medical system. An important factor for this organization that spurred an interest in electronic networks and connectivity was the continued rate of expansion and growth. The need to develop a network by which all departments could communicate and share records grew as the organization continued to open sites in different cities. The electronic medical record (EMR) linking all facilities through fiber optics deliver all of the types of information needed to all sites. This facilitated, improved, and streamlined data transfer and access to a large data base. Continued growth for the organization led to acquiring modern state-of-the-art treatment equipment with additional components and software programs.

The facilities are located in different cities. Despite effort to construct similar centers by cloning the infrastructures, changes occur over time due to varying doctor preferences for different treatment techniques, treatment accessories, and requests for new equipment. While increasing the learning curve for some, these differences among facilities stimulate a demand for learning new or different equipment. The organization prevents the radiation therapy staff from growing stale and complacent by using the geographic locations of facilities and their differences as a "natural training ground." In this respect the geographic separation of the facilities and their differences promote learning.

Exchanges and interactions occurring during on-the-job peer training provide radiation therapists encouragement, feedback, and direct, immediate communication. Several of the therapists I interviewed repeatedly described these communications as the best way to teach and to learn radiation therapy. Respondents expressed that they depended on their co-worker to take them under their wing to really explain things in detail. The three radiation therapists, Mary, Gabriel, and Joseph, as well as Abram, the chief physicist expressed specific motivations to teach fully noting consequences if they did not.

Since all respondents reported that learning and training is “mostly on the job,” I suggest that a new radiation therapist working at a busy facility treating many patients will have much more interaction with their seasoned partner and glean more from many experiences as compared to someone at a slow facility. Activity and participation in treatment delivery depends on how many patients have been scheduled for treatment. Staff at different facilities will have different learning experiences with greater or less degrees of knowledge sharing among staff based on patient load.

Administration and senior staff implement rotating schedules to stimulate interest and motivation for staff to “keep on their toes.” One aspect of the organization that fosters the sharing of information involves re-assigning radiation therapists to different facilities. Radiation therapists with different skill levels cultivate a fertile environment for learning from each other, through mixing experiences and ideas. Through assigned rotations, administration encourages staff to remain diligent with opportunities to work on different types of equipment. Radiation therapists work with new partners, on different equipment, and learn different treatment techniques as a result. The organization addresses gaps in awareness and learning in terms of these re-assignments to different facilities.

The cultural influences that encourage learning included holding a personal value of ownership for the facilities which creates a strong motivation to learn and to “use everything that you know" in various aspects of the job. Administration expressed strong expectations that staff will take steps to be fully informed and make attempts at problem solving on their own. An accepted norm among staff at all levels within the organization is to question without regard to position. Administration supports open communication that ranges from ground level staff, to the doctor and the CEO himself. Experienced radiation therapists emphasize this accepted practice upon training new hires.

Deeply embedded values in staff at all levels within the organization were expressed repeatedly. One value is in regards to the holistic approach to patient treatment and taking a very personal interest in your patient. Responses from multiple individuals clearly focused on "knowing your patient." This includes knowing the differences between patients, knowing how and why the plans are designed a certain way, knowing the basis for differences of dose. Most importantly, administration expects a deep, personal understanding of the patient and their family.

A unique aspect of this organization stems from the administrative background growing from the ranks of radiation therapists. Radiation therapists who are administrators understand the issues and identify with staff. This fosters closer relations and trust from the heights of administration and doctors to the working staff. Very strong bonds were expressed between radiation therapists and the physics staff. I perceive this to come from working closely towards maintaining a shared purpose. Good relations are built from repeated experiences of working together to ensure accurate treatment delivery. Both departments expressed high levels of trust in each other's work.

Radiation therapists also depend on each other as working partners to ensure an accurate treatment.

According to Dr. Anders, these important relationships were developed by the core group working side by side in the original, single facility before the period of growth and expansion. The first cancer center was founded on these principles working with a small core group. The "disciples", as one participant put it, look for and pass on these values as the organization grows and expands. This was evident as participants frequently quoted Dr. Anders in their responses and referred back to a time when they worked as one team.

## Implications for Theory: Inverse Principle of Situated Learning Theory

Significant in this case study, were findings that triangulated the recognition of deskilling by radiation therapists, co-administrators, and the CEO. I attempt to bring a specific, deeper focus on using inverse principles of Situated Learning Theory. If it is true that full participation is a mediator for development of identity and practice, then, removing participation has the opposite outcome.

An inverse function is one that reverses the effect or outcome. A function and its inverse may be descried as the "do" and the "undo." I have illustrated positive growth and development among the radiation therapists for this organization as they assume the values of "Ownership" and "Responsibility" as so-called "Junior Rangers" in this organization and are mentored to become "Facility Managers." As a positive attribute, radiation therapists may continue to solve new problems and work through new issues to improve working conditions thus expanding their practice and job roles. Drawing from the principles of Situated Learning Theory, it follows that new identities and work roles evolve as the radiation therapists work through different problems and seek solutions.

By creating a workflow chart of treatment processes mapping modern treatment, I provided a general view of multiple tasks leading to treatment delivery. The visuals also identified pre- (before the use of multi-leaf collimation, IMPAC, and other automated processes) and post-perspectives showing fragmentation of the treatment process. Comparing tasks and treatment processes show areas where the radiation therapist has been removed from the actual treatment process, eliminating participation and opportunity to visualize aspects of the treatment.

Removing processes (removing Participation) that use and keep foundations of radiation therapy in working memory has the effect of removing routine procedures that were once the norm within most departments (the Practice). Viewing an automated process through a display screen as an animation has the negative effect of establishing a new norm and a new practice with limited processes, procedures, or steps. In this way, technology serves to reduce the paths radiation therapists take, thereby having the effect of reducing knowledgeable practice as steps and processes dissipate.

Authors state that the problem with technology grows out of dependence. The problem with technology is that you become dependent upon it, and if it ever disappears we're suddenly paralyzed as individuals or as a society. From a socio-cultural point of view, this is "appropriation," the process of taking something that belongs to others and making it one's own as foundational knowledge is lost and internalized or captured within the technologies (Morch, 2009; Wertsch, 1998).

The proposed mechanism is a shifting of types of knowledge by repeatedly using only knowledge related to the modern technology that does not require applied skills that relate to foundational knowledge. Appropriation occurs as a gradual shift over a period of time where the radiation therapist uses technology, adopting new automation with inherent processes that replace tasks such as inserting the shielding block.

## Implications for Practice: Losing Knowledgeable Practice through Knowledge Appropriation

Radiation therapists monitor accuracy through a human interface with technology. It is through this interaction that different levels of awareness and critical judgment are called upon to control the outcome. For radiation therapists, human interfaces with technology have grown from using a simple timer similar to an egg timer for the cobalt unit, to using a medium size treatment console during the 1980s, to using such complex technologies as multiple computers, display screens, and key boards.

Problem recognition for the user is heavily dependent on foundations of knowledge to connect a screen display to the unseen treatment processes occurring within the treatment room. In the two cases reported by the New York Times, radiation therapists failed to process information on a computer screen for an appropriate response. An appropriate response requires making mental connections to bridge the gap between technology and the treatment process occurring in the room. It requires a "knowledgeable Practice."

A workflow analysis mapping modern work flow processes compared with a previously published task analysis enabled the identification of specific points where technology operations are now overshadowing and replacing opportunities to practice and rehearse foundational concepts. There is no substitution for seeing and practicing manual processes in radiation therapy for keeping adept at the critical thinking required within the treatment delivery setting.

I introduce the difference between focal awareness and subsidiary awareness to distinguish and establish a firm definition of Foundational Knowledge. Foundational knowledge includes the element of "knowing." Foundational knowledge includes "knowing why" as much as "knowing how." I use data from the case study; supporting literature from a socio-technical perspective; a situated learning perspective; and findings from the workflow cross analysis to form the argument that technology is appropriating radiation therapist knowledge. The propositions for this argument are:

Proposition 1: Automation and technology impose limitations on working memory.

Proposition 2: Automation and technology reduce the radiation therapist's intimate involvement in treatment delivery by eliminating human processes related to treatment.

Proposition 3: Foundations of knowledge are lost with decreasing practice; mental and manual involvement are overshadowed by technology.

Therefore, I conclude that Radiation therapists incur a reduction in knowledgeable practice. Knowledge appropriation occurs as a gradual shift over a period of time where the radiation therapist uses technology, adopting new automation with inherent processes that replace tasks such as inserting the shielding block.

Borrowing a practice from the chemical engineering industry, it may be feasible to implement processes that counteract where technology operations are now overshadowing and replacing opportunities to practice and rehearse foundational concepts. These may include integrating extra steps in the treatment process that include walking into the room more often, visualization of beam angle, and patient setups. This is equivalent to "field checks and taking readings in the field" by chemical engineering where personnel engage in "walk throughs" across the field as quality assurance checks.

The implications for practice of this study in terms of the human-technology interphase and regarding the new theory of knowledge appropriatoin involve other industries. This may bring focuse to the human-machine interphase across industries as it continues to be refined within systems.

## Implications for Policy

Safe treatment outcomes rely heavily on "knowledgeable practices." An environment where the technology separates the user from the process calls for action to bridge that gap using a much greater degree of cognitive thought processes and the ability to make mental connections drawing from foundations of treatment knowledge. Today, the multiple interfaces coupled with the extremely customized, narrow beams of intense radiation create a very complex system with questionable processes for treatment verification.

One significant finding from this case study is that the most important influence on learning during transitional periods was not organizational policy, but rather shared organizational philosophies and values. The implications for practice are that policy for change works better when grounded by beliefs and personal values across the entire organization, and that the greatest potential for organizational learning exists within the ability for management to create a feeling of partnership or ownership that instills responsibility in associates to achieve their goals. A strong infrastructure must also have a strong cohesive community where everyone has a voice fostering close relations and trust from the heights of administration and doctors, to the working staff. Self-determination and diligence in people working closely together contributes to maintaining a shared purpose – treatment accuracy. The data from this case study suggest that personal relationships are forged from repeated questioning and experiences of working towards understanding treatment plans and ensuring accurate treatment delivery at every level of the organization.

## Limitations to the Study

A potential limitation to this study is that data was collected from experiences and observations of eight participants within one organization. An exploratory case study using multiple organizations may have resulted in a richer data set allowing for the collection of a broader set of experiences and views.

Another potential limitation to this study is the limited time I remained in the field. I could have gained deeper information from interviewees had I spanned this study through a longer period. Thus, I would have completed my transcription with more time to absorb the information, identifying the critical themes through coding the material before the next interview. This would have given me a better focus for the next interview and enabled me to gain deeper and richer information in certain areas.

A third limitation may also be seen as a strength to the study as I was the primary collector, I transcribed, sorted, and analyzed the data. While there may be potential limitations, this also served to provide rich, detailed writing. A thick description can aid the transferability of findings. I dedicated myself to the transcription of every interview making sure I alone held discernment between what was important and what was not. In this way, I was able to catch inflection in voice, emotion, excitement, or phrases and comments that may have been made "tongue in cheek." The thick description in the report of findings (chapter four) and interpretation (chapter five), as well as in the description of methodology of this study permits the reader to make his or her own interpretations making possible applications in their own settings.

## Areas for Future Research

Future research may revisit this study expanding the target population to enhance participants and perspectives. Also, using another perspective, a qualitative study from the patient's point of view regarding their experiences during times of technology transitions may provide useful information for the practice. I have suggested in this study that there is no substitute for first-hand experience where radiation therapists see, do, and understand processes related to treatment delivery to keep knowledgeable practice in working memory. I also make the case that technology and automation remove the radiation therapist from these important processes. Further research is needed as both practitioners and educators work together towards modifying the current roles of both the radiation therapist and systems in order to revitalize the true “therapy” role of the radiation therapist. We know that technology drives this profession as organizations compete to claim the best and the newest treatment delivery system in town. Technology also serves to improve productivity, efficiency, and accuracy in our profession. Future research must harness the ability of current technology, while at the same time, find ways to utilize, rehearse, and practice foundations of knowledge that keep our role personally involved in the treatment process and involved in patient care.

It is feasible to hold panel discussions among both radiation therapy educators and practitioners at the national level in effort to establish appropriate roles allowing mental connections that bridge the gap between technology and the treatment process occurring in the room. A question to investigate may involve possible disconnects between personnel who design treatment software, or personnel who input data and information such as physicists or dosimetrists, with the radiation therapists. Since the backgrounds and educational orientations are different, do issues exist that are not recognized by either or both that somehow impact the other and effect treatment delivery?

Focusing only on the radiation therapist who must have the ability to multi-task under various levels of stress and distractions, with various forms of information competing for attention, future research may involve a cognitive science study exploring mental processes involved during treatment delivery that foster or hinder the ability to multi-task in this environment. This may explore the simple question of what’s going on in the way radiation therapists concentrate in their ability to multi-task through operations involved in treatment delivery.

## Chapter Summary

The aim of my study was to understand how radiation therapists learn new skills as they adopt new technologies for treatment delivery. I sought to understand the organizational and work-related influences, processes, and factors that promote or minimize opportunity for learning. As a multi-level study, taking a vertical path of inquiry within the organization, I attempted to understand the different perspectives of participants. Research questions were formed within a socio-technical frame using the infrastructure, the info-structure, and the info-culture of the organization to structure data collection and analysis.

For my interpretation, the study data providing organizational factors that influence postive growth and development, were integrated within a situated learning perspective. Constructs inlcude *Participation* as the critical element driving a continuum of learning towards a maximum potential that builds a knowledgeable practice.

Participation is viewed as the driving force that keeps stretching the boundaries of who we are, as a profession, and as a professional. Our identities within our community of practice continually evolves, but are also constrained by the degree of involvement, and active engagement according to what is expected by our community. I interpret my data using situated learning since it fits the model of building practice and identity through levels of participation as “Junior Rangers” were mentored to be facility managers in this case study; but it also explains the outcome of a reduction in knowledgeable practice.

Viewing an automated process through a display screen as an animation has the negative effect of establishing a new norm and a new practice with limited processes, procedures, or steps. In this way, technology serves to reduce the paths radiation therapists take, thereby having the effect of reducing knowledgeable practice as steps and treatment processes dissipate.

The proposed mechanism is a shifting of types of knowledge by repeatedly using only knowledge related to operating modern technology that does not require applied skills that relate to foundational treatment knowledge. Knowledge appropriation occurs as a gradual shift over a period of time where the radiation therapist uses technology, adopting new automation with inherent processes that replace tasks such as inserting the shielding block. I conclude that foundations of knowledge are removed from working memory and are lost with decreasing practice, with decreasing participation, and as manual and mental involvement are overshadowed by technology.

# Appendix A: Research Question Data Collection Matrix

## (Sample Page)

The broad research question of my study is: What are the key processes and mechanisms within the Infrastructure, Info-structure, and the Info-culture levels of the cancer center that form and shape new knowledge in adapting new technologies for treatment?

**Research Question 1. The Infrastructure. How does the hardware and software system promote or inhibit learning of modern treatment delivery?**

| | | Characteristics of Infrastructure Level | | |
|---|---|---|---|---|
| **Researching**<br>1a: What are the characteristics of the knowledge sharing networks? | | **Contact Between participants** | **Knowledge Sharing** | **Support for Explicit & Tacit Knowledge** |
| 1b: How do the systems support the sharing of both explicit and tacit knowledge? | | | | |
| **Interview Questions** | | | | |
| 1.What kinds of technical factors will influence your learning in the organization? | **1b** | | | ■ |
| 2.How does the technology, computer networks, electronic charts, record and verify systems influence your learning? | **1a** | | ■ | ■ |
| 3.When was the last time you reviewed a computerized treatment plan? | **1b** | | ■ | ■ |
| 4.When was the last time you read about the patient's staging? | **1b** | | ■ | ■ |
| 5.How easy is it to find a computer plan for the treatment? | **1a, 1b** | | ■ | ■ |
| 6.How easy is it to find a pathology report for the patient? | **1a, 1b** | | ■ | ■ |
| 7.How easy is it to find the staging for the patient? | **1a, 1b** | | ■ | ■ |
| 8.When colleagues are in need is it easy to offer them needed information and documents? How? | **1a, 1b** | ■ | ■ | ■ |
| 9.When you can't help your colleagues solve their problem, can you refer them somewhere else for more assistance? | **1a, 1b** | ■ | ■ | ■ |
| 10.How confident are you in your ability to use newly learned skills on the job? | **1b** | | | ■ |
| 11.How do you feel when you have to think about using something new on the job? | **1b** | | | ■ |
| | | | | |

# Appendix B: Study Consent

## Consent Form

**Title**:

An Exploratory Case Study of Continuous Learning for Radiation Therapists:

A Socio-Technical Systems Perspective

**Conducted By**:
Ronnie G. Lozano, MSRS, RT(T)
Texas State University College of Health Professions 512-245-1345

Dissertation Chair:
Ann K. Brooks, Ph.D.
Texas State University College of Education 512-245-2150

You are being asked to participate in a research study. This form provides you with information about the study. Please read the information carefully and be sure to ask any questions you feel you need to ask in order to make an informed decision about whether or not you are willing to participate in this study. **Your participation is entirely voluntary. You may withdraw from the study at any time, you may choose not to answer any question(s) for any reason.** Please keep a copy of this consent form for your records.

**The purpose of the study:**
The purpose of my study is to understand how staff radiation therapists continue to learn new skills and knowledge within the work culture and a context of a continuously changing, highly technical environment. I seek to gain a deep understanding of how people and technologies adjust until they "fit" during periods of socio-technical work adaptations. In this study, I will define and draw out a mechanism of the knowledge-sharing flow within the practice of radiation therapy that leads to the adaptation of new treatment technology. You are being asked to participate because you play an integral role in the treatment prescription, treatment planning or the treatment delivery process, or as the administrator, you hold an organizational perspective of processes leading to treatment delivery.

**What to expect:** If you choose to participate, you will be interviewed and asked questions about how staff radiation therapists continue to learn new skills and knowledge.

**Total Estimated Time:** The interview will take no more than one hour.

**Risk of participating**: There are no known risks to participating in the interview.

**Benefits of participating**: The benefits of the study could be a greater understanding of factors that may foster or impede your continuous learning within your job role. Another benefit could be a greater understanding of the flow of information into and out of the treatment department.

**Summary of Findings**: Participants will be asked to verify accurate interpretation of data collected after data analysis. A final summary of the findings will be provided to participants upon completion of the study, if requested. You may request this at any time be contacting me.

**Confidentiality and privacy:** The data from this study may be used for publication. There will be NO data that identifies information that could be associated with you or your participation in the study. To maintain confidentiality, the material will be kept in a locked drawer when stored and will be destroyed at the completion of the research project. Information gathered will only be used for the purpose of this research project.

If you have any questions about the study or want additional information, please contact Ronnie Lozano @ (512)245-1345.

**This is your copy of this form for your records.**

**Statement of Consent:**

I have read the above information and have sufficient information to make an informed decision about participating in the study.

_______________________________________________Date:_____________
**Signature of the Participant**

______________________________________________Date:_____________
**Signature of the Researcher**

**IRB APPROVAL # 2010E306**

**Appendix C: Institutional Assurances**

**IRB Approval**

TEXAS STATE UNIVERSITY
SAN MARCOS
*The rising STAR of Texas*

Institutional Review Board Application

# Certificate of Approval

Applicant: Ronnie Lozano

Application Number : 2010E306

**Project Title: An Exploratory Case Study of Continuous Learning for Radiation Therapists: A Socio-Technical Systems Perspective**

Date of Approval: 10/12/10 13:46:36

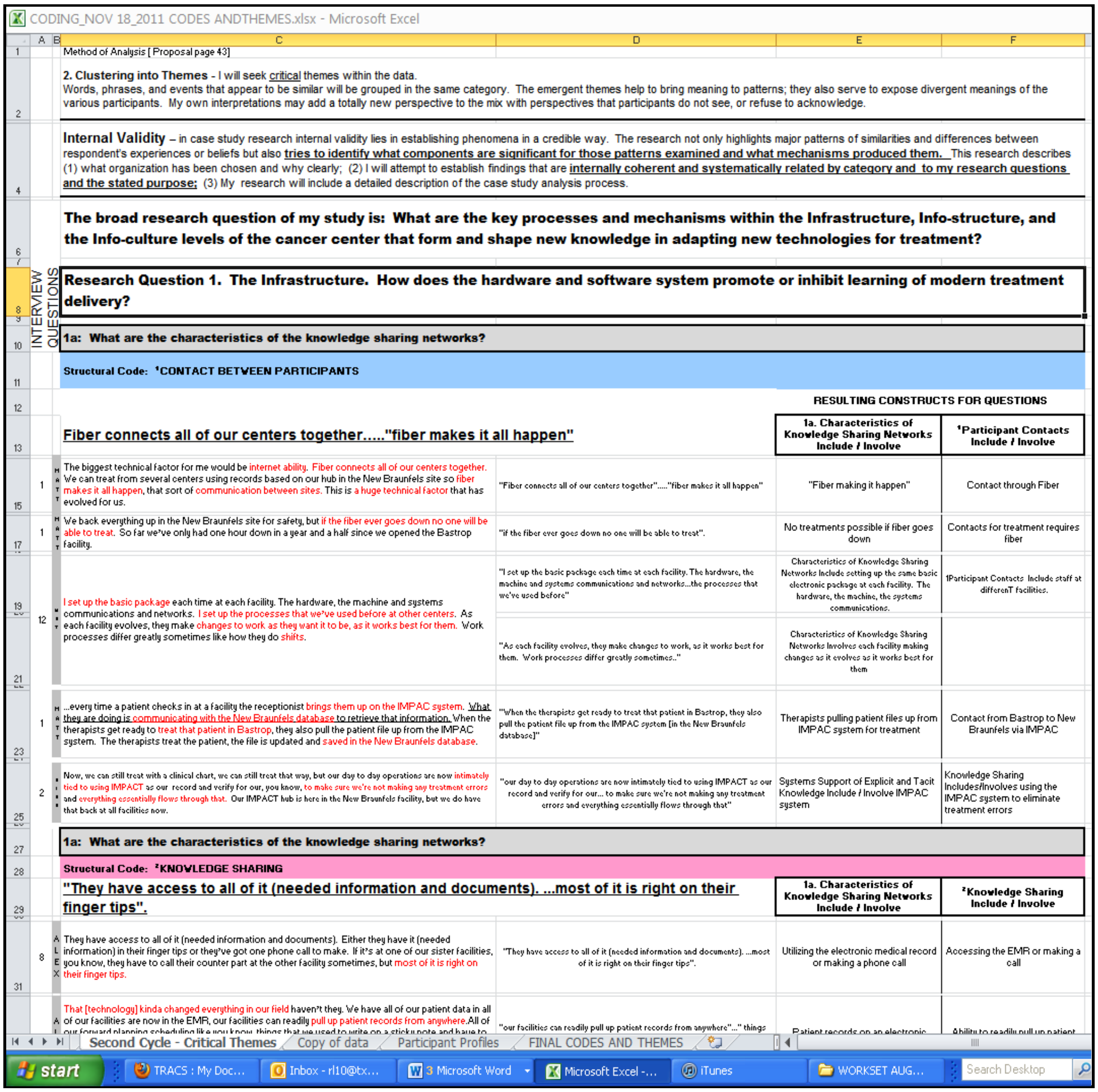
Expiration Date: 10/12/11

Assistant Vice President for Research and Federal Relations

Chair, Institutional Review Board

# Appendix D: Codes and Themes Matrix

## (Sample 1)



CODING_NOV 18_2011 CODES ANDTHEMES.xlsx - Microsoft Excel

Method of Analysis [ Proposal page 43]

**2. Clustering into Themes** - I will seek critical themes within the data.
Words, phrases, and events that appear to be similar will be grouped in the same category. The emergent themes help to bring meaning to patterns; they also serve to expose divergent meanings of the various participants. My own interpretations may add a totally new perspective to the mix with perspectives that participants do not see, or refuse to acknowledge.

**Internal Validity** – in case study research internal validity lies in establishing phenomena in a credible way. The research not only highlights major patterns of similarities and differences between respondent's experiences or beliefs but also tries to identify what components are significant for those patterns examined and what mechanisms produced them. This research describes (1) what organization has been chosen and why clearly; (2) I will attempt to establish findings that are internally coherent and systematically related by category and to my research questions and the stated purpose; (3) My research will include a detailed description of the case study analysis process.

**The broad research question of my study is: What are the key processes and mechanisms within the Infrastructure, Info-structure, and the Info-culture levels of the cancer center that form and shape new knowledge in adapting new technologies for treatment?**

INTERVIEW QUESTIONS

**Research Question 1. The Infrastructure. How does the hardware and software system promote or inhibit learning of modern treatment delivery?**

**1a: What are the characteristics of the knowledge sharing networks?**

**Structural Code: ¹CONTACT BETWEEN PARTICIPANTS**

RESULTING CONSTRUCTS FOR QUESTIONS

| | Fiber connects all of our centers together....."fiber makes it all happen" | | 1a. Characteristics of Knowledge Sharing Networks Include / Involve | ¹Participant Contacts Include / Involve |
|---|---|---|---|---|
| 1 | The biggest technical factor for me would be internet ability. Fiber connects all of our centers together. We can treat from several centers using records based on our hub in the New Braunfels site so fiber makes it all happen, that sort of communication between sites. This is a huge technical factor that has evolved for us. | "Fiber connects all of our centers together"....."fiber makes it all happen" | "Fiber making it happen" | Contact through Fiber |
| 1 | We back everything up in the New Braunfels site for safety, but if the fiber ever goes down no one will be able to treat. So far we've only had one hour down in a year and a half since we opened the Bastrop facility. | "if the fiber ever goes down no one will be able to treat". | No treatments possible if fiber goes down | Contacts for treatment requires fiber |
| 12 | I set up the basic package each time at each facility. The hardware, the machine and systems communications and networks. I set up the processes that we've used before at other centers. As each facility evolves, they make changes to work as they want it to be, as it works best for them. Work processes differ greatly sometimes like how they do shifts. | "I set up the basic package each time at each facility. The hardware, the machine and systems communications and networks...the processes that we've used before" | Characteristics of Knowledge Sharing Networks Include setting up the same basic electronic package at each facility. The hardware, the machine, the systems communications. | 1Participant Contacts Include staff at differenT facilities. |
| | | "As each facility evolves, they make changes to work, as it works best for them. Work processes differ greatly sometimes.." | Characteristics of Knowledge Sharing Networks Involves each facility making changes as it evolves as it works best for them | |
| 1 | ...every time a patient checks in at a facility the receptionist brings them up on the IMPAC system. What they are doing is communicating with the New Braunfels database to retrieve that information. When the therapists get ready to treat that patient in Bastrop, they also pull the patient file up from the IMPAC system. The therapists treat the patient, the file is updated and saved in the New Braunfels database. | "When the therapists get ready to treat that patient in Bastrop, they also pull the patient file up from the IMPAC system [in the New Braunfels database]" | Therapists pulling patient files up from IMPAC system for treatment | Contact from Bastrop to New Braunfels via IMPAC |
| 2 | Now, we can still treat with a clinical chart, we can still treat that way, but our day to day operations are now intimately tied to using IMPACT as our record and verify for our, you know, to make sure we're not making any treatment errors and everything essentially flows through that. Our IMPACT hub is here in the New Braunfels facility, but we do have that back at all facilities now. | "our day to day operations are now intimately tied to using IMPACT as our record and verify for our... to make sure we're not making any treatment errors and everything essentially flows through that" | Systems Support of Explicit and Tacit Knowledge Include / Involve IMPAC system | Knowledge Sharing Includes/Involves using the IMPAC system to eliminate treatment errors |

**1a: What are the characteristics of the knowledge sharing networks?**

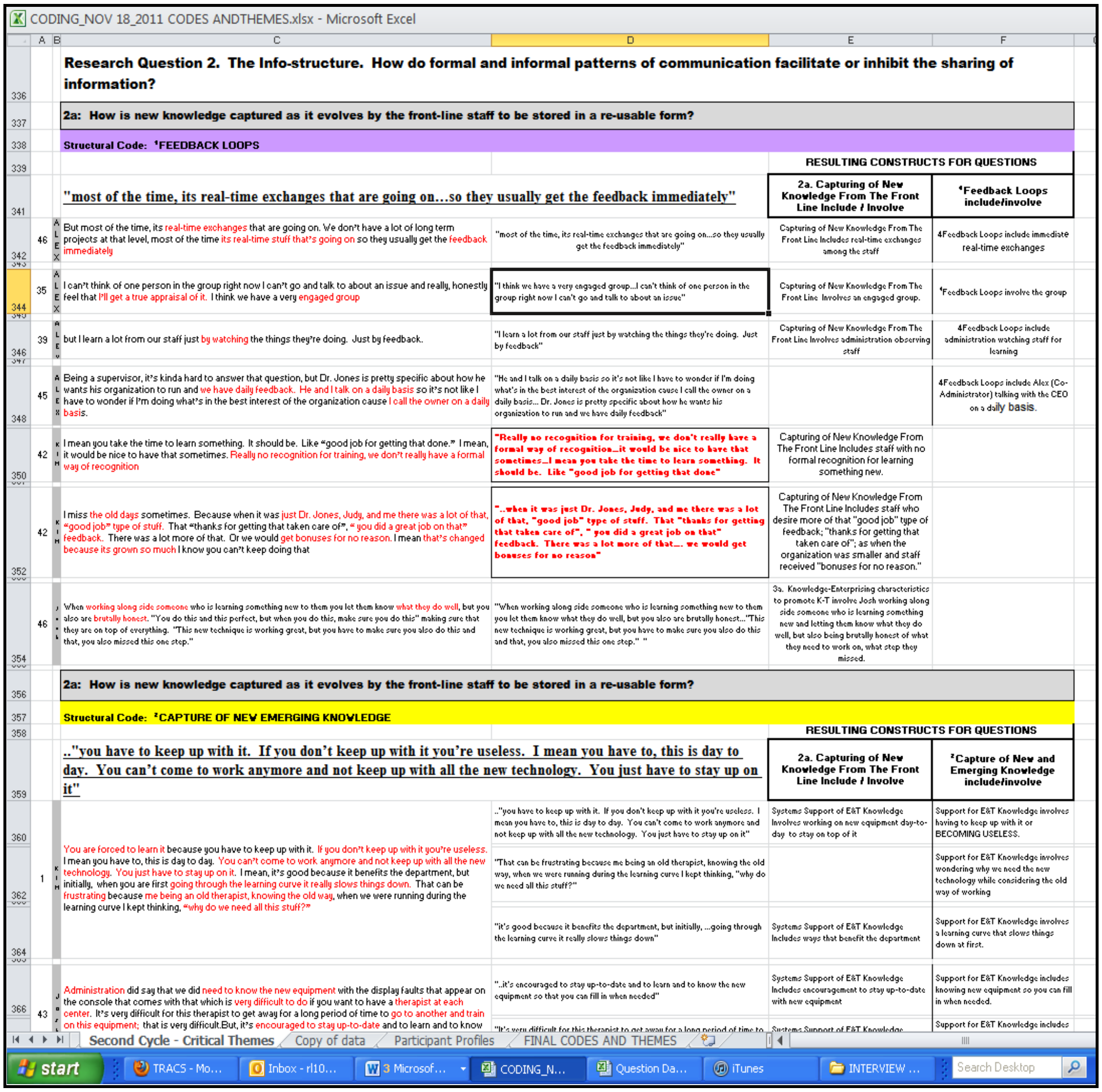
**Structural Code: ²KNOWLEDGE SHARING**

| | "They have access to all of it (needed information and documents). ...most of it is right on their finger tips". | | 1a. Characteristics of Knowledge Sharing Networks Include / Involve | ²Knowledge Sharing Include / Involve |
|---|---|---|---|---|
| 8 | They have access to all of it (needed information and documents). Either they have it (needed information) in their finger tips or they've got one phone call to make. If it's at one of our sister facilities, you know, they have to call their counter part at the other facility sometimes, but most of it is right on their finger tips. | "They have access to all of it (needed information and documents). ...most of it is right on their finger tips". | Utilizing the electronic medical record or making a phone call | Accessing the EMR or making a call |
| | That [technology] kinda changed everything in our field haven't they. We have all of our patient data in all of our facilities are now in the EMR, our facilities can readily pull up patient records from anywhere.All of our forward planning scheduling like you know, things that we used to write on a sticky note and have to ... | "our facilities can readily pull up patient records from anywhere"..." things | Patient records on an electronic ... | Ability to readily pull up patient ... |

Second Cycle - Critical Themes | Copy of data | Participant Profiles | FINAL CODES AND THEMES

# Appendix E: Codes and Themes Matrix

# (Sample 2)



CODING_NOV 18_2011 CODES ANDTHEMES.xlsx - Microsoft Excel

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 336 | | | **Research Question 2. The Info-structure. How do formal and informal patterns of communication facilitate or inhibit the sharing of information?** | | | |
| 337 | | | **2a: How is new knowledge captured as it evolves by the front-line staff to be stored in a re-usable form?** | | | |
| 338 | | | **Structural Code: ¹FEEDBACK LOOPS** | | | |
| 339 | | | | | **RESULTING CONSTRUCTS FOR QUESTIONS** | |
| 341 | | | **"most of the time, its real-time exchanges that are going on…so they usually get the feedback immediately"** | | **2a. Capturing of New Knowledge From The Front Line Include / Involve** | **¹Feedback Loops include/involve** |
| 342 | 46 | ALEX | But most of the time, its real-time exchanges that are going on. We don't have a lot of long term projects at that level, most of the time its real-time stuff that's going on so they usually get the feedback immediately | "most of the time, its real-time exchanges that are going on…so they usually get the feedback immediately" | Capturing of New Knowledge From The Front Line Includes real-time exchanges among the staff | 4Feedback Loops include immediate real-time exchanges |
| 344 | 35 | ALEX | I can't think of one person in the group right now I can't go and talk to about an issue and really, honestly feel that I'll get a true appraisal of it. I think we have a very engaged group | "I think we have a very engaged group…I can't think of one person in the group right now I can't go and talk to about an issue" | Capturing of New Knowledge From The Front Line Involves an engaged group. | ¹Feedback Loops involve the group |
| 346 | 39 | ALEX | but I learn a lot from our staff just by watching the things they're doing. Just by feedback. | "I learn a lot from our staff just by watching the things they're doing. Just by feedback" | Capturing of New Knowledge From The Front Line Involves administration observing staff | 4Feedback Loops include administration watching staff for learning |
| 348 | 45 | ALEX | Being a supervisor, it's kinda hard to answer that question, but Dr. Jones is pretty specific about how he wants his organization to run and we have daily feedback. He and I talk on a daily basis so it's not like I have to wonder if I'm doing what's in the best interest of the organization cause I call the owner on a daily basis. | "He and I talk on a daily basis so it's not like I have to wonder if I'm doing what's in the best interest of the organization cause I call the owner on a daily basis… Dr. Jones is pretty specific about how he wants his organization to run and we have daily feedback" | | 4Feedback Loops include Alex (Co-Administrator) talking with the CEO on a daily basis. |
| 350 | 42 | KIH | I mean you take the time to learn something. It should be. Like "good job for getting that done." I mean, it would be nice to have that sometimes. Really no recognition for training, we don't really have a formal way of recognition | "Really no recognition for training, we don't really have a formal way of recognition…it would be nice to have that sometimes…I mean you take the time to learn something. It should be. Like "good job for getting that done" | Capturing of New Knowledge From The Front Line Includes staff with no formal recognition for learning something new. | |
| 352 | 42 | KIH | I miss the old days sometimes. Because when it was just Dr. Jones, Judy, and me there was a lot of that, "good job" type of stuff. That "thanks for getting that taken care of", " you did a great job on that" feedback. There was a lot more of that. Or we would get bonuses for no reason. I mean that's changed because its grown so much I know you can't keep doing that | "..when it was just Dr. Jones, Judy, and me there was a lot of that, "good job" type of stuff. That "thanks for getting that taken care of", " you did a great job on that" feedback. There was a lot more of that… we would get bonuses for no reason" | Capturing of New Knowledge From The Front Line Includes staff who desire more of that "good job" type of feedback; "thanks for getting that taken care of"; as when the organization was smaller and staff received "bonuses for no reason." | |
| 354 | 46 | J | When working along side someone who is learning something new to them you let them know what they do well, but you also are brutally honest. "You do this and this perfect, but when you do this, make sure you do this" making sure that they are on top of everything. "This new technique is working great, but you have to make sure you also do this and that, you also missed this one step." | "When working along side someone who is learning something new to them you let them know what they do well, but you also are brutally honest…"This new technique is working great, but you have to make sure you also do this and that, you also missed this one step." " | 3a. Knowledge-Enterprising characteristics to promote K-T involve Josh working along side someone who is learning something new and letting them know what they do well, but also being brutally honest of what they need to work on, what step they missed. | |
| 356 | | | **2a: How is new knowledge captured as it evolves by the front-line staff to be stored in a re-usable form?** | | | |
| 357 | | | **Structural Code: ²CAPTURE OF NEW EMERGING KNOWLEDGE** | | | |
| 358 | | | | | **RESULTING CONSTRUCTS FOR QUESTIONS** | |
| 359 | | | **.."you have to keep up with it. If you don't keep up with it you're useless. I mean you have to, this is day to day. You can't come to work anymore and not keep up with all the new technology. You just have to stay up on it"** | | **2a. Capturing of New Knowledge From The Front Line Include / Involve** | **²Capture of New and Emerging Knowledge include/involve** |
| 360 | 1 | KIH | You are forced to learn it because you have to keep up with it. If you don't keep up with it you're useless. I mean you have to, this is day to day. You can't come to work anymore and not keep up with all the new technology. You just have to stay up on it. I mean, it's good because it benefits the department, but initially, when you are first going through the learning curve it really slows things down. That can be frustrating because me being an old therapist, knowing the old way, when we were running during the learning curve I kept thinking, "why do we need all this stuff?" | .."you have to keep up with it. If you don't keep up with it you're useless. I mean you have to, this is day to day. You can't come to work anymore and not keep up with all the new technology. You just have to stay up on it" | Systems Support of E&T Knowledge Involves working on new equipment day-to-day to stay on top of it | Support for E&T Knowledge involves having to keep up with it or BECOMING USELESS. |
| 362 | | | | "That can be frustrating because me being an old therapist, knowing the old way, when we were running during the learning curve I kept thinking, "why do we need all this stuff?" | | Support for E&T Knowledge involves wondering why we need the new technology while considering the old way of working |
| 364 | | | | "it's good because it benefits the department, but initially, …going through the learning curve it really slows things down" | Systems Support of E&T Knowledge Includes ways that benefit the department | Support for E&T Knowledge involves a learning curve that slows things down at first. |
| 366 | 43 | J | Administration did say that we did need to know the new equipment with the display faults that appear on the console that comes with that which is very difficult to do if you want to have a therapist at each center. It's very difficult for this therapist to get away for a long period of time to go to another and train on this equipment; that is very difficult.But, it's encouraged to stay up-to-date and to learn and to know | "..it's encouraged to stay up-to-date and to learn and to know the new equipment so that you can fill in when needed" | Systems Support of E&T Knowledge Includes encouragement to stay up-to-date with new equipment | Support for E&T Knowledge includes knowing new equipment so you can fill in when needed. |
| | | | | "It's very difficult for this therapist to get away for a long period of time to… | Systems Support of E&T Knowledge… | Support for E&T Knowledge includes… |

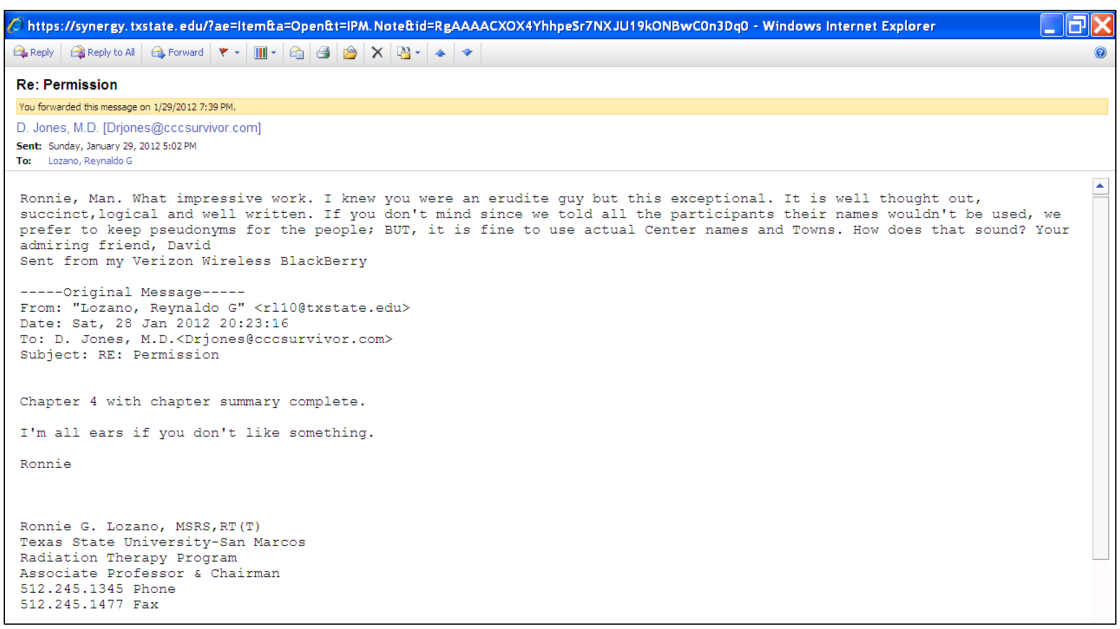
Second Cycle - Critical Themes / Copy of data / Participant Profiles / FINAL CODES AND THEMES

start | TRACS - Mo… | Inbox - rl10… | 3 Microsof… | CODING_N… | Question Da… | iTunes | INTERVIEW … | Search Desktop

## Appendix F: Credibility

## Response from the CEO of the Centers for Cancer Care

Credibility in qualitative research is an equivalent term to internal validity (Lincoln & Guba, 1986). It lies in establishing phenomena in a credible way, asking if the research is accurate. The goal in conducting credible research is to ensure that the participant was accurately described in the data and interpretations. Ways to ensure this included member checks. I shared written transcripts and thoughts with participants at different times and during different visits to the cancer center asking for additional notes and comments to guide my work. This helped with clarifications, interpretations and spurred new ideas not included during interviews. After writing chapter four, the report of findings, I mailed the chapter to participants. I have included an excerpt of a response by the CEO.


https://synergy.txstate.edu/?ae=Item&a=Open&t=IPM.Note&id=RgAAAACXOX4YhhpeSr7NXJU19kONBwC0n3Dq0 - Windows Internet Explorer

Reply | Reply to All | Forward

**Re: Permission**

You forwarded this message on 1/29/2012 7:39 PM.

D. Jones, M.D. [Drjones@cccsurvivor.com]

**Sent:** Sunday, January 29, 2012 5:02 PM

**To:** Lozano, Reynaldo G

Ronnie, Man. What impressive work. I knew you were an erudite guy but this exceptional. It is well thought out, succinct,logical and well written. If you don't mind since we told all the participants their names wouldn't be used, we prefer to keep pseudonyms for the people; BUT, it is fine to use actual Center names and Towns. How does that sound? Your admiring friend, David
Sent from my Verizon Wireless BlackBerry

-----Original Message-----
From: "Lozano, Reynaldo G" <rl10@txstate.edu>
Date: Sat, 28 Jan 2012 20:23:16
To: D. Jones, M.D.<Drjones@cccsurvivor.com>
Subject: RE: Permission

Chapter 4 with chapter summary complete.

I'm all ears if you don't like something.

Ronnie

Ronnie G. Lozano, MSRS,RT(T)
Texas State University-San Marcos
Radiation Therapy Program
Associate Professor & Chairman
512.245.1345 Phone
512.245.1477 Fax

# Appendix G:

## Cross Analysis of Workflow Processes for Pre and Post Treatment Technology

Data from the case study provided rich information that informed how radiation therapists use information to support learning in a highly technical environment. Participants shared their experiences and provided important insight about the preparedness to return to work with older equipment after working in a technology-centered facility. These personal experiences described a direct impact on maintaining and holding on to a knowledgeable practice. Regarding the practices of treatment delivery, this case study also triangulated the recognition of a trend towards deskilling among staff within the organization which I attempted to bring a specific, deeper focus to.

A task analysis for radiation therapy treatment procedures was published in the 2010 edition textbook, Principles and Practice of Radiation Therapy (Washington and Leaver, 2010). Informed with data of my study, I conducted a cross analysis with previously documented work flow processes and procedures. The original listing of processes provided excellent material for a pre and post -modern technology cross analysis. The analysis identified processes that are no longer suited for modern practices. I use this cross analysis to describe the mechanism from which a knowledge loss occurs from the user due to the use of technology and changing practices. I have extracted main points to use as propositions in chapter five to support my argument.

As a case study, my inquiry was of one organization; this cross analysis builds on that data to make generalizations. I create general cancer treatment workflow diagrams based on my study and experiences, on general radiation therapy practice literature, and views taken from proceedings from The American Association of Physicists in Medicine 2010 Safety in Radiation Therapy – A Call To Action, Miami, Fl.

Creating a workflow chart of modern treatment processes for mapping modern treatment provided a general view of multiple tasks leading to treatment delivery. The workflow diagrams allowed me to capture tasks identified as probable risk points for error as issues of focal awareness continue to grow. The visuals also identify a pre and post perspective of the fragmentation of the treatment process with specific areas where the radiation therapist is either removed or distant from the patient and treatment process.

One particular aspect of the socio-technical perspective effectively describes changes in behavior patterns in communities as technology users become accustomed to using new "smart" devices. This section provides several examples that illustrate how radiation therapists may become dependent on this new technology to accomplish several tasks. My purpose in presenting this material is to support my argument in chapter five; to bring attention to the loss of foundational elements from the user's memory with continued use of new technology. I bring attention to the notion of losing conceptual knowledge and information as new devices automatically replace certain manual processes to achieve our goals and as we no longer rehearse and practice simple tasks.

Figure 1 shows the general cancer treatment workflow diagram. General processes have not changed although there are complex sub processes. Detailed processes within each step have incurred major technological changes.

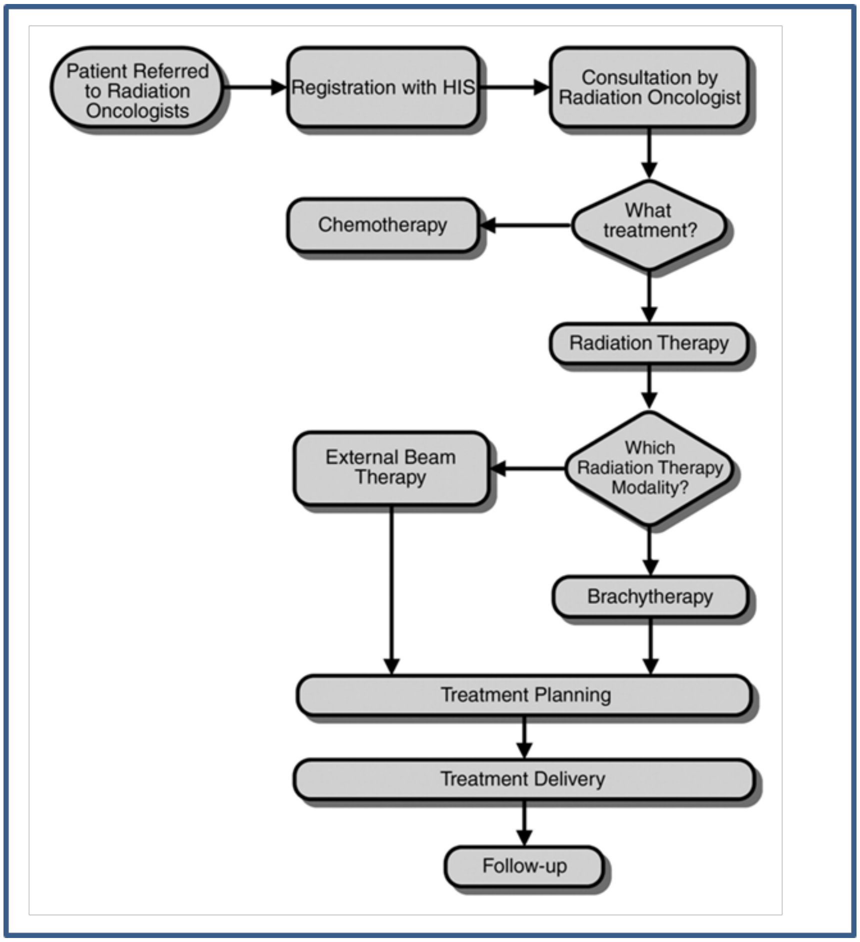



*Figure 9*. The general cancer treatment workflow.

Figures 2 and 3 below illustrate processes leading to the first treatment. The typical processes include a simulation after consultation and the acquisition of x-ray images having always been part of the simulation process. The process shows the work flow of the technology of that time for treatment delivery. Every event is further supported by many sub processes involving information shared between diverse groups within different departments. These processes are not shown or defined, as that is beyond of the scope of this chapter. The processes show the point of contact between patient and the technology (except for the computer treatment planning).

The steps for treatment planning in figure 9 during the 1980s included work flow processes that were conducted face to face. Simulation films were taken and reviewed by the doctor with the patient still on the table in the treatment position. The doctor could simply look at markings on the patient’s skin while holding the x-ray film he was to approve. Many times palpating an area of interest making sure it was within the treatment field. At that time the doctor could also draw blocking on the x-ray film. The blocks were to be poured at the same facility using a metal alloy typically on the same floor. Members of the physics department or dosimetrists would join the doctor during the simulation session to take needed measurements and add more information directly on the film hanging on the view box. After the generation of a computer treatment plan by the dosimetrist, the doctor would review and sign the printed treatment plan.

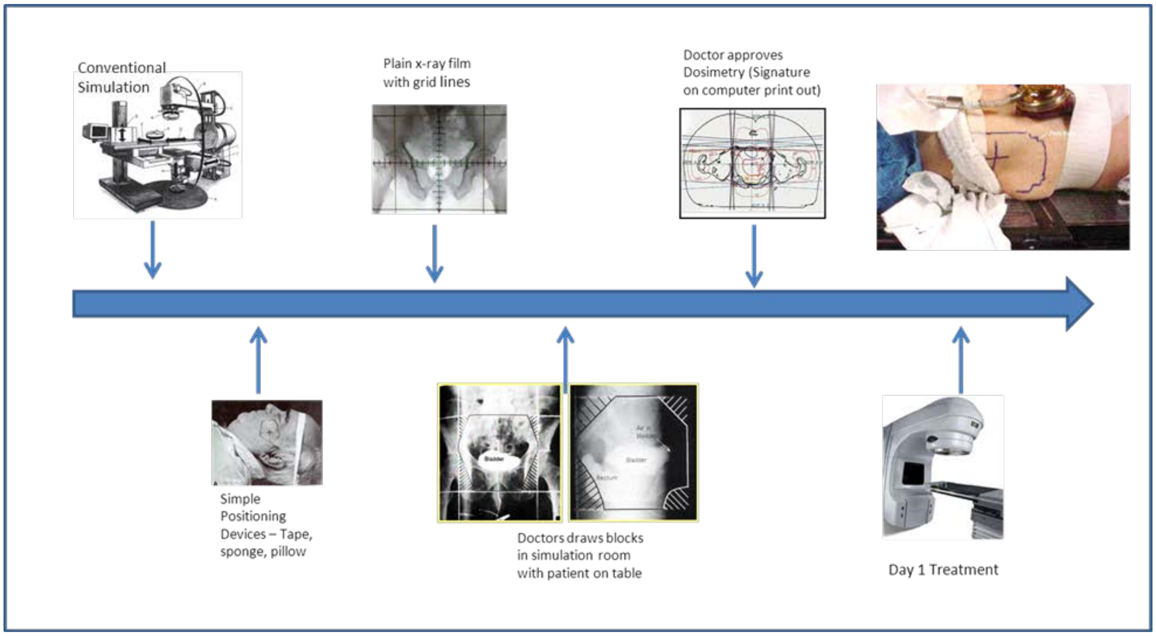



*Figure 10*. Pre-modern technology treatment planning work flow diagram.

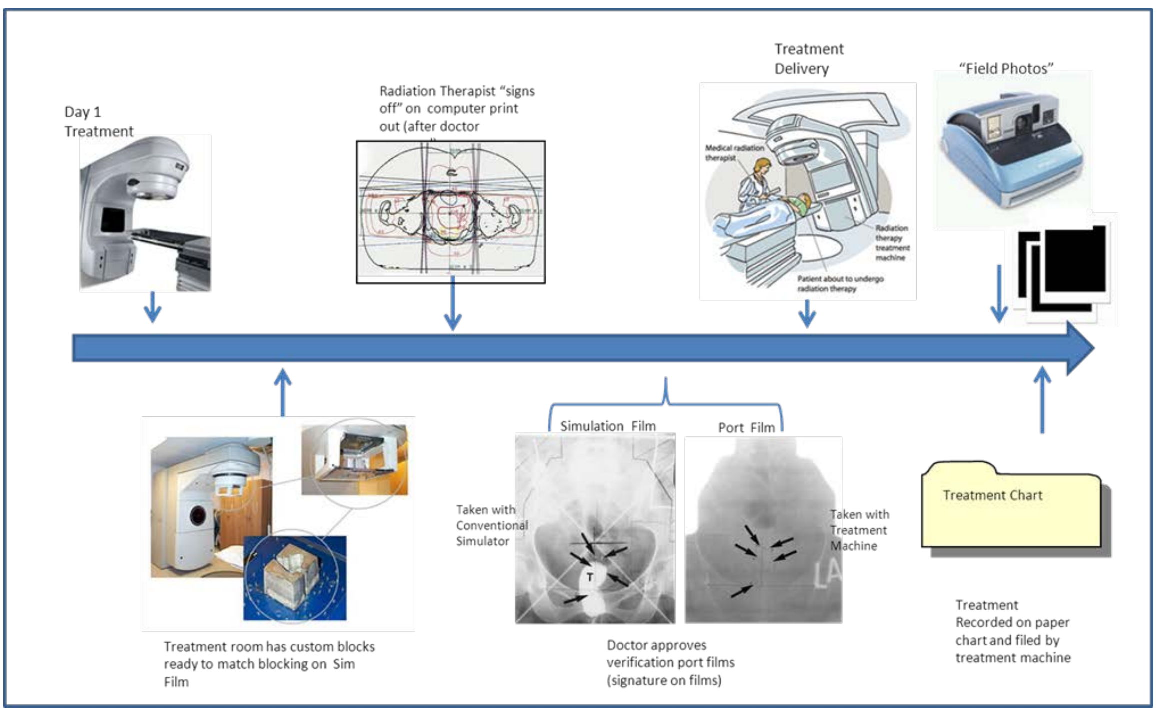



*Figure 11*. Pre-modern technology treatment delivery work flow diagram.

Figure 3 shows a work flow diagram for the actual treatment delivery. It was scheduled on another day allowing for the treatment plan and shielding blocks to be completed. Upon the first treatment day, the patient would meet the radiation therapists. The radiation therapists had shielding blocks ready and labeled, the treatment chart complete with prescription and approved computer plan. It was customary to treat each area that first day while taking verification films referred to as "port films." Each side was "ported" after treatment. A typical four-field prostate treatment would have four sides that were treated with the radiation therapist walking into the room to rotate the machine from right to left, above, below; changing the collimator (jaw) setting if needed. Each side would have a different shielding block that had to be changed as the machine was rotated to the appropriate angle. The radiation therapists then took x-ray films with the treatment machine that represents the treatment field. These films were used to check the shielding blocks, beam placement, as well as patient positioning. The films were delivered to the doctor who verified that the port films agreed with the simulation film. Doctors approved by signing and dating each port film. After the doctor approved the port films the radiation therapists physically marked on the patient's skin translating the shaped treatment field with permanent marker onto the patient. It was customary to tattoo the center of the (unblocked) rectangle field, as well as other critical identifying parts of the treatment field. Each field was then photographed with an "Instamatic" camera. The department policy included how each "Field Photo" must be labeled identifying the patient, the exact field, and the date. All information was recorded in the paper chart as a treatment record that was filed at the treatment machine. The treatment chart included a section specifically for taping the photograph documentation. Policy also required any changes to be marked on the patient and photographed to update the treatment chart.

The work flow includes the simple craftsmanship of fabricating and mounting shielding blocks onto Lucite trays using bolts and screws, continued use of x-ray film to verify and document treatment fields. A clear margin existed between technology and patient. The most advanced aspect of the treatment was computerized treatment planning that required hand-drawn outlines of the body part of interest. There were distinct steps within the workflow processes for checking and verification. The radiation therapist was in control at these specific points. The blocks were checked separately, filmed as part of the port film check, and signed separately by the radiation therapist. The computer plan was signed as well. Treatment delivery was segmented with pauses between treatment fields to change devices and change machine settings. This allowed ample time for visual verifications of several types between treatment fields and direct communication with the patient lying on the table.

For mapping modern treatment, creating a workflow chart of the modern treatment process provides a general view of multiple tasks leading to treatment delivery. Aspects of the workflow fall under the responsibility of the doctor, physicist, or dosimetrist, as well as the radiation therapist. This presents the workflow processes in a very general view excluding many complex processes within each major task (see figure 4). The workflow diagram captures tasks that do not fall directly under the responsibility of the radiation therapist; however, the radiation therapist as all members of the facility must verify all elements that involve the delivery of treatment. This visual begins to identify fragmentation of processes, but also the interrelatedness between technology and patient; as well as technology and radiation therapist.

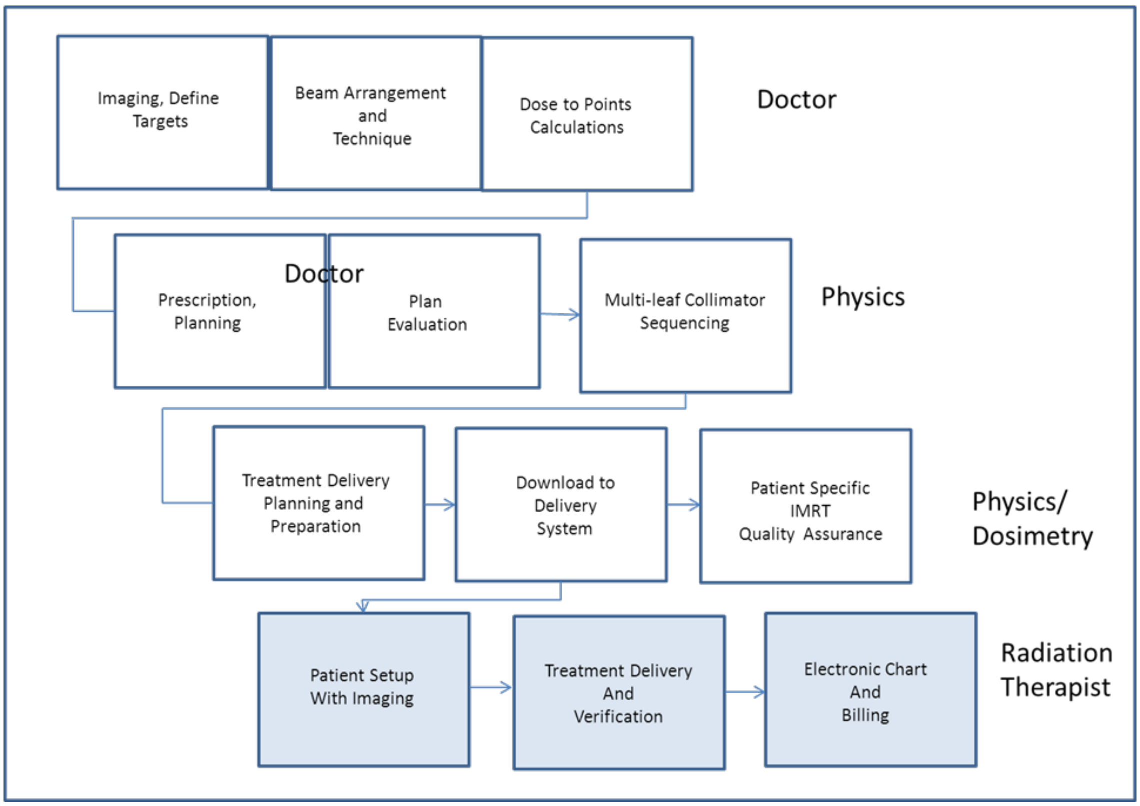



*Figure 12*. Simplified Work Flow of Modern Radiation Therapy.

Figure 5 illustrates the work flow depicting technological processes for modern radiation therapy leading to treatment delivery. The major impression within the modern scheme is that the patient has a CT scan as the initial step of the treatment planning process. After acquiring the CT scan, massive anatomical data is acquired by the database. The patient is no longer personally involved in the same simulation process as before. All of the work is completed "virtually" with the digital patient data. The "virtual simulation," a process of defining aspects of the treatment such as the number of beams, shielding of normal tissue, the number of treatments, etc. is established between the doctor and physics or dosimetry using virtual simulation software to localize anatomical structures and define target volume, then treatment planning software to establish dosimetry. The patient data continues to build with appropriate treatment elements as the material is transmitted from workstation to workstation eventually evolving into a perfect treatment plan.

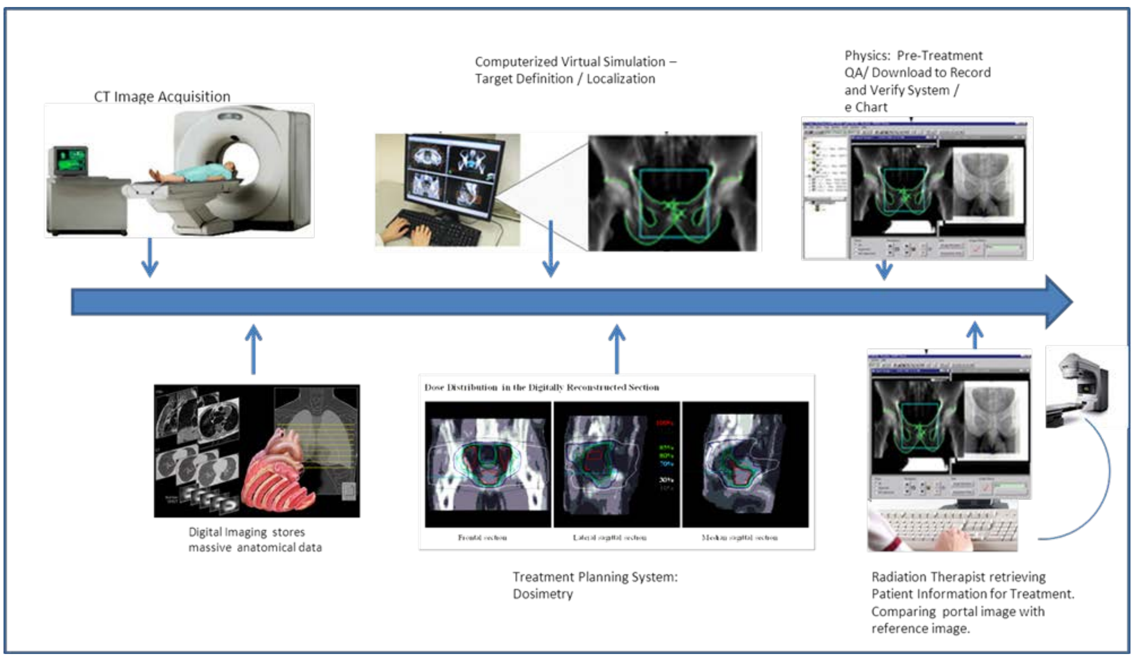



*Figure 13.* Modern technology treatment planning work flow diagram

In this respect, the patient data has circulated throughout the entire department, eventually downloaded to an electronic patient chart and into a record and verify system to be retrieved at the treatment machine by the radiation therapist. The patient is much less involved personally with their treatment planning than before. Aspects of human involvement in the transfer of data have also been eliminated as much as possible being replaced by automatic downloading from system to system until the treatment chart is called up for treatment. Studies to reduce risk probabilities in radiation therapy have concluded that an effective method to reduce error is by eliminating one person in the chain of processes thereby decreasing the chances of miscommunication and error (Ford, 2009). Another example where a new process replaces the radiation therapist specifically to reduce error involves the use of bar-code readers on the treatment control console to call up the correct patient record for treatment. A reduction in treatment error due to calling up the wrong patient record was achieved by requiring the patient to scan his own patient ID card across a bar-code reader instead of allowing the radiation therapist to search and call up the correct patient chart on the machine computer (Ford, 2009).

The radiation therapist works with large amounts of very different types of patient information stored within the different systems in use in the control area. The largest impression one gets when observing treatment delivery from the aspect of the treatment console is the many computer screens, each displaying a different piece of the treatment underway. The treatment process has grown from what was already very technical, to a very complex operation. Another difference seen from the past is the loss of steps in the treatment process that provided more human interaction with the patient on the table.

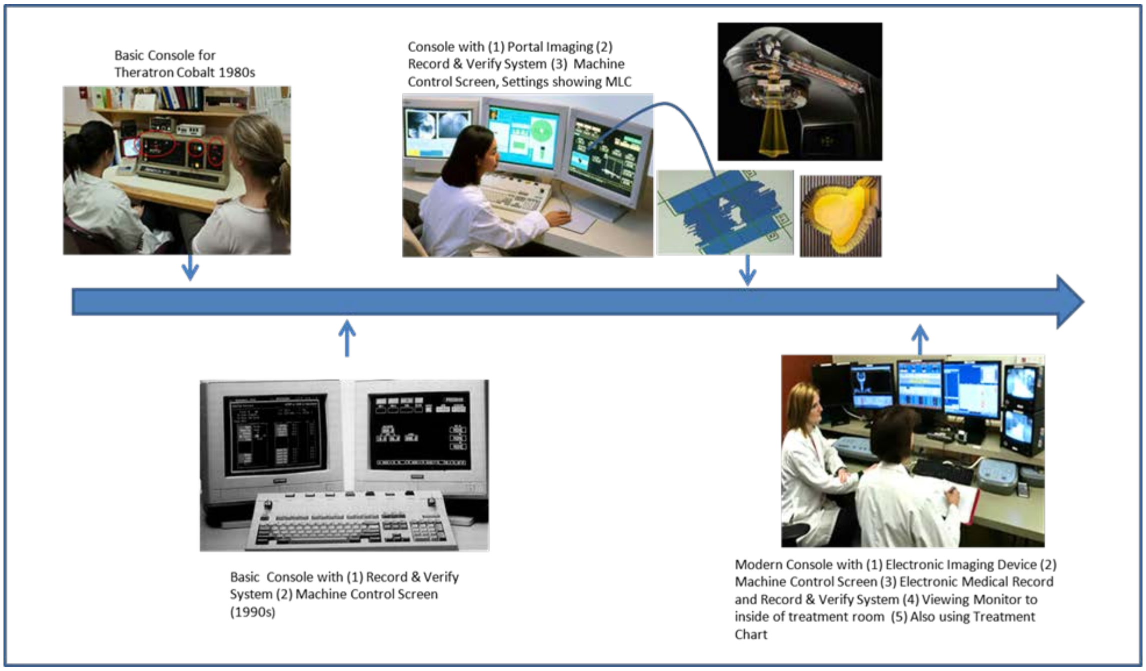



*Figure 14.* The evolution of the radiation therapy control console. Photos adopted from: French, J. (2010, June 24). Complex Systems and the Human Interface. Proceedings from *The American Association of Physicists in Medicine 2010 Safety in Radiation Therapy – A Call To Action, Miami, Fl.* Retrieved from http://www.aapm.org/meetings/2010SRT

Figure 6 provides an illustration of the progression and evolution of the information technology within the treatment control area. I have observed that in addition to the several screens pictured, computers may have several functions with different software integrated, with a simply keystroke calling up the other program running in the background, but not currently being displayed. The radiation therapists must divide their focus among the different levels of information being directed towards them during treatment to monitor accuracy. Figure 7 illustrates the kind of information that is typical of a treatment control work station. In addition to the traditional intercom and video monitor, are the record and verify system, modern linear accelerators included elaborate screen monitors displaying machine settings, electronic portal imaging, and the electronic charting system that may now have a record and verify integrated within that system with visual illustrations of the multi-leaf collimators and other machine parameters and device settings create a highly computerized work station. As pictured, some facilities still use paper charts as a redundant record of treatment delivery.

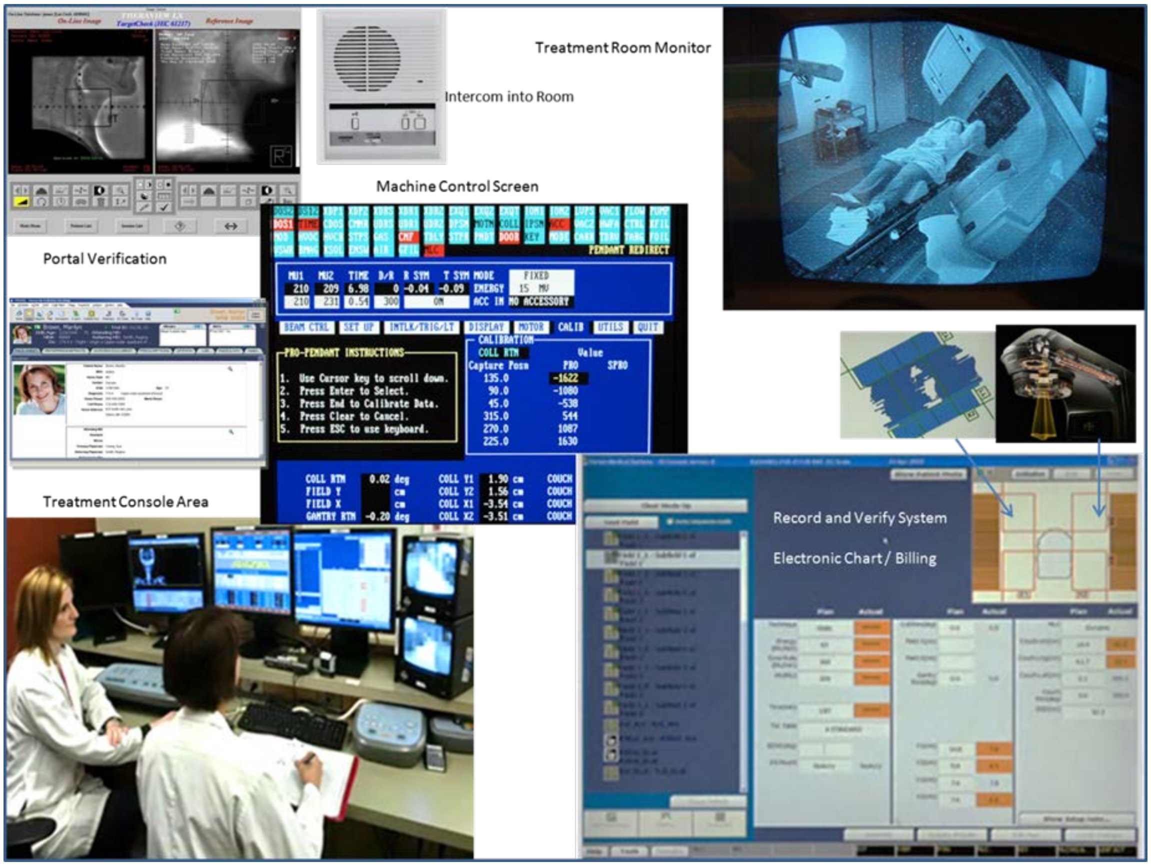



*Figure 15.* Complex Systems and the Human Interface for Modern Radiation Therapy. Photos adopted from: French, J. (2010, June 24). Complex Systems and the Human Interface. Proceedings from *The American Association of Physicists in Medicine 2010 Safety in Radiation Therapy – A Call To Action, Miami, Fl.* Retrieved from http://www.aapm.org/meetings/2010SRT

An important point to be made is that it is clear that maintaining the level of required awareness and to maintain focus on the multiple sources of information technology leaves little room and space within these work processes to contemplate foundational radiation therapy concepts. The mode is very operational, and critical. This illustration (figure 7) attempts to emphasize the multiple human interfaces competing for the radiation therapist's attention. Two points are to be made with this situation, **(1)** it is in this type environment where radiation therapists have failed to read critical messages regarding wedge orientation as well as failed to recognize a graphic illustration informing of totally open collimators. Two errors having fatal consequences for patients; (**2)** this environment demands mental activity geared towards technology operations. I have described the principle of knowledge appropriation as the overshadowing of foundational knowledge by operating knowledge that is gained and used to drive the technology systems. A second principle states that new technology, high degree of automation exacerbates the problem of rehearsing or recalling concepts by separating the user from fundamental processes. A third principle of knowledge appropriation states that gaps in foundational knowledge and knowledgeable practices (CSS, 1981) develop over time of no conceptual recall and failure to rehearse perceptions of concepts. In the role pictured and described, the phenomenon of knowledge appropriation continues to evolve over time as the technology continues to separate the user from fundamental radiation therapy.

A task analysis for radiation therapy treatment procedures was published in the 2010 edition textbook, Principles and Practice of Radiation Therapy (Washington and Leaver, 2010). Informed with data of my study, and using this as a comparison of previous documented treatment procedures, I have constructed a revised task analysis that reflects the modern role of the radiation therapist working with the most recent technologies. The task analysis is based on treatment delivery using multi-leaf collimation and newer aspects of patient positioning devices, modern practices using stored treatment setup data and machine parameters, and new treatment practices with aspects of treatment automation. Figure 8 illustrates a comparison of original tasks performed during treatment delivery with the new tasks reflecting the new treatment environment.

Task Analysis of Treatment Procedure

1. Review the chart (paper or e chart)
2. Prepare the room. Position immobilization devices on the treatment table and place treatment accessories within reach.
3. Greet and identify the patient.
4. Assist the patient onto the treatment table and into **the prescribed position.**
5. **Locate the surface landmarks.**
6. **Raise the couch, bringing the area to be treated to the beam area.**
7. Refine the patient position relative to the isocenter using lasers, field light, and surface landmarks. Perform setup verification procedures if required for treatment technique.
8. **Rotate gantry and collimator to prescribed positions.**
9. **Position beam shaping accessories (blocks) and visually verify using the light field.** Perform portal verification procedures if required by treatment technique.
10. Position beam modifiers (wedge, compensator, bolus).
11. **Inform patient that you are leaving and treatment will begin.**
12. **Monitor the patient (room camera, audio system).**
13. Set appropriate machine controls and review correspondence with prescribed values in the record and verification system.
14. Initiate beam-on. Monitor the patient and equipment function. When multiple fields are to be treated, do the following:
15. Validate parameters downloaded to accelerator and enable accelerator motion, **or enter the room and check the patient, field position, and beam modifiers.**
16. **Repeat steps 8 through 14 for all fields until the completion of treatment.**
17. Assist the patient from the couch and room.
18. Complete the treatment record.

Coleman, A. (2010). Chapter 33 Treatment Procedures. In C.M. Washington, & D.T. Leaver (Eds.), Principles and practice of radiation therapy: Practical applications 3rd edition. St. Louis, Mo: Mosby-Year Book Inc.

Task Analysis of Treatment Procedure Based on Multi-Leaf Collimation and Automation of Technology

1. Review the chart (paper or e chart)
2. Prepare the room. Position immobilization devices on the treatment table and place treatment accessories within reach.
3. Greet and identify the patient.
4. ***Adjust appropriate immobilization device base frame to table. Match the positioning indexing data recorded on the e-chart and device for proper placement to achieve coincidence of the base frame / table coordinates. This ensures proper placement of the immobilization base frame upon the table.***
5. Assist the patient onto the treatment table and into the prescribed position ***using immobilization device(s).***
6. ***Locate the reference indexing data on immobilization device. Match the positioning indexing data recorded on the e-chart and device for proper placement to achieve coincidence of the device / table coordinates. This ensures proper placement of the patient within the immobilization device now connected to the table.***
7. Raise the table, to ***the level of the isocenter referencing the lateral and vertical digital readouts of the record and verify system viewed on the computer screen inside the treatment room. Verify proper table rotational angle or set at "zero".***
8. ***Verify*** the patient position relative to the isocenter using lasers, field light, and surface landmarks ***and other data if possible.*** Perform ***other*** setup verification procedures if required for treatment technique ***QA policy.***
9. Rotate gantry and collimator to prescribed ***position for initial beam entrance from which the machine gantry will travel to deliver multiple beams for planned angles for IMRT or press "auto setup".***
10. Inform patient that you are leaving and treatment will begin.
11. Monitor the patient ***(room camera, audio system).***
12. Set appropriate machine controls and review correspondence with prescribed values in the record and verification system.
13. Validate parameters downloaded to accelerator ***for multiple fields according to treatment technique QA policy*** and enable accelerator motion.
14. Initiate beam-on. Monitor the patient and equipment function
15. ***Visually verify the "fluence patterns" of the mulit-leaf collimators on the machine console computer screen.*** Perform portal verification procedures ***with the Electronic Portal Imaging Device (EPID)*** if required by treatment technique ***"send" to doctor for electronic approval as per department policy.***
16. Position beam modifiers (wedge, compensator, bolus) ***between treatment fields and/or visually verify the (dynamic) wedge orientation with the graphics or text on the machine console computer screen.***
17. Assist the patient from the couch and room.
18. Complete the treatment record.

Revised from: Coleman, A. (2010). Chapter 33 Treatment Procedures. In C.M. Washington, & D.T. Leaver (Eds.), Principles and practice of radiation therapy: Practical applications 3rd edition. St. Louis, Mo: Mosby-Year Book Inc.

*Figure 16.* New Task Analysis for Treatment Procedure Based on Automated Technology.

The original listing of processes provides excellent material from which to compare and draw conclusive analysis that combines my findings of modern work processes with those previously documented by another radiation therapist. The bold print indicates processes that are no longer suited for modern practices. The red print indicates updated revisions informed by my study data. This comparison of written processes also allows further elaboration defining specific points of knowledge appropriation, additional danger points with risk probability for error, as well as defining a point of physical integration between patient and technology. I provide rational and elaboration for my revisions below.

Task Number and Explanation of Revision

(4) The original task simply states to assist the patient onto the treatment table.

**[4]** Modern radiation therapy calls for exact, reproducible position daily. The focus of accuracy due to the narrow beam of radiation has changed goals for patient positioning from using skin marks and positioning of larger anatomy like the hips, to accuracy along lines of organ movement. For this degree of accuracy, patients are fitted with specific immobilization devices. The devices are attached to base frames. These base frames are indexed using coordinates that line up with the treatment table. This ensures accurate reproducibility of the base frame before the patient is immobilized with the device. Coordinates are recorded in the appropriate section of the electronic chart and immobilization device. Figure 9 illustrates this transition from using simple tape and plaster for more difficult cases. The illustration also shows the evolution towards using many narrow beams instead of one or two larger beams. A table shows the "indexing" system for exact and reproducible positioning of the patient onto the table.

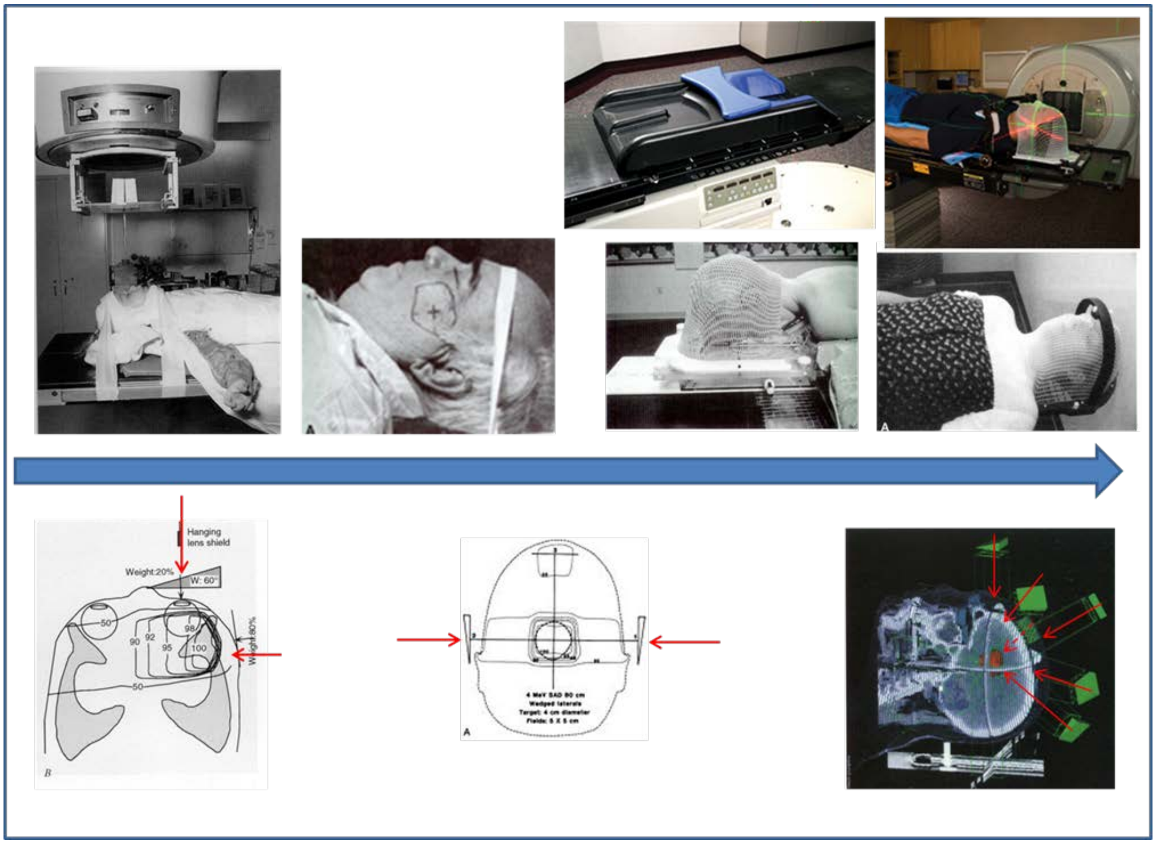



*Figure 17*. The Evolution of the Complex Patient Set up and Treatment Delivery.

(5) Locate the surface landmarks. Using surface (anatomical) landmarks no longer offer the degree of accuracy seen with modern treatment techniques.

(6,7) The original task instructs to raise the table using the field light and surface landmarks. Surface land marks refers to the surface of the skin.

**[4 – 7]** Modern devices and equipment, with specific machine parameters allow for quick and more accurate positioning. All patients are setup with an immobilization device to ensure no movement and better accuracy Except for the central axis, skin marks for full fields are not used. A patient may have no marks with all reference markings found only on an immobilization device. All patients are fitted with a device that also has positioning references on the thermoplastic device that cradles part of the patient's anatomy. With the base frame in the proper indexed table position, the patient is then positioned and locked in place on the base frame. Table, base frame, patient, and immobilizing cradle fitted to the patient are now physically joined as one. Coordinates for indexing each device are recorded within the electronic chart. The table is raised to the proper vertical measurement and positioned laterally to that proper parameter as read on the large digital screen within the room. Reference marks on the immobilization device are also used for proper positioning.

This is an important point as it may be perceived that (1) the patient is now locked onto the equipment and may move in conjunction to the operation of the treatment machine, and the computer treatment plan. (2) Raising the table (and patient) to the specific recorded vertical and lateral parameters according to the treatment planning system places the target – within the body of the patient at an extremely specific point in space where all technological equipment converge. This is the "isocenter" within the treatment room – the center or focal point of all systems engineered within the treatment room. For the technology in play, the patient is now a coordinate in space with a target that the software is programmed to hit with an intense beam of radiation from various angles.

This is an important point where the system turns the patient over to technology as the patient and machine become one and dependent on accurate machine settings, accurate alignment, entering correct data, and using the correct treatment plan. Figure 10 illustrates the exact point in space as the targets of all beams converge within the patient to deliver the prescribed total dose of radiation.

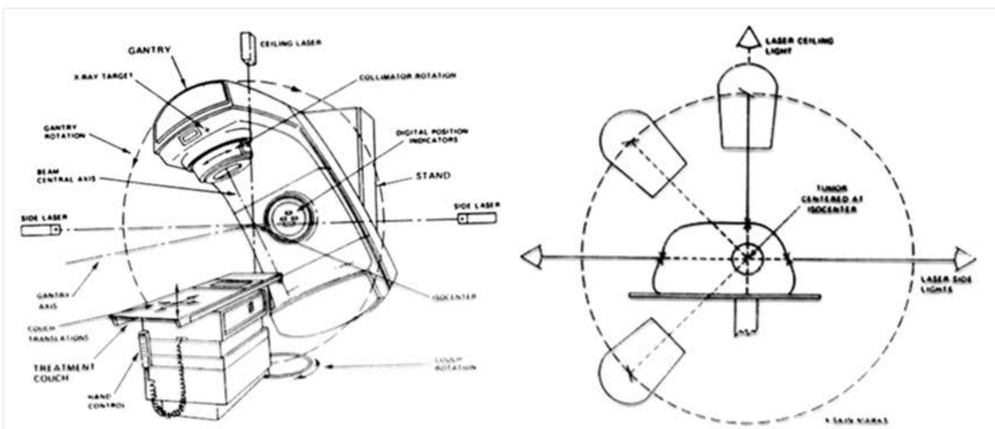



*Figure 18.* The Isocenter. The focal point of all systems in the treatment room. Adopted from Karzmark, C.J. & Morton, R.J. (1989). *A Primer on Theory and Operation of Linear Accelerators in Radiation Therapy, 2*. Wisconsin: Medical Physics Publishing Corporation.

(8) Rotate gantry and collimator to prescribed positions. The original process refers to rotating the gantry and collimator to prescribed positions.

(9) Position beam shaping accessories (blocks) and visually verify using the light field.

**[9]** Whereas the original task calls for rotating the gantry and collimator for the prescribed positions. I have revised this to reflect modern treatments using multi-leaf collimation with IMRT. In such cases the gantry angles are not set for each treatment field. The machine rotates around the patient while the collimators move to create specific beam shapes to match tumor volume from different approaches. This treatment is fully automated. The gantry may be set to the starting beam angle or the radiation therapist may activate the "auto setup" feature before exiting the treatment room.

(9) Position beam shaping accessories (blocks) and visually verify using the light field. Perform portal verification procedures if required by treatment technique. The original process refers to positioning the "beam shaping accessories," the blocks and personally checking the "blocked field" for each field. Also to take the appropriate "portal verification procedure" or the port film for each field being treated.

**[12 – 16]** The original task refers to positioning blocks and visually verifying the blocked field using the collimator light. Modern treatment machines use multi-leaf collimators for conformal radiation therapy and for IMRT. All fields may be treated without the radiation therapist entering the room between treatment fields. This is a very automated treatment delivery process.

This is an extremely important point in the process that contributes to both knowledge appropriation and increased risk probability for error and patient injury. Conformal radiation therapy facilitates treatment delivery with a continuous, non-stop progression from the first to the last treatment field. The following facts contribute to seeing less, doing less, and understanding less as related to typical conformal radiation therapy and IMRT.

- Safety: Patients are highly immobilized with special devices. Moving and speaking is limited hindering communication as compared to previous processes.
- Error Risk Probability / No Personal Observation to Make Knowledgeable Connections: Patients have less skin markings as treatment references, perhaps two or three "+" central rays (isocenter). Treatment includes multiple narrow beams as treatment fields, many more than in previous techniques. What were four-field prostate treatments now include as many as sixteen different IMRT beams. To avoid confusion, only the central rays are marked. This makes visual verification of any one beam impossible.
- Error Risk Probability / No Personal Observation to Make Knowledgeable Connections: Conformal treatments with MLCs of multiple fields are non-stop from first to last treatment field. Radiation therapists may not enter the room to verify visually once the treatments begin. This serves to separate further the user from the treatment process as the user never sees therefore may not think about the connection between what is displayed on the control screen and the patient.
- Error Risk Probability / No Personal Observation to Make Knowledgeable Connections: Conformal radiation therapy and IMRT may involve dynamic therapy with moving collimator leaves as the beam travels around the patient. A risk probability of error exists as radiation therapists may observe an animation of

> "fluence patterns" of leaves on the treatment console display. Although the diagrams may show leaf patterns moving in and out, the graphic lacks true meaning as accurate verification of correct sequence is not possible by visual observation alone.

Comparing modern tasks and processes directly with previously documented tasks show areas where the radiation therapist has been removed from the actual treatment process, eliminating opportunity to visualize aspects of the treatment. The process also removes the radiation therapist from the room as compared to previous periods of walking in to check on the patient during treatment (between fields), to check patient alignment, and to provide reassurance. Opportunities to visually verify the alignment of a gantry angle and make connections with the corresponding body part on either the right side or left side, or more detailed inspections of the actual site of treatment while the patient is in the treatment position are not evident with conformal and IMRT radiation therapy treatment as they were with previous treatment delivery techniques.

For the patient, restraining and immobilization by fixing the patient onto the treatment table may be perceived as using a system that literally turns the patient over to the technology. This is also <u>a critical point</u> as the process I have mapped suggests that when the patient is in the treatment position at the correct vertical and lateral parameters defined by the treatment planning system, the human on the treatment table is now the point in space – the digital "isocenter" the focal point of all systems in the room. That defined isocenter has been generated through the several stages of data transmission from system to system that may be traced to the patient's very first CT scan. Through process flow charts, one may observe the point where the patient's information was initially transformed into number data sets by the technology to create his or her digital profile leading to this very special point in space for treatment delivery.

# Appendix H:

## The Hierarchy of Thought and Logic for Chapter Five

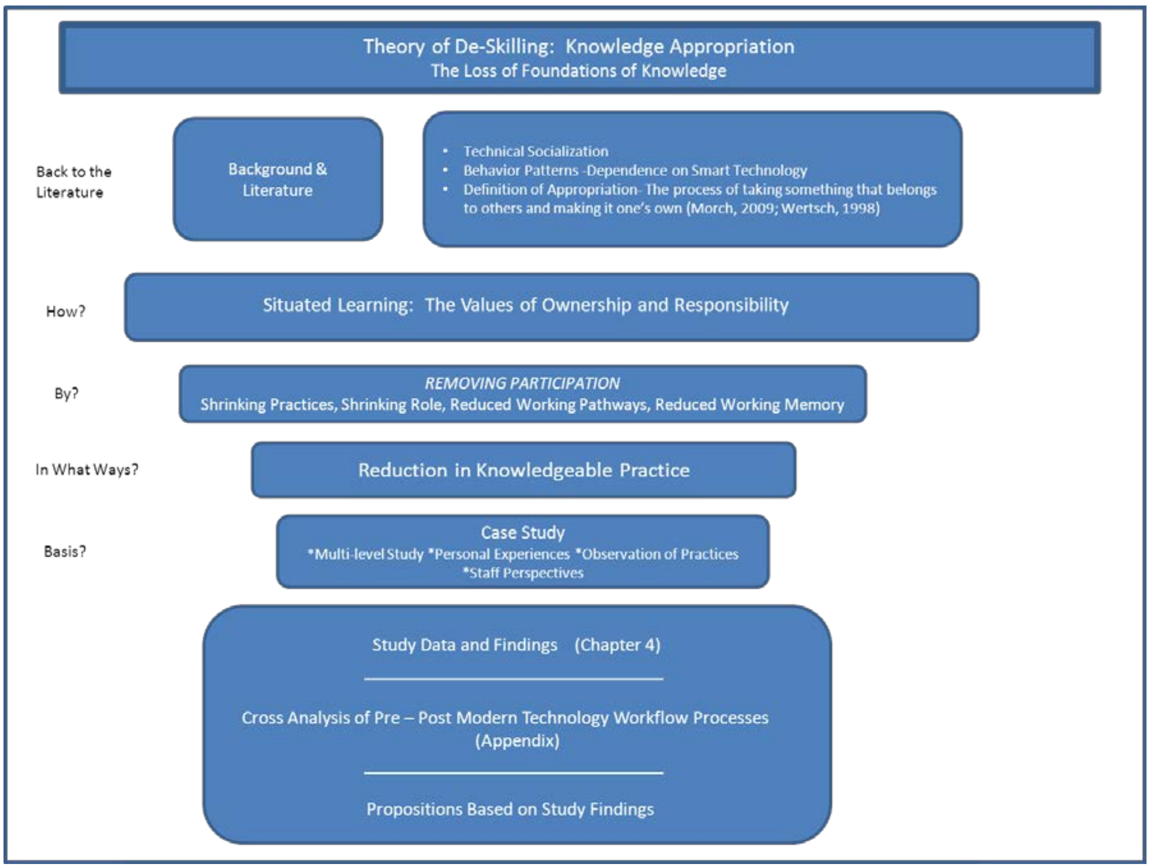



*Figure 19.* The hierarchy of thought and logic for chapter five.

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# VITA

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