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Shades of Grey: An Exploration of the Student Learning Experience in Diagnostic Radiology Education

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For my family
My parents, Barb and Laurie Linaker
My husband, Clint Eliason
Our daughter, Katie Eliason

Aren’t the most important questions facing our field related to how students learn and how they can be taught more effectively?

Johnson, 1995, p. 4

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ABSTRACT

Diagnostic radiology education is a specialty within healthcare education and encompasses education at both the undergraduate and resident level. There is little research regarding what constitutes effective radiology education. The broad purpose of this study was to investigate through the student perspective how chiropractic students learned diagnostic radiology within their curriculum and what contributed to this learning. This interview-based, qualitative research explored the learning experiences of 12 fourth-year chiropractic students at two colleges. Specifically this study investigated (a) the learning strategies students believe both worked and didn't work in learning radiology, (b) student perceptions of the effectiveness of instructional methods used by faculty, (c) the challenges faced in learning radiology and how students addressed these challenges, (d) the recommendations that students offer for both faculty and for peers regarding the teaching and learning of radiology, and (e) whether the learning strategies and perceived effective instructional methods are reflective of the resources found in course syllabi. The key findings of this study were that students strongly preferred active learning experiences, students want real life clinical cases incorporated into their learning experiences, radiographic search patterns and appropriate vocabulary should be implemented throughout the curriculum, the style of examination drives the learning experience and attention must be paid to selecting appropriate examinations in order to

prevent strategic studying, syllabi are not well utilized, and the biggest challenge students face in learning diagnostic imaging is effective time management.

Recommendations for future practice arising from this study include: increase active learning activities; provide anatomical models in normal radiographic anatomy laboratories and examples of normal radiographs in pathology laboratories; incorporate radiographic search patterns and vocabulary throughout all classes; utilize challenging examination formats and allow students to review exams; utilize clinical cases as much as possible; establish safe, challenging learning environments; develop syllabi that fulfill the functions of an effective syllabus; increase institutional support of scholarship in teaching and provide faculty development programs that model safe, challenging, learning-experiences; and provide time management and study skill training to first term students.

CHAPTER I

INTRODUCTION

Background and Context for the Study

There is very little research regarding what constitutes effective radiology education. This study is an exploration of how students experience learning diagnostic radiology during the curriculum at chiropractic colleges. It allows the field to better understand which pedagogy(ies) may be most effective in teaching undergraduate diagnostic radiology. This knowledge can then be applied to future curricular revisions and utilized as the groundwork upon which to build future research.

Diagnostic radiology education is a specialty within healthcare education and encompasses education at both the undergraduate and resident level. Undergraduate level education can be defined as four-year first-professional degree programs such as Medical Doctor (MD), Doctor of Chiropractic (DC), and Doctor of Osteopathy (DO). Resident-level education encompasses postdoctoral specialized training and can vary from two-to-five years in length, depending upon the area of study. Diagnostic radiology is a subsection of radiology that focuses on diagnosis and not on interventional imaging or radiation treatment.

As with most areas of education, diagnostic radiology education is a complex mix of varying pedagogy, assessment, and administration – all governed by beliefs about what should be taught, when it should be taught, and how to most effectively teach the

information. While there are many opinions in the literature in all of the health sciences with diagnostic radiology specialties (allopathic, podiatric, chiropractic, dental, veterinary and osteopathic) about what constitutes "good education," usually presented with the author stating his or her opinion of "what should be taught" (Collins, 2000; Croy & Dobson, 2003; Subramaniam & Gibson, 2007; Subramaniam, Kim, Scally, & Tress, 2003) or "how it should be taught" (Gunderman, Williamson, Frank, Heitkamp & Kipfer, 2003; Williamson, Gunderman, Cohen, & Frank, 2004), a dearth of literature exists that examines how diagnostic radiology is taught, learned, or evaluated. Nor is there much research that compares different diagnostic radiology programs with regard to any of the myriad of variables that exists within a given curriculum. What little literature exists clearly demonstrates that undergraduate diagnostic radiology education, diagnostic radiology curriculum, and diagnostic radiology pedagogy vary widely between disciplines and even between colleges within disciplines (Barlev, Lautin, Amis & Lerner, 1994; Subramaniam, Kim & Scally, 2007). The paucity of literature addressing these issues has been summarized recently with the succinct statement that "evidence-based radiology education and radiology education research are glaringly lacking" (Tay, Kamei, & Tan, 2009, p. 195).

Chiropractic education, unlike other healthcare programs, has long incorporated formal courses in diagnostic radiology throughout its undergraduate curricula. In general, chiropractic curricula include courses on radiation physics, radiation protection, radiographic positioning (the obtaining of radiographs), normal radiographic anatomy, bone pathology, and soft tissue pathology. On average, in undergraduate chiropractic

education in North America, 360 hours are dedicated specifically to diagnostic radiology education (see Appendix A). Diagnostic radiology classes generally begin in the first or second term of the program, and continue every term until students have completed the didactic portion of their education and enter full time clinic in year four. In addition, portions of the National Board of Chiropractic Examiners (NBCE) exam are devoted specifically to diagnostic radiology content (NBCE, 2012).

Allopathic and osteopathic medicine programs have highly variable radiology curricula (Tay et al., 2009). Many do not have dedicated diagnostic radiology courses within their undergraduate programs and the United States Medical Licensing Examination does not have radiology-specific portions within its examinations (Examination, 2008). The American Dental Association Licensing Examination does have a radiology-specific portion contained within its Part Two examination, but it is limited to radiation physics and normal anatomy of the oral cavity (American Dental Association, 2008). As such, it does not examine the breadth that the NBCE (2012) does with regard to diagnostic radiology interpretation. The podiatric programs, by definition, are focused on the lower extremity of the human body. Accordingly, the National Board of Podiatric Medical Examiners (2008) focuses its examinations on the lower extremity. Consequently, the podiatric qualifying examination also does not have the breadth of the NBCE examination. Veterinary programs, and thus the National Board of Veterinary Medical Examiners (2008), do not cover human diagnostic imaging.

The Council on Chiropractic Education (CCE) provides accreditation standards for the 18 chiropractic education programs in the United States, while the Canadian

Federation of Chiropractic Regulatory and Educational Accrediting Boards (CFCREAB) provides accreditation standards for the two chiropractic education programs in Canada. These two agencies belong to an international accrediting body that ensures that all member colleges worldwide offer programs that will meet licensure standards. These agencies ensure that a minimum standard is maintained at all colleges in relation to all aspects of the educational process.

An exploration of how students experience learning diagnostic radiology during the curriculum at chiropractic college would allow the field to better understand which pedagogy(ies) may be most effective in teaching undergraduate diagnostic radiology. Allopathic and chiropractic physicians (Christensen, 2005) are both considered primary health care providers and are granted licenses that include the interpretation of radiographs within their scope of practice. Both professions are entrusted by the public to order and interpret radiographs in order to effectively manage patient care and practitioners have varying skill levels in interpreting radiographs (Taylor, Clopton, Bosch, Miller, & Marcelis, 1995). A reasonable starting point to address the lack of research defining effective pedagogy for diagnostic radiology education would be to perform an exploratory study into the experiences of fourth-year interns at chiropractic colleges in the United States.

Such a study is important for several reasons. First, it will provide a reflection of what students experience in their diagnostic radiology courses. Second, it will demonstrate what the students believe to be effective delivery, learning resources, and study methods of the material. Third, it will provide a baseline study that will allow

future exploration of any common themes discovered during the course of the study. Fourth, any specific pedagogy identified by the participants as particularly beneficial or unhelpful would serve as a springboard for further investigation into improving diagnostic radiology education. Fifth, tangible findings would enable individual instructors to reflect on how their particular course design could be altered to enhance student learning. Finally, it will provide a foundation of information that will encourage future discourse and research into evidence-based diagnostic radiology education.

In my experience as an administrator at four educational institutions, radiologists often spend years teaching diagnostic radiology to their students and rarely reflect on the methods that they utilize to instruct those students. They often utilize the same lectures, learning resources, and laboratory radiographs for years with little or no alteration in the material. This is not unusual as teaching has historically been viewed as "a routine function, tacked on, something almost anyone can do" (Boyer, 1990, p. 23). The idea that teaching skills are inferior to research skills persists in current medical education realms (Chen, 2009; Shapiro & Coleman, 2000). Teaching is often the neglected area of scholarship in higher education (Boyer, 1990). This is particularly true in clinical education, of which radiology education is a subcategory, in that physicians fail to turn their experience into scholarship. Physicians do not "systematically assess the effectiveness of different techniques and communicate these findings in a way that allows others to benefit from that expertise" (Shapiro & Coleman, 2000, p. 896). Physicians need to learn what makes an educator effective and then apply that knowledge within their given area of expertise in order to successfully facilitate student learning (Collins,

2006; Fincher, 2000). Gathering student experiences gained within these courses, and examining their beliefs about what was truly effective within the learning experience, one can find a starting point to begin to address this lack of scholarship. By investigating student perceptions of the various aspects of pedagogical approaches in diagnostic radiology education, one can begin to determine their effectiveness. From that, one can start to address this failure to convert experience into scholarship in diagnostic radiology education. The knowledge gained through this process can then be applied, allowing faculty to improve classroom outcomes.

The types of instruction the students experienced and their reflections about their effectiveness about them are a key area of inquiry. It would be useful to discover what proportion of a course is delivered in traditional lecture-based instruction (a passive learning mode), as opposed to laboratory instruction, self-assessments, or small group discussions (active learning modes) and how the participants view the effectiveness of each type of delivery. This poses a particularly challenging question because what little literature exists examining this topic is contradictory. For instance, a recent, preliminary study suggests that learning to interpret radiographs may require a formal, rather than experiential, educational pedagogy (Margolis, Nilsson, & Reed, 2003) whereas other studies have concluded that lectures may not be an important factor in long-term retention of radiology (Chan, 2009) or that case presentation formats are just as effective (Smith, Berbaum, Franken & Ell, 1986).

Assessment methods have long been shown to correlate with depth of understanding and level of retention of material (Fisher, 1981; Halpin, 1981; Kulhavy &

Anderson, 1972) and they continue to raise several questions in medical education (Bruno, Ongaro, & Fraser, 2007). How were students assessed? Did the type of assessment change their preparation? Did they study in groups, by themselves, or both? What learning resources are utilized by students? Did they experience different assessment styles? If so, how did that affect their experience in the class and their perceived learning? Did they utilize the required and recommended texts, readings, learning files, websites, and other resources suggested by the faculty? Why or why not?

Theoretical Framework for this Study

My experience in teaching radiology has led me to think that students master the material best when they understand how it relates to clinical applications and when they actively perform radiographic interpretations through self-evaluations and examinations. Students seem to respond particularly well to laboratory situations with extensive interactions between the students and instructors where they are immersed in active discussions of actual cases. These observations relate to Lev Semyonovich Vygotsky's (1962) theory of social constructivism and the work of two different educational theorists, David Kolb and Malcolm Knowles. The experiential learning theory developed by David A Kolb (1984) and Malcolm Knowles' (1990) work on adult education, or andragogy, will provide a framework for making meaning of the students' experiences in this study.

Social constructivism holds that learning occurs as a result of an individual's social interactions (Atherton, 2010; Vygotsky, 1962). Examples of this type of learning activity include collaborative learning, case based instruction, games, and problem

solving (Chen, n.d.). Social constructivism has been tied to both the experiential learning theory (Holman, Pavlica, & Thorpe, 1997) and andragogy (Huang, 2002).

The experiential learning theory, developed by David A Kolb (1984), is often summarized with the Chinese proverb "Tell me and I'll forget; show me and I may remember; involve me and I'll understand." Essentially, Dr. Kolb theorizes that individuals continuously gain knowledge through their personal experiences. Gaining knowledge effectively requires that learners be actively involved in the educational experience so that they can reflect on, and make meaning of, the experience so that they can apply the knowledge in future situations. Experiential learning theory is widely accepted and utilized in many settings, but there are questions about its empirical validity and the quality of the research evidence in the literature (Cantor, 1997; Gosen & Washbush, 2004; Kayes, 2002).

Experiential learning theory is often discussed in medical education in relation to simulation training for clinical evaluations through the use of mannequins, simulated patients (actors), and actual patients (Bokken, Rethans, Jobsis, Duvivier, Scherpbier & van der Vleuten, 2010; Brin, Venkatan, Gordon & Alexander, 2010; Rosenbaum & Ferguson, 2006). As radiology is a clinical skill, one would expect that experiential learning theory would be utilized in radiology education research. However, this concept has not been reflected in the radiology education literature.

Malcolm Knowles' (1990) work on adult education, or andragogy, is based upon his belief that adults are self-directed learners who expect to take responsibility for decisions. Essentially, he proposes that adults learn best when they understand why they

need to learn something and when they can gain knowledge through active learning styles such as problem solving, role-playing, case studies, or self-evaluations. While this is probably the most widely accepted theory related to adult education, it is not without its critics. The main criticisms of this theory are a lack of consensus about what procedures constitute andragogical practice and that few studies have attempted empirical investigation of its use (Merrriam, Caffarella, & Baumgartner, 2007; Rachal, 1994, 2002; Taylor & Kroth, 2010). Others question the assumptions Knowles makes regarding adult learners, as arguments can be made that many, if not all the assumptions, can also be applied to children (K. Hibbert, personal communication, October 18, 2010).

There are five assumptions that set andragogy apart from pedagogy, the teaching of children: (1) as people mature they become more independent, (2) experience serves as the basis for new learning, (3) readiness to learn is related to events in the learner's life, (4) adults tend to approach learning through problem solving, and (5) adult motivation is internal in nature (Galbraith & Simon-Galbraith, 1984). These assumptions blend with clinical education methods inclusive of radiology education. However, only a handful of articles relate andragogy to clinical education, mainly in relation to problem-based learning (Blair, Templeton & Sachdeva, 1996).

Purpose of the Study and Research Questions

The broad purpose of this study is to investigate through the student perspective how chiropractic students learn diagnostic radiology within their curriculum and what contributes to this learning. This interview-based, qualitative research explores the learning experiences of 16 fourth-year chiropractic students at two colleges regarding

their learning of diagnostic radiology within their professional program. Specifically this study investigates (a) the learning strategies followed by students that they believe both worked and didn't work in learning radiology, (b) student perceptions of the effectiveness of instructional methods used by faculty, (c) the challenges faced in learning radiology and how students addressed these challenges, (d) the recommendations that students offer for both faculty and for peers regarding the teaching and learning of radiology, and (e) whether the learning strategies and perceived effective instructional methods are reflective of the resources found in course syllabi. This knowledge can then be applied to future curricular revisions and utilized as the groundwork upon which to build future research. Toward that end, the following questions will guide this study:

1. What learning strategies do students follow to successfully master the radiology courses in their program and which strategies worked best and which ones did not work for them?
2. To what extent do students believe instructor teaching approach effectively led to their learning radiology? What instructional approaches worked and did not work for students?
3. What specific challenges do students face in learning radiology and how do they overcome these challenges?
4. What recommendations do students have for faculty regarding the teaching of radiology?

5. What recommendations do students have for peers who are about to begin their radiology courses?
6. Do learning strategies, assignments, study materials, and instructional approaches described by faculty in course syllabi align with what worked for students in their learning of radiology?

Definition of Key Terms

Healthcare education terminology differs somewhat from standard educational terminology. For that reason, terms used throughout this study are defined below.

Undergraduate: a student in medical school or chiropractic college working towards a Doctor of Medicine or Doctor of Chiropractic Degree.

Pre-professional education: any education prior to the start of a first-professional degree.

First professional degree: any degree program that leads to a profession that requires licensure such as medicine, podiatry, chiropractic, or veterinary medicine.

DC: degree designation for a Doctor of Chiropractic.

MD: degree designation for a Medical Doctor.

Residency: Chiropractic – A residency is an optional 3 or 4-year full-time program undertaken by an individual with a DC, designed to lead the individual to a chiropractic specialty.

Residency: Medical – A residency is a required 3, 4, or 5-year full-time program undertaken by an individual with an MD, designed to lead the individual to a medical specialty.

Clerkship: a clinical rotation taken by an undergraduate medical or chiropractic student.

Internship: a formal clinical training period, in which the student is actively involved in patient care.

Radiology – unless otherwise noted, this refers to diagnostic radiology.

Conclusion

The goal of this chapter has been to introduce an exploratory study of student experiences in diagnostic radiology curricula in chiropractic colleges in the United States. To date, no significant inquiry has been undertaken into how students perceive they learn diagnostic radiology or what they believe worked in relation to their learning experience in diagnostic radiology. An investigation of these areas will reveal common themes in relation to these areas and create a basis for further study.

The following two chapters offer information about what is already known about the teaching and learning of diagnostic radiology at the undergraduate level and detail the methods that will be utilized for this study. Chapter II includes a comprehensive review of the literature investigating undergraduate diagnostic radiology education. It also includes a summative review of topical areas in resident diagnostic radiology education. The resident level information is included in order to fully explain the methodologies currently utilized in diagnostic radiology instruction as the undergraduate level literature does not address all areas of diagnostic radiology pedagogy. Chapter III describes the methodology that will be utilized for this research study. Discovering how students experience learning diagnostic radiology in chiropractic undergraduate curriculum will

provide information that is lacking in current radiology education research. This will benefit the health care education community as a whole and will hopefully lead to a more effective learning experience for undergraduate students.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

Introduction

"Aren't the most important questions facing our field related to how students learn and how they can be taught more effectively?" (Johnson, 1995, p. 4). Until recently, only a handful of radiology educators have voiced these questions and pursued meaningful answers (Calhoun, Vydareny, Haken & Blane, 1988; Collins, Kazerooni, Vydareny, Blane, Albanese & Prucha, 2001). As a result, little literature examines how radiology is taught, learned, or evaluated at the resident level and even fewer articles examine undergraduate radiology education specifically. Almost no literature examines the experience of the student as she seeks to master the ability to interpret imaging.

The articles relating to radiology education can be grouped into four general topics: (a) curriculum including both undergraduate and resident level curricula; (b) student evaluation and outcome assessments including national board examinations; (c) pedagogical methodologies such as case-based instruction, technology assisted instruction, and problem solving; and (d) training faculty to be effective teachers. This chapter reviews this literature in order to provide a foundation of knowledge for the study. This study focuses on the experience of the undergraduate chiropractic student in the radiology curriculum. As there is a significant amount of similarity found in resident and undergraduate radiology training, and these share similar needs and often utilize the

same resources (Collins et al., 1999), both the undergraduate and resident literature will be included in this chapter.

The first section of this review will examine the radiology curriculum literature at both the undergraduate and resident levels. The second section will examine the literature relating to student evaluations, learning outcomes, and national board examinations. The third section will describe pedagogical approaches including methods of instruction and delivery of curricular information. The fourth, and final, section will examine the literature relating to the training and preparation of radiologists to function as teachers.

Radiology Curriculum

Undergraduate Curriculum

Approximately 29% of American allopathic medical schools have a required core radiology clerkship (Samuel & Shaffer, 2000); while 72% offer a radiology elective. This required clerkship is becoming less common: a similar study in 1994 found that 32% had required radiology clerkships (Barlev, Lautin, Amis & Lerner, 1994). Internationally, hours spent in formal radiology training in undergraduate medical programs vary even more: a 1997 survey of 20 countries and 70 universities reveals that the variation in hours dedicated to radiology ranged from 0 to 88 hours over the entire medical undergraduate degree programs (Ell, 1997). However, 87% of 322 surveyed non-radiologist physicians believe that formal radiology education should be mandatory in medical school (du Cret et al., 1994), and a 2003 article found that practicing

physicians overwhelmingly support radiology electives in the curriculum (Shepherd, Dudewicz & Hindo, 2003).

Much of the literature regarding undergraduate medical radiology education centers on the importance of radiology education and, in particular, a formal radiology curriculum, (Afaq & McCall, 2002; Cassumbhoy & Lau, 2007; Lee, Aldrich, Eftekhari, Nicolaou, & Muller, 2007; Scheiner, Noto, & McCarten, 2002; Subramaniam, Sherriff, Holmes, Chan, & Shadbolt, 2006) and what it should entail (Lewis & Shaffer, 2005; Mullins, Lieberman, Shaffer, & Novelline, 2005; Subramaniam & Gibson, 2007; Subramaniam, Kim, Scally, & Tress, 2003), when it should be taught (Branstetter, Faix, Humphrey & Schumann, 2007; Branstetter, Humphrey & Schumann, 2009) and ways to incorporate radiology education into it, whether in the form of an integrated curriculum (Ekelund & Elzubeir, 2000; Ekelund & Lanphear, 1997; Ekelund & Langer, 2004), an independent curriculum, or some combination of the two (Anderson & Jost, 1988b; Collins, Reddy et al., 2001; Relyea-Chew & Chew, 2007; Robinson & Voci, 2002; Vydareny, 1985). This is problematic because not enough hours exist in the undergraduate medical program to adequately accommodate all the courses stakeholders wish to include in the curriculum (Afaq & McCall, 2002; Buckenham, 2005; Chapman, 1982). In addition, the stakeholders often have disparate goals, even when agreeing on curricular content (Anderson & Jost, 1988a; Subramaniam, Beckley, Chan, Chou & Scally, 2006; Subramaniam, Sherriff, Holmes, Chan & Shadbolt, 2006). Complicating factors are numerous (Gunderman, 2005b) and include poor remuneration for radiology clerkship coordinators and other academic radiologists (Choen, Gunderman, Frank, &

Williamson, 2005; Samuel & Shaffer, 2000), changing demands due to health care reform (Barlev & Amis, 1994), faculty members' time constraints (Choen, Gunderman, Frank, & Williamson, 2005), and the fact that radiology instruction in problem-based learning curricula is often performed by non-radiologists (Subramaniam, Scally, & Gibson, 2004). This issue has been present in the literature for decades (Bull, 1974; Clark, 1936; Freimanis, 1970; Hood, 1966; Syme, 1971; Syme & Bloomfield, 1985), crosses into the chiropractic undergraduate literature (Marchiori, 1996), and continues to worsen. The wealth of knowledge undergraduate medical students must assimilate during their four-year tenure continues to increase with the ever-expanding body of medical knowledge (Robinson & Voci, 2002). In fact, recent articles suggest that new graduates exhibit a minimal level of radiology knowledge—to the point that approximately half of graduates do not know the risks of common investigations or how to select the appropriate clinical investigation (Holt, 2001; Jeffrey, Goddard, Callaway, & Greenwood, 2003; Marchiori, Adams, & Henderson, 1999; Subramaniam, 2005; Subramaniam, Hall, Chou, & Sheehan, 2005). This translates to an enormous risk to patients.

Bloomfield (1977) argues that a comprehensive radiology-teaching program is needed in the undergraduate medical curriculum in order for all physicians to adequately interpret images when a radiologist is not immediately available and to know what imaging modality to order. Interacting with radiologists is something virtually all practitioners will do throughout their practice lives. He presents his experiences as the sole developer and instructor of a radiology educational program at a medical school in

Tasmania. He further suggests that a similar program needs to be incorporated into all medical colleges (Bloomfield, 1978, 1982, 1987) and recommends that radiology should be "the *key* subject in the medical curriculum" (Bloomfield, 1982, p. 981). Bloomfield (1978) develops this argument by explaining how he structured the courses to be in the form of tutorials rather than in basic lecture format. He found that students respond favorably to this teaching style and that evaluations ensured students grasped the necessary information. Similarly, in the 1980s, the University of Adelaide Medical School in Australia incorporated a six-week clinical skills training program in the fifth year of a six-year program that included nine hours in radiology: this inclusion was greatly appreciated by both the faculty and students (Albertyn, Davies, Newble, & Tucker, 1987). The University of Adelaide Medical School program echoed an earlier formalized teaching program in diagnostic radiology in a clinical undergraduate course at the University of Liverpool in England (Whitehouse, Scarrow & Evans, 1979).

The American Association of Dental Schools has published curricular guidelines for oral radiology that specify not only what needs to be taught, but also how to teach it, specifying that the students must have didactic and demonstration-type teaching, in addition to taking and interpreting radiographs ("American Association of Dental Schools curricular guidelines for oral radiology," 1980). In addition, these guidelines also specify the qualifications required of the individuals teaching these courses.

Several articles describe ways to alter the curriculum to integrate radiology in a variety of courses and times during students' training. For instance, integration of radiology lectures into third-year student internal medicine clerkships has been attempted

and was found to be just as favorably received by students as independent radiology lectures. However, while the study did evaluate compensation for the instructors for the two different courses, it did not assess the courses' effectiveness by comparing their outcomes (Collins, Dotti, & Albanese, 2002). Therefore, it is unclear from the article whether, academically, this is a worthwhile curricular revision.

Another form of integration, studied at Emory University College of Medicine and the University of Iowa College Of Medicine, is the merging of radiology and anatomy courses (Burkill, 2003; Chowdhury & Wilson, 2009; Chowdhury, Wilson, & Oeppen, 2008; Erkonen, Albanese, Smith, & Pantazis, 1990, 1992; Erkonen, Vydareny, Sandra, Ferguson, & Kreiter, 2000), including using digital radiographic images alongside the cadaver in digital anatomy teaching suites (Miles, 2005). This was shown to be effective at both institutions and is dependent on neither the instructor nor the institution (Erkonen et al., 2000). Similar curricular reform has been implemented at the University of Maryland, School of Medicine, where radiology education has been integrated into the second- and third-year core clinical clerkships (Lowitt, 2002). Other colleges are incorporating radiology into the basic anatomy classes at the start of the students' program (Allen & Roberts, 2002). A recent curricular change at Wake Forest University School of Medicine has resulted in a radiology clerkship supported by web technology, and preliminary evaluations have found that, while the students learned well with this approach, the implementation of the clerkship has been problematic in its administration (Chew, 2002; Chew & Relyea-Chew, 2002). An earlier attempt at

integrating radiology into another course was undertaken in the 1960s through the use of cinefluorography in a medical pharmacology course (Keats, Cochran, & Sweeny, 1965).

A small subsection of this area of literature deals with the debate of what, exactly, should be taught to the undergraduate level students. For instance, one article proposes a specific set of educational objectives for medical student radiology training to prepare qualified future junior medical staff in a general practice setting (Subramaniam, Kim, Scally, & Tress, 2003). Other articles propose general curricular content for medical student instruction. The authors posit radiation protection (Singh, McCoubrie, Burney & Ash, 2008) or suggest components of an overall radiology curriculum for medical students, such as cardiothoracic radiology, sonographic physical diagnosis, or the use of PACS for case presentation (Angtuaco, Hopkins, DuBose, Bursac, Angtuaco & Ferris, 2007; Collins, Reddy et al., 2001; Novelline, Scheiner, Mehta, & Mullins, 2001).

Resident Curriculum

In recent years, many articles have been published discussing the need for a well-defined, quality curriculum for radiology residencies. Arguments supporting a national curriculum for radiology abound, with many editorial and political articles and letters addressing the topic. Some of the articles merely discuss the definition of curriculum, arguing that it be more than a simple list of subjects. Other articles borrow heavily from educational literature and present the concepts of goals and objectives, the dynamic nature of curricular content, methods of instruction, faculty training, infrastructure needs, and methods of evaluating both faculty and students (Chew, 2003; Choen, Gunderman,

Frank, & Williamson, 2005; Collins, 2000; Mundy & Binet, 1995; Williamson, Gunderman, Cohen, & Frank, 2004). They do so to explain that it is imperative that radiology education adopt these educational models to adequately educate future radiologists (Collins et al., 2005).

Many of the articles present proposals for curriculum in specific areas of radiology, including cardiothoracic, musculoskeletal, mammography, or pediatric radiology (Babcock, 2002; Bakshi, Alexandrov, Gomez & Masdeu, 2003; Bassett, Cassady & Gold, 1991; Collins, 2000; Collins et al., 2005; Flemming et al., 2007; Kazerooni et al., 2000; Resnik, 1999; Resnik et al., 1999; Smith & Schlesinger, 1995); proposals for new topic areas such as imaging informatics and electronic imaging technology specialists (Bartholmai, Erickson, Hartman, King, James, Hangiandreou & Williamson, 2001; Siddiqui, Weiss, Dunne & Branstetter, 2006); arguments about the degree to which specialization should occur (Alderson, 2000; Arenson & Dunnick, 2006; Bacon, 1972; Dunnick, Applegate, Arenson & Levin, 2006); and topics that should or should not be included in the curriculum (Collins, 1996; Cuttino & Scatliff, 1979; Theros, 1969). Arguments of this nature can be found dating back to the 1960s. A few authors demand not only that a standardized national curriculum for radiology residencies be defined (Chew, 1990) and that the institutions be required to follow the guidelines (Brummett, Brummett & Robinson, 2001), but also that the radiology board exams test from the curriculum (Goske & Reid, 2004).

Authors also describe radiology education in its current manifestation, how it was developed, or how it was historically taught in their area of the world (Baddeley &

Middlemiss, 1973; Berquist, 2008; Felix, 1993; Isherwood, 1993; Moncada, 1993; Moncada et al., 1993; Rubin, 1969; Thomsen, 1994; Young, 2000). Many European medical schools are now offering master's degrees in conjunction with their residency programs (Flodmark, 2003). This is also a trend in the chiropractic radiology residency programs with master's programs currently offered at National University of Health Sciences and New York Chiropractic College (Mestan, Taylor, Blackshaw, & McDonald, 2006). The University of Glenmorgan College of Chiropractic and Life University are currently developing similar master's programs (Radiology, 2005).

A subsection of the curriculum discussion focuses upon non-interpretive skills (Alderson, 1999; Gunderman, 2001) that radiologists will need during their professional lives, such as job search and contracting skills (Collins, 1999), business savvy, professional standards, ethics (Chertoff, Pisano, & Gert, 2009; Gunderman, 2001; Oljeski, Homer, & Krackov, 2004; Vydareny, 2004), accreditation programs, critical thinking skills, interpersonal skills, communication skills (Goske, Reid, Yaldoo-Poltorak, & Hewson, 2005; Ouellette, Kassarjian, & McLoud, 2006), research skills (Baum, 2000), and medical organizational politics (Wood et al., 2004). One article describes a collaborative effort undertaken by the American College of Radiology and the Association of Program Directors in Radiology to meet this curricular need within residency programs. This effort entailed designing a set of videotapes to teach residents these skills (Collins, Amsel, & Alderson, 2001). This study found that the videotapes were an effective teaching method and that significant resident learning occurred as a result of viewing the videotapes. Feedback from residents and residency directors was

very positive. Additional skills requiring mastery by radiology residents are effective communication and an understanding of guidelines for making the most appropriate imaging or treatment decision for a specific clinical condition (Vydareny, 1997). In fact, the Accreditation Council for Graduate Medical Education mandates that radiology residency programs teach residents communication skills ("Medical school objectives project, report III contemporary issues in medicine: communication in medicine," 1999).

Interestingly, discussions exist of the importance of radiology training for residents in other medical specialties such as orthopedics (Chew & Smirniotopoulos, 1995), pediatrics, internal medicine (Bingley Jr, Messaros, & Anderson, 1988), family practice (Thompson, Berbaum, George, & Ely, 1998), and emergency medicine (Stubbs & Mundy, 1990). One article, examining the use of the morning report to provide radiological education to pediatric residents, revealed that, during 388 case presentations over a 10-month period, 559 radiological studies were shown. A concern raised in this literature is that morning reports are generally done by non-radiologists, which resulted in questions participants could not adequately answer. Common unanswered questions included radiological study indications and techniques, along with the radiological appearance of diseases. The article concluded that it was important for radiologists to take part in morning reports to enhance primary care residents' education (D'Alessandro & D'Alessandro, 1997). Several schools are integrating radiology resident training with that of emergency medicine residents (Stubbs & Mundy, 1990) and other specialties, and some are even requiring a clinical year in addition to the four years of diagnostic radiology residency (Wiest, Locken, Mettler, LoRusso, & Romero, 2002).

Summary

The only consensus found in the literature relating to radiology curriculum is that radiology education is very important in both undergraduate and residency medical education programs. However, formal radiology education is not taught at all allopathic undergraduate medical programs and, in most undergraduate programs, it is only offered as an elective. Similarly, little radiology training is incorporated into non-radiology residencies. The net result of this inadequate radiology education is that about one-half of new medical graduates do not understand the contraindications and indications for ordering diagnostic imaging tests, nor are they able to interpret basic radiology images in the event that a radiologist is unavailable.

The remaining radiology education curriculum consists of debates and suggestions for curricular content, descriptions of existing programs, and proposals for methods incorporating radiology into various programs and other related ideas. No evidence of consensus exists in these areas, and it does not appear that there will be in the near future.

Evaluations, Outcomes, and National Boards Examinations

Evaluations and Outcomes

Evaluation tools such as examinations, case presentations, and periodic performance evaluations can be used as both evaluations of performance (Blane & Calhoun, 1985; Curtis, Amis Jr, Cruess, & Riordan, 1985; Cuttino Jr & Scatliff, 1987; Littrell, 2003; Williamson et al., 2002) and effective teaching tools (Barnhard, 1974; Blane, Calhoun, Maxim, Martel, & Davis, 1985; Blane, Calhoun, & Vydareny, 1986;

Curtis, Riordan, Brower, & Amis, Jr., 1988). Some programs require that residents complete 'credentialing exams' at set times during their residency; these examinations serve to document residents' proficiency before they are allowed to interpret films within a given department (Amis & Alderson, 1991).

Despite that the Accreditation Council for Graduate Medical Education (ACGME) requires that radiology residents receive formal evaluations at least four times a year (Collins, Propeck, & Albanese, 2000), 22% of programs appear not to enforce this policy (Collins et al., 2004), and only approximately 25% provide the residents with copies of these evaluations. However, 92% allowed the resident to view the evaluations. Similarly, a 2007 survey of clerkship directors (O'Brian, Torre, Mechaber & Durning, 2007) found that only 33% of clerkships assessed chest radiology interpretation skills even when these were covered within the clerkship. Interestingly, electronic evaluation systems appear to improve both the response rate and timeliness with no impact on the quality of responses when compared to paper based evaluation systems (Boiselle & Mainiero, 2006).

A few researchers examine the importance of evaluation and the correlation of various evaluations with student outcomes. For example, resident rotation evaluation scores appear to correlate with the American Board of Radiology standardized written examination (Adusumilli, Cohan, Korobkin, Fitzgerald, & Oh, 2000; Baumgartner & Peterman, 1998), and student scores on a radiology station in a Comprehensive Clinical Skills Assessment correlated with National Board Examinations and GPA (Blane et al., 1996), whereas applicant rank order (how a resident compared against his or her peers

during the residency matching process) does not correlate with these exams (Adusumilli, Cohan, Marshall et al., 2000). Pre-clinical medical school grades of honors/A grades in anatomy and pathology show some degree of correlation with radiology board scores, as do honors grades in some clinical courses and student scores on the United States Medical Licensure Examination (USMLE) (Boyse et al., 2002).

Other discussions of possible correlation of outcomes focus on the impact of pre-radiology clinical year(s) on radiology resident performance (Cuttino & Scatliff, 1979; Ellis, Vydareny, Bookstein, & Gross, 1989). However, this discussion is mainly editorial in nature, with a handful of equivocal studies looking at outcomes. A few researchers examine possible pre-existing factors relating to radiology residents' success, in particular, their perceptual abilities (Brazeau-Lamontagne, Charlin, Gagnon, Samson & Van Der Vleuten, 2004). These articles revealed the possibility of improving resident selection by discriminating, in a very preliminary manner, between applicants based on their perceptual aptitude (Smith & Berbaum, 1991; Smoker, Berbaum, Luebke, & Jacoby, 1984).

Method of examination delivery is also discussed mainly in relation to the conversion of the profession to digital image delivery for interpretation, education, and evaluation. These articles focus on the ease of digital examination style in relation to creating and proctoring the exams, as well as the cost effectiveness of the examination delivery (Mullins, Will, Mehta, & Novelline, 2001).

Researchers explore the relationships of examination style in radiology to measuring student mastery levels and other factors involved in undergraduate

evaluations. One author in particular examines the differences in students' perception of examination style on their level of exam preparedness, anxiety levels, and study habits in relation to a practical radiology examination (Peterson, 2004). Peterson found a minimal difference in students' anxiety levels with the open book format versus the closed book format, while the remainder of the variables remained unaffected. The examination style consisted of short answer questions, problem solving, and case-based questions. An interesting pair of articles describe the use of a clinical competency examination in radiology in the undergraduate setting (Marchiori, Adams et al., 1999; Marchiori, Henderson, & Adams, 1999). These researchers presented the creation and implementation of such an exam and discussed the results of the pilot examination. The authors were able to arrive at two conclusions: first, that the use of content-based curricula may result in poor clinical competency and, secondly, that the implementation of ongoing clinical competency measures must be administered regularly within a given curriculum. A recent article described the reliability and validity of an x-ray difficulty scale for selecting chest radiographs for examinations (Boutis, Pecaric & Pusic, 2009), a useful tool for creating examinations of appropriate difficulty for a given set of students. The University of Michigan, Medical School has shown that adding a 15-minute case of the week, taught by radiology faculty, significantly improved the students' comprehensive clinical assessment examination scores (Rochester et al., 1998).

National Board Examinations

Several authors have found that student GPA in chiropractic education correlates well with board scores (Cunningham, Percuoco, Marchiori, & Christensen, 2004; Jensen,

1988; Kalthoff, 1985; Lawson, McDonald, & Naseem; Lawson & Till, 2006; Wolfenberger, 1999). This has also been demonstrated by a variety of authors in both the nursing (Melcolm, 1981; Muhlenkamp, 1971; Outtz, 1979; Seither, 1980) and medical professions (Spellacy & Dockery, 1980). In addition, just as scores on the chiropractic college admission test (CCAT) correlate with success in professional college and on board exams (Cunningham, 2003; Cunningham, Desjardins & Christensen, 2005), so, too, does undergraduate GPA (Cunningham et al., 2004; Green, Johnson, & McCarthy, 2003; Jensen, 1988; Lawson et al.; Schoof, 2003). A study published in 1979 (Coulter & Delgrande) found a correlation between board scores and the college the students attended. Board preparation programs do not appear to affect board exam scores (Cunningham et al., 2004). These studies suggest that national board examination scores are reflective of long-term mastery of knowledge rather than short-term memorization of facts.

Summary

In spite of the fact that evaluations can be used as effective teaching tools many radiology programs are not utilizing them in this manner. Many undergraduate and residency programs have inadequate evaluations and often do not allow students to review their evaluations. Additionally, no definitive conclusions have been found linking mastery of radiology with any specific evaluation, outcome, or pre-professional or preclinical grades. This area of research is markedly understudied and the little research completed only offers preliminary clues for areas to best examine in future research.

Pedagogical Approaches

Problem Solving

One pedagogical area of interest in medical education literature deals with students' ability to solve problems. Radiology is a clinical problem solving skill that requires students to be able to integrate what they see on the film with their knowledge of anatomy, pathology, and clinical information. This ability, combined with the use of an adaptable radiographic search pattern, has been shown to correlate with successful interpretation of radiographs (Peterson, 1999). The article "Problem-Solving Model in Radiology for Medical Students" (Blane, Vydareny, Ten Haken, & Calhoun, 1989) suggests that the use of algorithms will improve students' ability to develop this skill set. The authors propose that radiology, with its multitude of rapidly developing imaging techniques and associated escalating costs; demand that students become proficient medical decision makers. Non-clinical issues such as cost-effective use of imaging modalities, safety, and patient comfort incorporated into the clinical decision-making process have been discussed in the literature for some time (Clark, 1981; Cockshott, 1971; Cozens 1987; Dussault et al., 1983; Edeiken-Monroe, Harris & Jackson, 1988). A senior-level course, utilizing small groups with faculty guidance to develop investigative plans in imaging, allows the students to learn to develop algorithms designed for specific patients rather than memorizing generalized algorithms that may not be effective for individual patients (Blane, Vydareny, Ten Haken, & Calhoun, 1989). Teaching medical students through the use of algorithms, also known as scripts, is based in cognitive psychology and provides the students with pre-stored knowledge that can be applied

quickly and easily in the clinical setting (Charlin, Tardif & Boshuizen, 2000; Eaton & Cottrell, 1999). The Medical College of Georgia compared a traditional observation instructional method to an interactive learning method that involved specific learning objectives and tasks that enabled students to be actively involved in radiology. The results showed that medical students, residents, and faculty preferred involving students in appropriate decision making and problem solving (Locksmith, Mundy, & Passmore, 1992). Similarly, Erinjeri and Bhalla (2006) found that shifting radiology case-based instruction from a passive observational approach to an active learning delivery was beneficial. An interesting article published in 2005 illustrates the importance of clinical histories in the interpretation of radiographs: groups of students examining the same set of radiographs were given different patient histories. The authors posited that different histories will drive the algorithm or script appropriately (Chew, Ochoa & Relyea-Chew, 2005).

When residents are asked to discuss an unknown case, they are expected to focus on one question: what is the abnormality? This question assumes one correct answer. Thus, radiology residents, and radiologists themselves, often have an underlying assumption that in order to be a good radiologist one has to have the accurate diagnosis every time (Gunderman & Nyce, 2002). Gunderman and Nyce argue that, while this is an important part of being a good radiologist, this need for accuracy can be problematic when no absolute right answer can be derived from a given set of images. Residents need to learn to be active investigators and incorporate clinical information into their evaluation of a case. The authors suggest that residents be encouraged to ask questions

and that, when residents or radiologists make errors, it be viewed as a learning opportunity rather than a sign of failure. In addition, they recommend that residents be presented with cases in which the diagnosis is not known, or at least not provided to the residents, in order to encourage them to evaluate their performance by criteria other than getting the right diagnosis. The "art of uncertainty" creates an opportunity for learning (Gunderman, 2005, p.801).

Technology as Teacher and Independent Learning Tools

Many articles examine the types of technology that can be used to assist in teaching radiology to both undergraduate medical students and residents. These articles began appearing around the early 1970s (Cockshott, 1973), and the technologies discussed range from the traditional textbook (Chew & Stiles, 1994b), videodisk (Chew, 1994; Chew & Lanier, 1995), analogue film teaching files (Amorosa, Geller, Horrigan, & Saxanoff, 1985), interactive games (Roubidoux, Chapman, & Piontek, 2002), digital/picture archiving and communication systems (PACS) and Digital Imaging and Communications in Medicine (DICOM) based teaching files (Afaq, 2001; Burger, Kunzel & Brenner, 2001; Dugas et al., 2001; Mullins, Mehta, Patel, McLoud & Novelline, 2001; Mullins, Will et al., 2001; Seshadri & Arenson, 1992), computer instruction (Aronberg, Rodewald & Jost, 1985), hand-held computers or personal digital assistants (PDAs) (McKenney, 2004; Scarsbrook, Graham, & Perriss, 2006), to radiologic websites (Kalb & Gay, 2003) such as web-based tutorials (Azevedo, 1999; Azevedo, Lajoie, Desaulniers, Fleiszer, 1997; Sparacia et al., 1997), web-based teaching files (Jakobovits, Brinkley, Rosse & Weinberger, 2001; Wagner, Heckemann, Nomayr,

Greess, Bautz & Grunewald, 2005; Weinberger, Jakobovits & Halsted, 2002), web-based radiology information sites (Johnson, Rowell, & Fishman, 2006; Streeter, Lu, & Rybicki, 2007), open-source, social network virtual learning environments (Howlett, Connelly & Vincent, 2009), and intranet-based assessment tools (Davison, Tello, & Blickman, 2000).

These advances in technology have allowed the student to be able to study radiology without the use of the traditional cut-film teaching files in medical/chiropractic schools and radiology residence programs (Chew & Smirniotopoulos, 1993; Roberts & Chew, 2003). This has resulted in lower costs (Chew & Smirniotopoulos, 1995) and smaller space requirements for the educators (Chew, 1994) and greater convenience to the student (Mullins, Mehta et al., 2001). Additionally, this technology has allowed the practicing radiologist to continue to learn and keep up with the exponentially increasing body of knowledge that represents modern radiology (Swett, 1991). Interestingly, authors recognized the value of using computers to teach problem solving in medicine as early as the 1960s (Swets & Feurzeig, 1965).

Using an audience response system creates a more interactive learning environment and appears to improve performance and student participation in an undergraduate anatomy/radiology class (Alexander, Crescini, Juskewitch, Lachman, & Pawlina; 2009). Another study found that using a computer to monitor cases in case presentation conferences allows better control of conference content, generation of teaching files, and facilitated modification of case content to allow for a more even

representation of the spectrum of disease found in the organ or organ system being studied (Creasy, Cuttino, & Sokhandan, 1988).

A mainstay of radiology education is independent learning, or self-learning. This is achieved through the use of textbook reading, American College of Radiology and institutional teaching pathology files (Tegtmeyer, Keats, Pullen & Langman, 1974), educational slides/tapes/videos, educational videodisks (Hennessey, Fishman, & Ney, 1994), and CD-ROM/DVD/Internet programs. In the early 1990s, residents purchased and read five textbooks per year, spending an average of nine hours per week studying textbooks (Slone & Tart, 1991). The improvement in technology and image quality (Schellingerhout, Chew, Mullins, & Gonzalez, 2002), along with the explosion in the use of the Internet in radiology education, has enabled educators to create interactive educational websites that allow them to expand the sphere of their talents and contributions to the radiology education world (Frank & Dreyer, 2001) to a previously unparalleled extent. The radiology education literature follows the evolution of various technology developments and the utilization of technology as tools for increasing the quantity and quality of this type of study (Gunderman, Kang, Fraley, & Williamson, 2001). Both undergraduate medical students and residents employ these materials, so it seems it was inevitable that the question of whether both populations can learn as effectively with the same educational materials arises. In the instance of resident-prepared chest radiology teaching cases, it appears that the answer is yes – the same materials can be used to teach both undergraduates and residents (Collins, Riebe et al., 1999).

A few authors (Gunderman, Williamson, Fraley, & Steele, 2004) make an effort to point out that new technologies will assist in helping with both the dissemination of information and with the workforce shortages facing medical academia. However, they stress that technology cannot replace the insight, experience, and dedication of human educators. The authors argue that technology must be used to ignite a passion for learners to seek out knowledge for themselves and to work with teachers and each other to solve problems, rather than simply use technology to transmit information. In short, technology must help the teacher provide learner-centered education (Gunderman, Williamson, Frank et al., 2003).

Using technology to enhance the education experience, rather than viewing it as a mechanical teaching method that removes common sense from the process, is many authors' goal. Jaffe and Lynch (1993) point out that computers are especially useful in allowing learners to complete self-evaluations, thereby receiving objective feedback about their level of mastery of the materials. Furthermore, they note that computer-aided instruction supports different learning styles and allows the student to progress at his or her own pace. Additionally, computers allow learners to complete self-assessments that provide immediate, non-judgmental feedback (Jaffe & Lynch, 1993, 1995).

Visiting Lectureship Programs

A common activity in the radiology education arena is a visiting lectureship program. This is designed to bring experts on site to train residents and house staff. Visiting lectureship programs are generally expensive and effort intensive. However, preliminary research suggests that it is an effective method of information transfer and

that the level of retention of knowledge is independent of location and level of training (Franken et al., 1983). This can sometimes be incorporated into a didactic conference. Every radiology residency program has a series of didactic conferences as part of its curriculum (Roberts & Chew, 2003).

Case-Based Radiology Teaching and Conferences

One of the traditional and standard methods of teaching radiology is commonly known as the 'hot seat' whereby the instructor sits with the student and presents a case consisting of imaging on a particular patient. The instructor then attempts to extract observations, diagnoses, and information from the student while other students observe the interaction. Ideally, this is an effective and enjoyable method of education (Collins, Miller & Albanese, 1997) reflective of Socratic inquiry. However, as pointed out by Chew in his article discussing a means of improving on this method of instruction, it can easily become viewed by students as an inquisition rather than as a valuable opportunity to learn (Chew, 2001). Chew suggests allowing all students to preview cases for 45 seconds, write down their findings and thoughts about each case, and take turns discussing their responses under the direction of the instructor. He found that this modification of the traditional 'hot seat' resulted in greater student participation and favorable feedback, and was overwhelmingly preferred by the students over the traditional approach. However, there are radiologists who believe that the traditional approach of creating stress during these 'hot seat' sessions is a sound pedagogical principle because it recreates the stress of clinical practice settings, such as the ER

setting, and that the residents need to be able to make decisions under stressful conditions (K. Hibbert, personal communication, January 22, 2012).

Another proposed variation of the traditional 'hot seat' case presentation consists of pairing residents and giving them a set of cases to review for a set period of time. The cases are subsequently discussed, with one resident from each team partaking in the presentation (Roberts & Chew, 2003). The conference moderator then provides a written handout outlining the findings and diagnoses for each case. This format was found to be a statistically significant improvement over the traditional approach (Collins, Garofalo, & Albanese, 1996). Additionally, due to the increased visibility of findings associated with digital hot seat presentations, students appear to prefer these to analog film-based or slide-based presentations (Su & Shaffer, 2004).

Requiring residents to autonomously review resident-prepared independent learning/teaching cases has also been shown to be an effective learning tool (Collins, Blankenbaker et al., 1999). The cases included a short clinical history, radiographs, CT scans, concise description of the radiological findings using correct terminology, a list of differential diagnoses, the proven diagnosis, a discussion of that diagnosis, two or three learning points, and between one to three references. Having radiology residents present cases to each other at chest radiology conferences is also an effective teaching method (Collins et al., 1997). Resident-prepared conferences are an effective way to teach radiology residents imaging utilization guidelines. However, this method of instruction does not appear to improve residents' perception of their ability to provide diagnostic imaging consultation (Mainiero, Collins, & Primack, 1999). Correspondingly, having

undergraduate chiropractic students prepare and present radiology cases resulted in the majority of students reporting that it was a valuable learning tool, helping them in their roles as both presenters and observers (Young, 2003).

Relative Effectiveness of Educational Formats

Few authors examine the relative effectiveness of educational formats in improving radiology residents' short- or long-term retention of factual knowledge. Smith et al. sought to do just that and compared the effectiveness of lecture versus case presentation formats for teaching residents radiology. Their study failed to show any difference between the two formats (Smith, Berbaum, Franken, & Ell, 1986). Thompson et al. (1998) examined the effectiveness of a single didactic session on family practice residents' performance and found that there was a significant improvement in their ability to detect pneumonia on plain film radiographs.

Preliminary studies have not been able to detect long-term differences between the instructional effectiveness of multimedia textbooks, traditional lectures, and printed textbooks (D'Alessandro, Kreiter, Erkonen, Winter, & Knapp, 1997; Erkonen, D'Alessandro, Galvin, Albanese & Michaelsen, 1994). Similar studies found no difference between lecture, printed texts, and digital content delivery on examination results for radiographic anatomy (Ketelsen et al., 2007) or between linear and web-style layout of computer tutorials for learning to interpret radiographs (Pusic, LeBlanc & Miller, 2007). One intriguing study found that computer-based teaching with case studies improves students' problem-solving ability in radiology as compared to paper-based case studies (Maleck et al., 2001).

Other authors, however, suggest that self-instructional seminars, combined with examinations, are more effective than the traditional tutorial methods and formal radiological training (Blotnick, Squire, & Becker, 1972). According to their study, 10 seminar hours result in the same level of performance as 140 hours of elective courses. One study suggests that no difference exists in long-term knowledge retention between students who attend lectures and those who are absent (Chan, 2009). Conversely, others have found that formal radiology teaching significantly improves student performance (Dawes, Vowler, Allen, & Dixon, 2004). Another study suggests that long-term retention of radiographic anatomy into the fourth year of medical school is poor overall (Feigin, Smirniotopoulos, & Neher, 2002). This article was followed by two additional studies that found that a pre-clinical course in radiology may result in facilitation of long-term retention of radiographic anatomy (Feigin, Magid, Smirniotopoulos & Carbognin, 2007; Magid, Hudson & Feigin, 2009). A blended learning approach with integration of web-based, small group modules with didactic instruction was found to be effective at Harvard Medical School (Shaffer & Small, 2004), and a similar case-based integrated teaching model that appears to be improving outcomes and increasing academic efficiency is being used at Taipei Medical University in Taiwan (Chan, Hsu & Hong, 2008). Subramaniam, Scally, and Gibson (2004) address problem-based learning as a whole, pointing out its advantages and disadvantages in relation to radiology education, and provides a list of suggestions to improve this method of teaching radiology to medical students.

Studies into the efficacy of using interactive software as a learning method show that it is effective and well received by both medical students and residents (Alvarez,

Gold, Tobin, & Desser, 2006; Chew & Smirniotopoulos, 1995; Jacoby & Lynch, 1992). Others have found that, while students learn more radiology with computer-assisted instruction videodiscs than with a textbook, it was more time intensive (Chew & Stiles, 1994a). Only one study appears to examine the traditional interactive tutorials compared to computer-assisted instruction. It is a prospective, randomized study that compared the two methods of instruction using the same instructor and teaching style for both groups. The study found that, while both methods are effective instructional formats, interactive tutorials are more successful than computer-assisted instruction in teaching factual radiology knowledge (Lieberman, Abramson, Volkan, & McArdle, 2002).

Summary

Radiology is a clinical problem solving skill that requires integration of basic sciences such as anatomy and pathology, clinical information, clinical experiences, and the information recorded on the diagnostic imaging study. As such, much of the research in this area has focused on problem solving, the use of algorithms or scripts, introducing uncertainty in clinical scenarios, incorporating technology in the learning environments, other active learning techniques, and various methods of independent learning opportunities. While the literature in this area is still in its infancy, the research examining the relative effectiveness of these various educational formats is often contradictory suggesting this is a complex area of study with numerous factors that influence student learning.

Faculty Training

Ensuring that faculty are effective educators is also an area of interest in the radiology education literature. Scheiner and Mainiero (2003) found that radiology residents were just as effective as attending radiologists at presenting lecture material. This finding suggests that radiology faculty *never improve beyond the teaching skill set that they had as residents* and, if this is correct, this is troubling. This is most likely a result of a failure include the scholarship of teaching and learning in their educational training; without consciously reflecting upon their practice or integrating new learning people tend to reinscribe what they experienced as students (K. Hibbert, personal communication, January 22, 1012). The author that addresses this area most extensively in the radiology education literature is Dr. Jannette Collins. In 2002, she published an article entitled "Motivation of Radiology Residents" wherein she discusses a variety of methods to motivate students to learn, drawing from both educational and psychological foundations. In a more recent article, Collins (2006) presents three keys to being an effective educator: knowledge, skill, and professional traits. She defines knowledge as mastery of facts within an area of expertise and as understanding pedagogy. Skills include communication, professional relationship building, ability to create interactive learning environments and develop organized learning activities with clearly defined goals and expectations, ability to provide quality feedback to students, adequate skills at self-evaluation, ability to adapt to different learning styles, and enthusiasm for teaching (Collins, 2006). Professional traits of an effective educator are defined as engaging in lifelong learning, being an advocate of, and demonstrating, sound ethics in all aspects of

life, and collaborating with others to improve the quality of education (Collins, 2006). Others have observed that experts may not always be the best instructors since their depth of knowledge may render them unable to view the material from the learners' point of view (Gunderman, Williamson, Fraley, & Steele, 2001). Indeed, individuals who are often deemed excellent instructors are often the individuals who simply show a "sincere commitment to the comprehensive welfare of those they teach"(Gunderman, 2002, p. 329). In short, excellent instructors are mentors as well as teachers (Amorosa, 2004; Barr, Shaffer, Valley, & Hillman, 1993) and create supportive learning environments (Gunderman, 2003); in effect, they are student-centered individuals. This is supported by recent research that found that involving medical students more in imaging procedures and fostering a mentor-mentee relationship improves the interest of the student and results in an increased likelihood of the student choosing a radiology residency (Baerlocher & Asch, 2006).

A current shortage of academic radiologists, combined with financial difficulties, has resulted in an increased reliance on computers and digital imaging for at least part of the teaching workload in most radiology departments (Samuel & Shaffer, 2000). Another result of this shortage was the piloting of a three-month residency elective in education at the Indiana University School of Medicine. This pilot project resulted in very positive feedback from the participants regarding their increased educational skills and in the development of a successful electronic radiology tutorial program (Gunderman, Heitkamp et al., 2003).

Limited research is directed at providing guidance to academic radiologists to assist them in becoming better teachers and in understanding the complexities of teaching radiology to students at various academic levels (Gunderman, Williamson, & Steele, 2003), and explaining concepts such as 'adult learners', 'expert learners' (Halstead, Perry, Racadio, Medina & LeMaster, 2004), 'co-operative learning' (Mueller, Georges & Vaslow, 2007), 'active learning' (Miller, Rudland, Hurrell & Ali; 2009), 'problem-based learning' (Subramaniam, 2006; Thurley & Dennick, 2008), 'simulation-based training' (Steadman et al., 2006), and 'evidence-based practice in education' (van Beek & Malone, 2007), along with suggestions for implementation of these concepts. Roberts and Chew (2003) offer a review of the literature examining six different teaching techniques used in radiology residency programs. The authors explain how and why each teaching technique is useful and offer suggestions to improve these learning experiences (Roberts & Chew, 2003). Feedback, for example, can be beneficial, harmful, or even useless to the student, depending both how it is presented and how it is perceived (Gunderman & Williamson, 2002). Gunderman and Williamson provide a lighthearted look at how and how not to provide feedback. Through the entertaining use of tongue in cheek examples of conversations between faculty and residents, the authors illustrate how to provide feedback that will enhance residents' educational experience. Articles discussing learner-centered education also assist the academician in becoming a better teacher. By presenting various concepts that embody the ideal of student centeredness, such as respecting the learner, providing experience-based learning, assisting the student to develop intrinsic motivation, understanding different learning styles, and providing

various methods of instruction, the authors are attempting to prepare educators to guide students towards becoming engaged learners (Baykan & Nacar, 2007; Gunderman, Williamson, Frank, Heitkamp, & Kipfer, 2003). Collins has published a series of articles aimed at improving radiology educators' skills to cover a range of topics, including basic concepts such as creating and giving PowerPoint lectures (2004a; 2004b) and writing multiple-choice examinations (2006b), and more complex concepts such as explaining the principles of adult learning and how to design learning experiences (2004c; 2007). Other authors are providing instruction on examination methodologies (Fajardo & Chan, 1993) and the use of games as assessment tools (Kihiczak, Amorosa & Siegel, 1999) to increase student learning and retention and provide valuable and accurate assessments. Numerous authors argue that radiology departments should invest in improving the quality of their radiologists' teaching abilities and should recognize excellent teaching skills as an important part of their faculty members' value to the department (Gunderman, 2000; Gunderman et al., 2000; Gunderman, Kang, Fraley, & Williamson, 2002).

Summary

The literature examining faculty training in the area of radiology education is sparse. Several articles address the need for more academic radiologists and the need for better training of academic radiologists. The few articles aimed at providing training to radiologists in this area introduce basic educational concepts such as lecture creation, examination writing, and learning styles or simply delineating what makes an effective educator.

Conclusion

A relative dearth of articles examines the pedagogy of teaching radiology to undergraduate medical/chiropractic students. The body of literature that examines the pedagogy of radiology resident education is only slightly larger. Both groups of articles tend to be focused on one of seven areas of pedagogy: problem solving, undergraduate medical curriculum, resident curriculum, evaluation, faculty development, technology as teacher, and case-based radiology teaching conferences.

A general consensus exists within this literature that radiology education is important at both the undergraduate and resident level. To date no definitive studies have examined how to effectively incorporate radiology into the curriculum, or how to successfully teach radiology to either undergraduates or residents including how it is efficiently assessed as a clinical competency. Additionally, little literature is available in the radiology realm that addresses the inadequate educational training received by academic radiologists.

Thankfully, the most current literature suggests that these inadequacies are beginning to be recognized and with that recognition will come further research towards addressing these needs. The qualitative study proposed here will provide groundwork upon which to build future research and knowledge for future curricular revisions.

CHAPTER III

METHODOLOGY

The overall objective of this qualitative exploratory study was to examine the lived experience of students in radiology curricula at chiropractic colleges in the United States so that I can begin to understand students' perceptions of how they learn to interpret plain film radiographs. In interviews, students were be asked to reflect on their experiences in terms of learning radiology, the factors they believe contributed to successful completion of the radiology curriculum, and the contexts or situations that have influenced or affected their experience of learning radiology. A comparison of these factors to the materials provided by the faculty and institution, identified if the tools provided to the students aligned with their perceptions of what factors worked for them. Lev Semyonovich Vygotsky's (1962) theory of social constructivism, the experiential learning theory developed by David A Kolb (1984) and Malcolm Knowles' (1990) work on adult education, or andragogy, provided a framework for making meaning of the students' experiences. This chapter describes the study's phenomenological research design.

Introduction: A Personal Perspective Illuminating My Positionality

The perspectives and underlying assumptions of the researcher in qualitative studies are important in order to understand the context of the research being conducted. Altrichter and Holly (2005) explain this concept by asking the researcher to examine her

past experiences, motivation, and philosophical assumptions so that she can better understand how they might affect her ability to adequately interpret the research data. By understanding and acknowledging that gathering data in a qualitative study occurs in a cultural context (Rossman & Rallis, 2003), both the researcher and the reader are better able to interpret information generated from a qualitative study. Therefore, the following section describes my background in radiology education and my interest in understanding student perceptions of radiology education. Providing this description and reflecting on how my personal background influences my interpretation of the data collected in this study, both here and throughout the course of my study through the use of an electronic personal study journal, will help me to understand how I am positioned within the research I am conducting. This is an important part of qualitative research process as researchers must "recognize that their own backgrounds shape their interpretation, and they position themselves in the research to acknowledge how their interpretation flows from their personal, cultural, and historical experiences" (Creswell, 2009, p. 8).

I began my chiropractic education at Northwestern College of Chiropractic in 1994 after completing a Bachelor of Science degree from the University of Alberta. The sheer number of classes translated into an intimidating amount of information that had to be mastered in a very short period of time. In my first trimester of chiropractic college, I had 14 classes, whereas at the University of Alberta, five classes were the normal course load per term. As a result, I had to alter my approach to studying in order to maintain good grades and to gain mastery of the material.

The radiology curriculum began in my second trimester of the program and, while it was one of the most difficult subjects at college, it quickly became my favorite topic. That the amalgamation of gross anatomy and pathology in the human body can be captured in a two dimensional image was fascinating to me. However, my usual 'read the book the night before the exam' study style was not adequate for this material. I found that I learned this material best by working with two or three other students in the laboratory going over cases together, actively quizzing each other, and discussing the cases. While I did not realize it at the time, this triggered my interest in different learning styles and would eventually lead me to work on a Ph.D. in higher education.

After graduation, I practiced for a few years and eventually returned to college to complete a radiology residency. During this period, I experienced a myriad of different teaching styles as I rotated through imaging centers and hospitals and found that I quickly learned to seek out those physicians who asked questions of the residents, created supportive learning environments, and provided positive reinforcement of concepts. As I progressed through the residency I, in turn, began to be cast in the role of teacher for the undergraduate chiropractic students. I unconsciously began to mimic those instructors and their teaching styles that worked best for me as a student.

After completing my radiology residency, I became a full-time radiology faculty member at National University of Health Sciences and began looking for information about how to be a better teacher. This desire to be a better teacher led me to enroll in the Ph.D. program in Higher Education at Loyola University Chicago. I have taught radiology and been involved in the administration and development of radiology

curriculum at both the undergraduate and graduate levels in Canada, USA, and the United Kingdom for over ten years. As a senior faculty member and administrator, I have also been called upon to mentor junior faculty members in radiology and clinical settings.

My years of experience in teaching radiology to chiropractic students have led me to have the following viewpoints about effective teaching in radiology. I think that students learn best through active, supportive learning encounters. While passive information delivery methods, such as traditional lectures, are important in order to ensure that students are exposed to all the material they are expected to learn, my experience has been that students actually master the material through the use of more active learning experiences, such as self-assessments and interactive laboratory sessions.

My love of radiology, my interest in both how students learn and how I, as a teacher, can foster that learning, and my need to mentor junior faculty merge in this qualitative study. An understanding of how students experience learning radiology and how they believe they mastered the material will help faculty and administrators deliver a better learning experience for students.

Rationale for the Research Methodology

As discussed in Chapter II, very few articles are published, either qualitative or quantitative, on how radiology is taught and assessed involving the undergraduate medical/chiropractic student and no published research exists on how students experience the phenomenon of mastering the clinical skill of interpreting radiographs. Qualitative research is an appropriate approach to explore problems about which little is known

(Creswell, 2009). In order to conduct an analysis of how students perceive they learned radiology, an exploratory qualitative investigation was performed.

Epistemology is a branch of philosophy that examines not only the nature of knowledge, but also how that knowledge is acquired. Interpretivist epistemology holds that "social reality is a set of meanings that are continually constructed by the individuals *who participate in that reality* [italics added]" (Gall, Gall, & Borg, 2005, p. 551). Johnson (1995) contends, "qualitative methods of inquiry…are powerful tools for understanding the social, psychological, and environmental factors that support learning and teaching" (p. 4). Qualitative research attempts to answer not only questions of how and why a given phenomenon occurs but also how the participants in the phenomenon perceive the phenomenon (Gay, Mills, & Airasian, 2008). Qualitative research tries to address these questions by taking an in-depth look at a small number of individuals and strives to do so in as natural a setting as possible. It is often used in an area of inquiry where very little is known in order to explore a topic in depth to arrive at an understanding of how and why a phenomenon occurs. This allows the researcher to create a richer appreciation of the experience, event, or group being examined (Creswell, 2008).

While a myriad of different approaches exists for conducting qualitative research, the goal is the same: to try to understand the "meaning" behind the phenomena that researchers are studying and to explain it in terms of human experience (Creswell, 2008). Simply put, qualitative studies are a way to acquire knowledge about people (Rossman & Rallis, 2003). Phenomenology is a subset of qualitative inquiry that examines the

"experience of an activity or concept from these particular participants' perspective" (Gay, Mills & Airasian, 2008, p.12), essentially studying individual conscious experience from a subjective or first person point of view (Smith, 2009). Van Manen (1997) describes this as the study of lived experience or the life world. Given that the overarching question behind this study focuses on what students experienced in terms of learning radiology, a phenomenological approach was utilized in this study.

Medical/chiropractic student learning of radiology is a very complex phenomenon. By exploring the experience of participants who are learning radiology, one can begin to understand how the subject matter may be mastered. Interviewing is an appropriate data collection tool for this study as it provides the opportunity not only to explore, but also to provide the opportunity to investigate the experiences of other people and the meaning they made of the experiences (Seidman, 1998). This exploratory study therefore used a qualitative phenomenological approach through in-depth interviews using open-ended questions to serve the research purpose of investigating the student perspective how chiropractic students learn diagnostic radiology within their curriculum and what contributes to this learning. Personal interviews with fourth-year interns at two separate chiropractic colleges were utilized to paint a portrait of what it was like to be a student in the radiology curriculum, the challenges faced, how students addressed them, and how they perceive they mastered radiology over the course of the undergraduate program.

The use of a qualitative methodology involving interviews allows for a richer, more complete description of beliefs held by the students. Examining the lived

experience of several individuals involved in this particular phenomenon at two separate institutions allowed for triangulation, or integration, of results, thereby creating a deeper, more thorough understanding of the experiences (Creswell, 2008; Gay, Mills & Airasian, 2008). In this way, this research study explored not only what beliefs individual students hold about how radiology is learned, but also gained an understanding of common themes that arise across participants. Exploring these common themes provided a more complete understanding of how students perceive they mastered radiology, which will then serve as a foundation for further study into radiology andragogy.

Population

Potential participants for this study included students in their final year at the 18, Council on Chiropractic Education (CCE) accredited chiropractic colleges in the United States. Assuming an average of 200 students in each year group at the colleges, an estimated 3,600 students are typically enrolled in their final year of chiropractic college in the United States. All colleges offer similar programs and are accredited by the same accrediting body: the Council on Chiropractic Education. The colleges offer sequential radiographic interpretation courses along with radiology physics and radiography (the taking of radiographs) courses. All colleges offer normal radiographic anatomy and the following topical areas of imaging: congenital and developmental anomalies, trauma, bone pathology including blood vascular diseases, infection, endocrine disorders and tumors, arthritites, chest imaging, and abdomen imaging. While the focus of the curricula is primarily on interpreting plain film radiographs, the main imaging modality

utilized in clinical practice, the curriculum also addresses the basics of ordering advanced imaging and normal anatomy on MR and CT imaging.

Sampling Criteria

In phenomenological studies "the number of interviews conducted in such studies is of less importance than the extent to which the phenomenon is explored in each interview" (Drew, 1989, p. 431). The purposive sample for this study consisted of eight fourth-year interns at each of two different chiropractic colleges. The student population at chiropractic colleges includes a somewhat diverse group of individuals, with the majority being traditional first professional student who enters right after undergraduate training and the remainder being older students embarking on a second career. The vast majority of students are full-time.

In an effort to narrow the population for this study, the sample will focus on the traditional first professional student at chiropractic colleges that operate on a trimester system. The student population therefore consisted of students in their twenties and early thirties who entered chiropractic college immediately following their undergraduate education, or shortly thereafter. The student participants will be enrolled full time in their final year of chiropractic college. While the goal was eight students at both institutions for a total of 16, a minimum sample size of four students at each college would have been accepted if necessary. Participants were required to meet the following criteria: (a) be willing to articulate their experience of learning radiology, (b) have completed all diagnostic imaging interpretation courses with grades of B or better , and (c) be willing to spend approximately 60-90 minutes in the interview process. The student sample at each

college was reasonably reflective of the demographic composition of chiropractic college enrollment in the USA, as found on The National Center for Education Statistics (NCES) website (2010) in relation to gender and race. As such, the goal was four male, four female and two participants of color at each site.

Gaining Access to Participants

The Association of Chiropractic Colleges executive committee consists of representatives from all of the accredited chiropractic colleges worldwide. The representatives are generally either college presidents or vice-presidents. After approval from the Institutional Review Board at Loyola University Chicago, an invitation to be a research liaison (see Appendix B) was sent to the Association of Chiropractic Colleges representative from each of the 11 institutions that operate utilizing a trimester format, in the United States in order to gain access to students who meet the sampling criteria. Two colleges responded favorably to the invitation. The use of a liaison served three functions: first he or she allowed me to identify and negotiate the selected colleges' institutional review board (IRB); second he or she will identified the students who meet the sampling criteria at each institution; and third, he or she may have increased the level of student interest in the study by demonstrating the institution's support of the research by distributing my invitation to participate to the students. As the researcher, I was not given the names or contact information for any students contacted.

With the assistance of the liaison, I submitted a proposal to the IRB of the two colleges stating my desire to conduct a study at their institutions through the use of a cooperating institution letter (see Appendix C). After approval from the institutional

IRB, the liaison an email invitation to participate in the study (see Appendix D) and a synopsis of the study (see Appendix E) was sent by the research liaison to all of the students at the institution who met the selection criteria. The letter of invitation to participate clearly explained that a decision to participate would have no impact on academic or clinical standing at the institution and that all data collected will be protected through the use of pseudonyms. The only person who knew the participants real names was me. It also outlined the time commitment of approximately 60-90 minutes for the interview and gave students the option to review transcripts of the interview. Those students willing to participate were asked to respond directly to me via email. This ensured that the liaisons did not know which students agreed to participate, thereby maintaining confidentiality.

Obtaining Participant Consent

In order to gain useful data all participants must have a solid understanding of both the study and the commitment it will take to complete the study (Seidman, 1998). Obtaining informed participant consent is also a fundamental ethical requirement a study involving human subjects. Students who agreed to participate in the study and who contacted me were asked to sign a consent form at the time of the interview (see Appendix G). Additionally, participants who volunteered were sent a copy of the interview protocol (seevAppendix H) in advance in order to afford them the opportunity to review the questions. This allowed them to gain a better understanding of the study and help ensured that they were comfortable and able to provide an informed consent to participate at the time of the interview (see Appendix G). In the event that I would have

had more than eight willing participants at an institution, they would have been sent a decline letter (see Appendix F), this did not occur.

Interviews were conducted on-site at the students' institution in a quiet, comfortable location that I arranged through the liaison. The researcher provided students who participated in an interview a $20.00 gift card to Amazon.com as a token of appreciation for their time.

Data Collection Procedures

Personal Interviews of Participants

Pheonomonogical interviews focus on a person's experiences and how she makes meaning of those experiences. Three general types of qualitative interviews include informal or conversational interviews, semi-structured interviews, and standardized open-ended interviews (Patton, 1990). Semi-structured interviews utilize a predetermined list of general questions to ensure that the same basic information is gathered from each participant but the "interviewer is free to probe and explore within these predetermined inquiry areas" (Hoepfl, 1997, p. 52). This approach ensures that the interview is conducted in a systematic, comprehensive manner and helps to keep the interview focused making good use of the interview time (Hoepfl, 1997). For these reasons, I utilized a semi-structured approach to the interview in this study, asking open-ended questions in an environment that allowed participants to be comfortable and to respond in a candid and thoughtful manner. Initially, I will simply asked participants to describe their lectures and labs, any self-guided learning materials that were provided to them, as well as how they were assessed. I then asked participants to describe their radiology

curriculum experiences, to reflect on what it was like to be a student in these courses, and how they believe they were successful. I asked about what they think were the best learning experiences they had in radiology, what they believed worked/did not work for them in relation to labs, lectures, assignments, exams, and any other resources they used as they worked at mastering the material. During this interview, participants were asked not only to describe their experiences, but also to reflect upon them now that they are nearing graduation and have been able to utilize their radiology training in a clinical setting. They were asked to discuss their perceptions and thoughts about the various instructional methods they experienced, what it was like to try to learn the material and prepare for exams, how they adapted their study strategies, what resources that they utilized, and why they chose to utilize those particular resources during their radiology classes.

I provided the participants with a list of questions for their review prior to the interview process (see Appendix H). The interview was audio-taped and transcribed into text by a transcription service. To ensure compliance with the study's confidentiality protocol the transcriptionist signed a confidentiality agreement (see Appendix I). Following the transcription, a copy of the interview was forwarded to each participant to afford him or her opportunity to verify the accuracy of the interview content and to provide any additional feedback or clarification regarding his or her comments, should he or she wish to do so. This process is referred to as member-checking (Merriam, 2001). I requested that participants respond within two weeks of receiving their transcript. Three individuals elected to respond.

Research Diary

Following each interview, I compiled my perceptions of the interview and the participant along with my reactions to our interaction in my electronic journal. I reviewed the tape of the interview within one week to ensure my notes of the interview and my thoughts were accurate. The use of a field log to record data from participant observation, along with the researcher's thoughts and reactions to the data being gathered, has long been recognized as an important research tool (Altrichter & Holly, 2005). I utilized a research diary throughout this study and keeping my written thoughts and ideas in an organized manner assisted in the coding process.

Documents

While interviews are the primary source of data collection for this study, I collected syllabi for the radiology classes taught at the institutions where my research will take place. I asked my research liaison to assist me in locating a syllabus for each of the radiology classes offered at his or her institution. Syllabi are commonly the first communication students receive from faculty and are usually the formal mechanism for providing information to students regarding a course (Eberly, Newton & Wiggins, 2001). Two primary purposes of a syllabus are to serve as a contract between the student and faculty member, and to act as a learning tool by providing a list of resources available to students for the course along with explanations of how they will be assessed (Parks & Harris, 2002). Comparison of this information with the experiences of the students was an important aspect of making meaning of their experiences in relation to the theoretical framework of the study.

Peer Review/Debriefing

Two individuals agreed to review my data analysis and data interpretation sections of my study in order to help me overcome any personal bias that may have influenced my ability to interpret the data in a fair and accurate manner. One is a professor in the departments of chiropractic and radiology at a university in Switzerland with a master's degree in medical education; the other is both a licensed teacher and chiropractor and, as such, is familiar with both the medical and educational issues of this study. Participants were made aware during the informed consent process that while these two individuals will be reviewing data, they will not be given the real names of the participants or institutions.

Data Analysis

Transcript coding is the primary means of data analysis for this study. Coding allows the researcher to identify themes or recurring concepts across participants (Corbin & Holt, 2005), thereby allowing the researcher to recognize themes within the data collected during the study. By approaching the data analysis in an analytical, methodical manner the researcher is less likely to allow her own biases to affect the study as she continually questions the findings (Bloor & Wood, 2006; Strauss & Corbin, 1990).

This study utilized the general procedure suggested by Creswell (2008). According to Creswell, coding occurs throughout the study as the researcher organizes the data. Through exploring and becoming familiar with the data, themes related to the research questions emerge. Further analysis will allow interrelating of the themes and any identification of additional sub-themes, thereby allowing the researcher to report and

interpret findings in relation to the research questions. I employed Creswell's (2007) simplified version of Moustakas' (1994) method of data analysis for phenomenological analysis for the transcript-coding phase. As such, I went through the data and highlighted significant statements, a process called horizontalization of data. These significant statements were then grouped into themes, explored, and fully described in the analysis stage. This included; a description of what the participants experienced, a textural description, a description of how the experience happened, a structural description, and a composite description that will incorporate the textural and structural descriptions into the overall essence of the phenomenon.

To code the data from the faculty syllabi, I identified what resources faculty outlined, if and how faculty communicated instructional and/or assessment styles, expectations of students and any other statements aimed at providing the students with learning opportunities or resources. I compared the data acquired from interviews to the data acquired from review of the syllabi to determine if the information in the syllabi is reflective of the student experience in the classes.

Trustworthiness and Ethical Considerations

Trustworthiness is an essential component of qualitative research and consists of the efforts to address the concepts known as validity and reliability in quantitative research. Validity is simply how well one measures what one says he or she is measuring and reliability is how well the results could be replicated at another time or by another investigator (Gay, Mills & Airasian, 2008). According to Gay et al., in qualitative research these items are addressed through the credibility, transferability, dependability,

and confirmability of the study and its findings. They describe credibility as the ability of the researcher to explain the complexities of the data whereas transferability requires the author to include descriptions of the phenomenon and the participants to the degree that the readers can identify with the setting being examined. Dependability is the constancy of the information and confirmability the level of objectivity in the study.

There are numerous ways that trustworthiness can be addressed. In this study, it was addressed through the use of data triangulation, member checking (Bassey, 1999; Creswell, 2008; Merriam, 2001), peer review/debriefing (Bassey, 1999; Gay, Mills & Airasian, 2008; Merriam, 2001), and by identifying the researcher's biases at the start of the study (Merriam, 2001).

Triangulation, the use of corroborating evidence from different individuals or multiple data sources (Creswell, 2008; Gay, Mills & Airasian, 2008; Merriam, 2001), allows a study to reflect a more accurate representation of the area it is examining. To increase the trustworthiness of the findings of this study, and to provide triangulation, two separate distinct groups were studied: fourth-year chiropractic interns at two separate colleges. Additionally, while the primary source of data for this study is the student interviews, I also utilized document analysis of syllabi, appropriate literature, and maintained an electronic journal of my thoughts, feelings, and findings throughout the study. The utilization of these five separate data sources will help ensure the trustworthiness of my study.

In order to ensure that I accurately and completely recorded participants' interviews, I employed a process known as member checking (Gall, Gall & Borg, 2005;

Merriam, 2001). Additionally, I utilized peer review/debriefing to assist me in overcoming any personal bias that may affect my ability to interpret the data in a fair and accurate manner.

Finally, I addressed my own bias and background in relation to teaching radiology education. Throughout the entire study, I tried to be aware of preconceived notions, opinions, and my emotional attachment to the issues. While I endeavored to prevent my beliefs from influencing my research, I acknowledge that this is a limitation to my study.

Conducting this study in an ethical manner is a vitally important part of the research process. As such, every effort was made to ensure that all participants were informed of the study's purpose, focus, and methods prior to the interview. A signed consent form was obtained prior to beginning the interview process. The participants were advised of any potential risks and benefits of being involved in the study and informed that they may choose to withdraw from the study at any time. I endeavored to protect the interests and privacy of all participants. However, due to the small number of participants, it is possible that individual informants may be identifiable. I attempted to minimize this risk by utilizing pseudonyms for all participants and their institutions and maintained confidentiality of all files and data obtained during the course of the study. The data will be stored in a locked filing cabinet in a private office for up to two years after completion of the study, at which time it will be destroyed.

Participants were able to receive a copy of the study's findings if they wished to have a copy sent to them. Copies of the letters of invitation, information/synopsis of study provided to participants, and consent forms utilized in this study can be found in

Appendices A, B, C, D, E, F, G and I. Finally, this study was reviewed and approved by the Institutional Review Boards at Loyola University Chicago and at the two chiropractic colleges where the research took place to ensure that all possible measures were taken to protect participants.

Limitations of the Study

The study was limited due to the small sample size. This is a common limitation for qualitative studies and the combined total of 12 interviews was a reasonable number of participants given the scope of this study. I addressed this limitation through purposeful sampling and through triangulation. The deliberate selection of the groups at two different institutions and the use of an electronic journal helped to mitigate the effect of the small sample size.

The data was obtained through the use of interviews, which implies that the data are only as reliable as the sources. However, as the interview was directed at the actual experiences of participants they are, by definition, reliable in that they are hopefully accurately reporting their own experiences and thoughts.

The setting of the interview could potentially impact the data I obtained. I endeavored to secure a private interview location that was convenient to the participants and comfortable to them. I also tried to make the interview itself a comfortable, supportive experience for the participant.

The selection of only two institutions is another limitation, as is the selection of students within each institution. Chiropractic students cross every age, gender, and race and include full time and part time students. While I made every effort to select

participants to meet the standard demographics of chiropractic students in the United States, not all chiropractic students fit the standard demographic picture. Thus, while I endeavored to make the findings of this study transferable to other chiropractic institutions, the study only addresses the traditional student population at chiropractic colleges.

Finally, as previously mentioned, my position at a chiropractic college and my years as an instructor of diagnostic imaging create an inherent bias. I did not interview students at my home institution or any institution I have taught at over the last four years so that the participants did not feel coerced or otherwise uncomfortable about how their response to my inquiries will affect their academic or professional lives. In addition, I attempted to "practice reflexivity" (Gay, Mills & Airasian, 2008, p. 377), endeavoring to remain aware of my personal bias, and ensuring that I continually and intentionally examined my underlying assumptions as I conducted this study by maintaining a journal to record my thoughts and reflections throughout the study. Additionally, the use of peer review/debriefing minimized the possible impact of my personal bias on this study.

CHAPTER IV

RESULTS

Introduction

The literature review in Chapter II highlighted the lack of information about the student learning experience in diagnostic radiology. This review, and my own experience in teaching radiology over the last decade, led to five basic areas of inquiry around which the student interviews were organized. The goal of the interviews was to provide illumination of the student experience in the following areas: (a) the learning strategies followed by students that they believe both worked and did not work in learning radiology, (b) student perceptions of the effectiveness of instructional methods used by faculty, (c) the challenges faced in learning radiology and the ways students addressed these challenges, (d) the recommendations that students offer to both faculty and peers regarding the teaching and learning of radiology, and (e) whether the learning strategies and perceived effective instructional methods are reflective of the resources found in course syllabi. Individual interviews were conducted with 12 students that explored these research topics.

In addition to interviews, two additional methods of data collection were employed. Reviews of all 12 radiology course syllabi provided by the two institutions, my personal research journal, and the literature were used as a means of triangulation, a standard method for limiting bias in qualitative studies. The data from all these sources

were integrated into this narrative. Member-checking (Merriam, 2001) was used to ensure the accuracy of the transcription and the thoroughness of the participants' responses. Additionally, two qualified individuals reviewed my data analysis and data interpretation to ensure that I interpreted the data in a fair and accurate manner.

Participant selection was conducted in a manner designed to create a participant pool reflective of chiropractic students in North America as a whole. The study was conducted at two chiropractic college campuses in the United States, another means of triangulation. The two chiropractic colleges selected both utilize a trimester system of the same length with similar curricular designs. They have similar class sizes and clinical rotations. The original sampling criteria described in Chapter III provided a goal of 16 students, eight at each college, with one-half of the students being male, at least two students of color, participants' average age under 30, and the students having achieved grades of B or better in all of their diagnostic imaging classes. The research liaison at each college invited all students who met these criteria to participate in the study. There were 12 students in the final participant pool, and all had grades of B or better in their radiology classes. Three students of color participated, and participants' average age was 28.6 years. Unfortunately, two-thirds of the participants were female, so the goal of 50% male participation was not met. However, the overall resultant demographic was reasonably representative, and I was pleased with the results of my purposeful sampling (Seidman, 1998). The following chart (see Table 1), organized by the pseudonyms of the student participants, show how the participants fit my sampling criteria.

Table 1: Student Participant Criteria

Student (Pseudonyms)	Age	Gender	Student of Color	Grades of B or Better	Institution
Angela	25	Female	Yes	Yes	A
Beth	26	Female	Yes	Yes	A
Christine	26	Female	Yes	Yes	A
Dave	27	Male	No	Yes	A
Eric	28	Male	No	Yes	A
Frank	26	Male	No	Yes	B
Gwen	25	Female	No	Yes	B
Hank	30	Male	No	Yes	B
Ingrid	24	Female	No	Yes	B
Jessica	40	Female	No	Yes	B
Karen	27	Female	No	Yes	B
Lisa	39	Female	No	Yes	B

This introduction summarized the sampling criteria and resultant population represented by this study. The next three sections reveal findings related to (a) participant self-efficacy and the learning style to understand their overall experiences in learning radiology, (b) the participants' thoughts on their overall experience in learning diagnostic imaging, and (c) their best and worst experiences in their radiology education. These general reflections are then followed by sections describing the findings relative to the five major areas of inquiry: (a) the learning strategies followed by student reflections

on both what worked and did not work in learning radiology, (b) student perceptions of the effectiveness of instructional methods used by faculty, (c) the challenges faced in learning radiology and the ways students addressed these challenges, (d) the recommendations that students offer to both faculty and peers regarding the teaching and learning of radiology, and (e) whether the learning strategies and perceived effective instructional methods are reflective of the resources found in course syllabi. The final section summarizes the main themes found in this study.

Student Learning Styles and Self-Efficacy

Before I examined into the specifics of the students' radiology experience, I thought it important to understand how the students performed academically, in both chiropractic college as a whole, and during their undergraduate and high school careers. As a result, I initially asked students whether they knew what their learning styles are, and I also asked questions about their academic self-efficacy and their overall study habits. These questions led them to reflect upon their academic experiences before attending chiropractic college and to identify any differences in their approach to academics in the professional degree setting.

In general, the students identified themselves as multimodal, mainly visual and tactile learners, who strongly preferred active learning approaches, preferably ones that tied the learning activity to real life. Eight participants identified themselves as having more than one type of learning style, which correlates with the few studies that have looked at the VARK (Visual, Auditory, Read/write, Kinesthetic) learning style inventory of medical students. The studies all found a majority of medical students (between 55

and 75%) have a multimodal learning style (Baykan, & Nacar, 2007; Lujan & DiCarlo, 2006; Nuzhat, Salem, Quadri, & Al-Hamdan, 2011; Slater, Lujan, & DiCarlo, 2007). Only three students did not list visual as one of their strong learning styles (see Table 2). All three students indicated that having the opportunity to practice reviewing films in the labs and to practice writing reports was beneficial to them in learning radiology. Gwen indicated: "I found that the lab paired with the lecture really helps because you were able to see the things that you've learned in lecture and then you actually get to see them and kind of pick apart the x-rays with a teacher and small class setting was in the lab." Frank found that using plain films rather than digital imaging was helpful for him, and Jessica thought that writing the reports was particularly helpful for her in learning the material. Jessica suggested several times during the interview that faculty always put an example of normal up beside images of pathology. In my journal, I reflected that this idea might help non-visual learners to see the difference between normal and abnormal images.

While most students indicated that they have always been strong academically, three stated that they were much stronger students now that they were in the professional program. Those who indicated that they have always been good students indicated that their academic success was related to the effort they put into each class. For instance, Hank stated, "I don't really care about my grades, but you put the time in and get good grades." Gwen indicated that grades reflected her interest in the course, "…depending on which class it was…like, one of my classes for my major, I did well at, but if it was, like, history class that I really had no interest in, I would drop the ball on that one." Similarly, Dave summarized his academic self-efficacy with this statement: "I am an A, B student,

probably more of a B. I could get the A, but I just don't want to stay up until 2 a.m. studying. I would rather go to bed at 10."

Table 2: Student Participant Learning Styles

Student	Student Self Identified Learning Style
Angela	Visual
Beth	Visual & Kinesthetic
Christine	Visual & Kinesthetic
Dave	Visual
Eric	Visual & Kinesthetic
Frank	Auditory & Read
Gwen	Kinesthetic
Hank	Visual, Kinesthetic & Auditory
Ingrid	Read & Visual
Jessica	Kinesthetic
Karen	Visual & Kinesthetic
Lisa	Visual, Kinesthetic & Auditory

The three students, who disclosed that they were not good students in their undergraduate programs or in high school, each had a different explanation for the discrepancy. However, the main theme in their answers was indicative of the priority in their life at the time. Karen's comment about her undergraduate experience illustrates this disconnect between her undergraduate and chiropractic college academic success: "I

was very lazy in undergraduate, and I do better now when the course load is two or three times as much. I'm not too sure how that works out…" Lisa related the difference was due primarily to her personal life:

> Beginning, you know you are young, and I think I withdrew one term because I had some, you know, personal stuff going on and whatever, but, for the most part, I will say, like, in high school I was a student that didn't really care, and I think I got my act together junior year or senior year, and then I was, like, oh, I need to be smart and get myself together.

Beth's reasons for not being an A student in undergrad related to her priorities as a student athlete at a Division I school:

> I am a student athlete, so that the majority of my time there, that [sports] was my main focus. Academics was secondary even if they say academics should always come first, but, since I was on a scholarship and all that stuff, it is, like, you know, sports all the time…now that I am not in sports, I could focus solely on academics and I actually enjoy it.

My general inquiries into the students' prior academic experiences and self-understanding of their learning styles revealed commonalties between the participants. All students considered themselves solid students who achieved good grades in all their academic endeavors with three of them identifying that they were better students now that they are in professional school. Their explanations for this change demonstrated that their grades reflected the priorities in their personal lives during their education. Additionally, most students thought that they were multimodal learners with the majority of them identifying visual and/or kinesthetic learning styles as their preferred style(s).

Overall Student Experience in Radiology Classes

The students unanimously felt that their overall experience in their radiology courses was positive. Beth said, "I love everything about it…Both of them were great

teachers, they challenge me, and it paid off because I did well on boards." Karen indicated, "It was probably one of the classes I enjoyed most." Several students commented that the classes' organization worked well, emphasizing that the first class is normal anatomy and that, in all classes, the lectures were paired with labs, giving students hands-on experience throughout the term. Hank stated that he liked how they "broke down" classes and taught "normal anatomy and *then* congenital anomalies, and *then* go to trauma, arthritis, and *then* tumors. It was a nice idea to know what you're dealing with *before* you get into the stuff that is harder to see (emphasis his)." The students also indicated that they believed their programs prepared them well for clinical practice. Gwen remarked, "I have talked to students in med school and other chiropractic schools that don't seem to get the extent of x-ray training that we do, and I think it is an important tool to use because we obviously used the x-rays in clinics." Ryan commented, "The [radiology] instructors are well educated. I have always said that they are the most intelligent in their subject of all the professors that I have ever had. Any questions that you ask them, they have an answer for, which is refreshing."

I noted in my journal that almost every student remarked that radiology is important because it is a clinical skill and that the faculty consistently related what they were teaching to clinical practice. I got the impression from the students that, in general, radiology classes and radiology faculty were both popular with, and well respected by, the students on both campuses. This theme resonated throughout my reflections on the interviews. I noted in my journal that Angela's statement, "I enjoyed it even though it was hard," summarized the overall student experience on both campuses quite well. I

found it interesting that their experiences were uniformly positive and that two of the 12 students I interviewed, Frank and Christine, planned on going into a radiology residency after they graduate. Additionally, two other students were considering doing so and, at the conclusion of the interviews, asked me several questions about residency programs and career possibilities for chiropractic radiologists.

Best and Worst Learning Experiences in Radiology Curriculum

After asking the students about their overall learning experience in their diagnostic imaging classes, I inquired about their best and worst learning experiences in the diagnostic imaging curriculum. These questions allowed me to gain a deeper understanding of their experiences and to see if the phenomena they identified as 'best' or 'worst' would be reflected in their answers to my later, more specific questions about what worked for them in their programs.

Best Learning Experiences in Radiology Curriculum

Two basic themes were revealed in the student responses to my request to describe their best learning experience in their radiology courses. The most common theme was a preference for two interactive small group encounters that students experienced: the radiology lab or the radiology department rotation. The other theme related to the methods used by instructors in delivering the lecture materials; the use of humor and clinical vignettes to convey the course content. These responses also reflected the relationship of the instructors with the students and the support that the students felt the instructors had for them in the radiology courses.

Small group encounters, the radiology lab. The most common response at both institutions was that the laboratory setting was the best learning experience. The radiology laboratory experiences described by the students entailed about a 10:1 instructor-to-student ratio where the students worked through cases and the instructors answered questions and provided immediate feedback on their work. Frank's response explained this succinctly: "I think it [my best learning experience] was the labs and coming in and having the instructor and TAs right there in order to ask questions and get help if you need it." The students felt that the lab setting made them practice their skills and allowed them to learn in a fun, interactive fashion. Ingrid explained, "as much as I didn't like the pass the chalk, it was always, it was fun, it was just a laid back atmosphere and I always felt like I learn a lot out of them." The students described the 'pass the chalk' or 'the hot seat' as a time where the lab instructor would ask for a volunteer to describe what he/she sees on the radiograph for the class and answer questions about the case in question. While some of the students found this activity to be stressful, all of them described it as beneficial and most of them enjoyed the activity. Hank's comment when he was discussing how he preferred the laboratory interactions over the traditional lecture setting was that "you got to be more actively involved instead of someone just blah, blah, blah, blah." Beth had an additional experience in the radiology lab. She worked in the radiology open lab as a student worker, supervising 'open lab' hours where students could come in and review films on their own time. Beth found that

> …because I was constantly in there and whenever there were other people in there, I would always manage to go over it with them so it's constantly going over stuff. Whether it was that person that was ahead of me in the curriculum, or behind me.

Small group encounters, the radiology department rotation. Similar to the lab experience, the radiology department rotations at Institution A consisted of about 10 interns spending a week in the radiology department after they began their clinical year. The interns were required to write radiology reports on 30 different sets of radiographs that were assigned to them by radiology residents. The residents then graded the reports and reviewed the cases with the interns. The interns also attended the resident oral rounds where they were able to listen to radiology residents interpreting radiographs and working though various clinical cases. This rotation was only part of the radiology curriculum at Institution A; Institution B had students write their radiology reports during their radiographic positioning course prior to their entry into clinic. The interns felt that this was a very beneficial experience in that they not only had the interactive small group experiences that they did in the labs, but they also had the chance to work through radiology cases that could be from any disease category. This is in contrast to the course labs where they usually knew what category of disease the pathology on the radiograph fit into before looking at the films by the simple virtue of what class they were taking. For example, if they were in the diagnostic imaging class that taught about imaging of trauma the case they were looking at was most likely a trauma case and not say, a tumor. Eric explained:

> My best I feel was not in the course, in our internship we have to go for a week in the radiology lab and write radiology reports and then we have to do 30 I believe is what it was. 25 or 30, so they gave us cases that would

> have come into the clinic. The x-rays could have been a five view lumbar and we just go through and then we have to write a report and send to the residents and then they okayed or not, and then we make the changes… So, it was more a real life on your own. Here is an x-ray it could be normal, it could have cancer, and so it really put you on your toes. A lot of times when you go into the x-ray lab you know I am looking at pathology, it is a pathology class, they not going to put up a normal x-ray …In that class and real life it could be normal, it could be abnormal. So, that was very helpful sitting there and actually looking at real x-rays and having to make the diagnoses and pertinent findings on your own. And then them telling you what mistakes you made.

The instructors. Four students identified the instructors themselves, and how the instructors presented the material in class, as their best learning experience in the radiology curriculum. The students were impressed by the faculty members' passion about the topic, and how they incorporated both humor and clinical cases into lecture and lab settings. Lisa explained

> I think they always put some personal stories and stuff that would happen [in the lectures], and I think doing that helps those things stay with you better because you have something to tie the information to emotionally. Other than that, I mean they really had good personalities and I think that's the biggest thing. Learning anything from a teacher who is excited and who really loves what they do.

Gwen indicated that when "they kind of throw in some humor to their lectures that kind of makes things easier to pay attention, like it's more of a story as opposed to them just speaking information at you." Similarly, Dave talked about how the instructors made it easy to relate the information being presented as pertinent to what they will be doing every day in the clinical setting. This clinical correlation allowed him to understand how important this material was for patient care and fostered a desire to master the diagnostic imaging classes. He explained this with the statement: "just knowing that we are going to do that on patients, you want to be able to put up an x-ray and be able to read it and not

have to refer back to your notes and stuff like that… Like when I put up an x-ray, I want to be able to just know everything." Jessica spoke about both the use of humor and how the instructors loved what they were teaching.

> She was funny, she would tell stories, but she is really very professional and would tell you 'look you guys need to know this, you can see here it is'. She is passionate about what she does, I mean Dr. X was too, so it was good going to class, but you know, they made it fun to learn.

Worst Learning Experiences in Radiology Curriculum

Students really struggled with this question and, in several instances; we moved on to other questions in the interview and revisited it at the conclusion of the interview. I often noted in my journal that the fact that students struggled to answer this question was a very positive reflection on how they felt about their overall experience in the radiology program. When pressed to provide an answer of some sort to this area of inquiry, two students stated that they could not answer it because they had no negative learning experienced in the diagnostic imaging interpretation classes. Lisa's answer, "I think anything that they provide was always helpful… Anytime I was in class or they were giving information it was beneficial," reflected the overall difficulty that the students had in identifying their worst learning experience in their diagnostic imaging interpretation courses.

The other 10 participants each gave a different answer after spending a fair bit of time trying to come up with an answer. Of the various answers the students provided to this inquiry, six of them related to a passive learning setting, lectures, and the time spent in that setting. Students found that lectures tended to be long, boring, and to cover material too quickly. Ingrid's answer, "days in lecture when things get boring and you

just zone out, and don't pay attention," reflects this issue. Angela expanded on this with, "if we had lecture at the beginning on a Monday for example, and we had the lecture again later that week we covered a lot of material. Then at the end of the second lecture Dr. Y gave us kind of a quiz." Gwen pointed out that this combination is problematic to learning the material with the comment,

> Some of the concepts that they teach in that class are kind of difficult to get a hold of and, again like I mentioned, sometimes it's an easy class to zone out of and just kind of skip all together. So when you do have to sit down to study you see it for the first time.

Additionally, two students, Jessica and Dave, mentioned experiences where the instructors did not have enough time to cover the material adequately in classes. Jessica found that, "You know at certain point we didn't have enough time and we missed a couple classes." Dave pointed out that this was particularly problematic when instructors utilized PowerPoint slides that were text heavy,

> …it was just like text, just like that, no real x-rays to look at, and then during the lab exams, it was like, holy smokes like you know, I had no clue what's going on… it was all text. He will show images during class but that was not enough, you know. Because you're busy writing notes and trying to take it all in, you don't have time to just look at the x-rays.

Frank's response to this question reflects how important it is to the students that instructors use time wisely in lectures. Frank explained that his worst learning experience was "when the clickers wouldn't work, because they will have quizzes and sometimes it wouldn't work out. So, we will waste about five minutes or so trying to get it to work."

The other four responses uncovered during this line of inquiry echoed the participants' thoughts about how things could be improved by the instructors in the

diagnostic imaging courses and their recommendations for future students. Two of the responses shed light on how instructors can improve overall learning experiences for their students. Christine provided an early hint of the unanimous belief at Institution A that the group presentation was not a beneficial learning experience with the comment, "I will definitely say the presentation…I don't think that was helpful." Whereas Eric expanded on the issue of faculty at Institution A not reviewing exams with students,

> I didn't like how after an exam they wouldn't go over the x-rays with you. I thought that would have been helpful if they can explain why you got it wrong. I hate going into a test and not knowing if I was right on that answer. They give you your score like 93% but what's that 7% that I missed? And you will work on that if I am missing that 7%. So not being able to look at the x-rays again after the exam and having them explain to me why I got it wrong.

The remaining two students provided an initial insight to the recommendations for future students in learning to master diagnostic imaging. Beth, for instance, indicated that she regretted, "not using all the supplements. When I would get like a bad grade then I would be like, I should have done this, or I should have done that. The book is probably the most important thing." Karen thought her worst learning experience reflected the need for students to learn how to study diagnostic imaging effectively early in their educational curriculum.

> …at the beginning when I hadn't realized what is the best way to tackle the course and probably just trying to learn straight from the notes just because that's what I have always done in school so probably that would have been my poorest learning experience. Would have been before I realized I really needed to have a balance of hands on and notes (to learn diagnostic imaging). (Karen)

Student Strategies for Learning Radiology

One of the main areas of interest of this study was to examine the ways students approached learning radiology. To that end, I asked a variety of questions aimed at examining what they used to study, what methods they used, whether those methods changed depending on the instructor or course, and the reasons they chose the methods they used. The participants' answers revealed several commonalities and two important differences between the two colleges. In general, both groups used all of the resources suggested in class and provided by instructors; they sporadically used anatomical models when studying normal radiographic anatomy; and they spent more time studying for diagnostic imaging than studying for most of their other classes. The resources provided by instructors at the institutions were the same with one exception: practice exams or self-assessments were made available to students at Institution B and not at Institution A. Additionally, both groups stated that they felt the radiology report writing class was exceedingly important in terms of their ability to interpret radiographs. The two groups of students differed in terms of when they were taught a radiographic search pattern. The pattern taught at both institutions was that of the "TABCS" (Technical, Alignment, Bone, Cartilage spaces, and Soft tissues), which is also known as "ABCS". The following sections explore these similarities and differences in detail through the voices of the students in relation to their utilization of resources, practice exam availability, use of anatomical models, time spent in studying, and the timing of the two institutions' implementation of the TACBS/ABCS search pattern and the effect that had on student mastery of diagnostic imaging.

Resource Utilization

The participants were very consistent in that they used all the resources instructors provided, most to the exclusion of other materials. There was an interesting exception to this however; at one of the colleges, one syllabus listed a DVD on reserve in the library. Not a single student was aware that it existed. The students explained that they used the resources the instructors spoke about in class and did not read the syllabus to learn of other resources. Students at both institutions used the same resources: the assigned textbook, class notes, radiology learning laboratory cases, the website www.mypacs.net, and online materials posted by instructors. Most of the students felt there was no need to search out other resources since the instructors provided all the notes online and looking for other resources would take more time than was available. Gwen explained that the instructors

> ...did a great job finding websites that they thought were good for images, and putting them on Moodle so we could use that as a resource as well. Just the time that it takes to search; I mean, our schedules are packed, and I just thought my time would be used more valuably to actually study rather than to search for something that I should study. I had plenty of material already; I felt that I didn't need to go above and beyond to try to find other material. Because I think that they gave us enough to know, and it will just be a waste of my time when I should be studying and not just kind of searching the Internet.

Angela's statement expresses not only that she did not know where to find other materials, but also that the instructors had already provided enough, "I didn't really know better, and I guess I like sticking just to the textbook and the notes not to have too many things to look at." Christine suggested that they already had too many resources for the time they have to study, "I just don't have time either, you know; like, I seriously don't

have time to go through, like, everything. Usually if am lucky enough, I could go through the book, but sometimes I don't have time to go through the book."

Practice Exams

One of the colleges offered students study aids in the form of practice exams. These were uniformly popular with the students. Interestingly, at the college that did not offer these items, some students actually created their own to prepare for exams. Eric, for example, created PowerPoint presentations to use and shared them with his classmates. He commented that, "I thought making those PowerPoints using those Google images was the most helpful thing that I did in studying, especially for the interpretation classes where we got into the pathologies." Others turned the cases provided in the learning lab into practice exams for individual or group study use. Hank described how he would use the images provided in the learning laboratory:

> …have what it is covered up and then you will have to look and figure it out first, and then reaffirm it as opposed to just seeing the name with the picture right way. With the textbook, you know what you are looking at before you get a chance to look at it, so it's easy to say 'Oh, yeah, no problem, that's an encondroma.'

Lisa and Ingrid's comments about instructors' practice exams were reflective of the feelings of all the students interviewed at their college with respect to instructors' practice exams.

> Dr. B will usually send out practice test type things where she will give you all the images and then ask you questions, and then the answers will be at the bottom. So that really helped me a lot. They forced me to look at it the big picture and go, 'Okay, what am I supposed to be looking at?' (Ingrid)

> They used to put out, like, little practice tests, which was kind of nice because you could challenge yourself and know if you are right, and if you

> know, like, 50, 60, 70%, where your weaknesses were and then I would use my notes along with pictures and stuff to kind of refresh my memory, really get a deeper understanding of it. So, some of those things seemed to work pretty good for me. (Lisa)

Anatomical Models for Normal Radiographic Anatomy

Several students mentioned that they periodically used anatomical models when studying for normal radiographic anatomy. Doing this helped them understand how the images related to the actual three-dimensional anatomy of the human body. Students indicated that the models were sometimes available in labs and that having them available was helpful. Lisa explained that "we had, like, parts of models in the room, so, like, trying to figure out what we looking at for vertebrae or C1 or C2, or a foot, even… we had them right there, so you could kind of compare and turn them around and look at it." A few of the students found having the anatomical models so helpful that they purchased their own for use at home: "my roommate and I have a skeleton at home, so that was really helpful for radiology and anatomy" (Karen).

Time

Many students indicated that part of their success in radiology classes was due to the amount of time they spent studying the material. The participants clearly spent more time learning radiology than they did in most of their other classes. Eric explained this bluntly: "I put in a lot more time in radiology than in any other class," and Angela explained that she spent "significantly more time, but I don't know, just because I knew it was a hard class, I put a little more effort into it I guess."

Search Patterns

Both institutions, in their radiology curriculum, taught the same approach to reviewing radiographs: the standard "TABCS" (Technical, Alignment, Bone, Cartilage spaces, and Soft tissues) which is also known as "ABCS". However, Institution A trained the students to do this systematic search process throughout their curriculum, while Institution B taught it as part of the final diagnostic imaging class in which the students were required to write radiology reports on the radiographs. Eric (Institution A) explained that the instructors emphasized the importance of the search pattern in their classes:

> Dr. Y made it a key point to use the ABCS; in every class, he will stress it, and even in his examples, he will put in an obvious condition, but there will be a secondary that, if you weren't using a search pattern, you will just focus right there on the main problem and then there is cancer going on in 50% of the people you miss because you didn't use the search pattern. So, yeah, I liked that he made that a special point to focus on using a search pattern.

The participants from Institution A, which integrated the search pattern into all of their classes, indicated that, when they were studying for a test, they would "go through the ABCS first and if I had no idea of what it is when I would look at it, then I would go back and see what I missed" (Beth). Some students did comment that, when they were in a specific class in which they knew category of disease the pathology on the radiographs fell, they would do a shortened search pattern. Christine explained it thus: "the ones that they put up in labs, because we already know the topics, I just kind of identify, like, 'Okay, that is RA or that is psoriatic arthritis…' I will still go through it but not like a thorough ABCS."

The students at Institution B, which did not regularly integrate ABCS search pattern throughout the curriculum, all indicated that they wished the instructors had emphasized the ABCS throughout their classes. Hank explained, "Towards the end, we started getting more search patterns. You know, look at this first, and this, then this, and then to rule them out more. I think it would be helpful to get the search pattern done a little bit earlier." Lisa related the search pattern with her ability to describe the findings on the radiographs and in writing radiology reports:

> You know, I think the search pattern came way too late… kind of. You know, they talked about it, 'Oh you need to find a search pattern' and stuff, and I don't think it was touched on enough because when I got in T7 [trimester 7], where we were actually writing radiology reports, and I was, like, 'Oh my gosh, how do I describe this?' But, as far as a search pattern, that's when I'm, like, 'Oh where do I go first?' And then you get the ABCS: 'Okay, look at alignment, look at bone.' I mean they talked about it in earlier, you know, trimesters but not as much as they did all of a sudden when it was T7: 'Oh gosh, I have to find a way to look at this stuff.' So, I think that would've helped more if I had done it sooner.

In summary, the discussions regarding the students' strategies for learning diagnostic imaging, and what influenced those strategies, uncovered some interesting trends while addressing my research question which asked, what are the learning strategies followed by students that they believe both worked and did not work in learning radiology? Students utilized the resources that the instructors talked about in classes and, for the most part, did not seek out other avenues of information and did not utilize the syllabi as a resource for studying or finding other resources. The students also indicated that they valued practice exams greatly as an effective tool for mastering diagnostic imaging and that, in general, the use of anatomical models in learning normal radiographic anatomy was beneficial. Students spent more time studying for diagnostic

imaging than they did for their other classes and they found the ABCS search pattern an essential tool in mastering the skill of interpreting radiographs. The difference in when ABCS was introduced into the curriculum at the two institutions highlighted the students' perception that this should be incorporated throughout the entire curriculum along with writing imaging reports in every course.

Student Perceptions of the Effectiveness of Instructional Methods Used by Faculty

While exploring the research question 'what are student perceptions of the effectiveness of instructional methods used by faculty?' I asked students to reflect on their experiences throughout their diagnostic imaging classes and discuss the things that they think their instructors did that 'worked' and 'didn't work.' Their thoughtful responses provided a plethora of material that revealed two major themes of instructional styles that 'worked.' These were the use of active learning instructional methods and instructors' high expectations of students reflected in giving challenging written exams rather than multiple-choice examinations. One clear theme for what 'didn't work' included group presentations. The theme of active learning instructional methods could be further delineated into six sub themes: (a) use of audience response systems, (b) practice quizzes, (c) oral rounds/hot-seat/pass-the-chalk, (d) the use of real-life clinical cases, (e) requiring students to write in lectures and labs, and (f) requiring students to use the ABCS search pattern in class to write radiology reports.

Students at both institutions related that most instructors tried to incorporate active learning techniques into both lectures and laboratory settings. Students universally

preferred lectures and labs that included activities that engaged them as active participants in the learning process. This overall preference for active learning encounters is nicely reflected by Dave's response when I asked him if he felt like his instructors used teaching styles that matched how he learns. Dave related how one instructor (Dr. Y) delivered lectures without using any active learning techniques and how that affected his attendance in the lectures and then compared it to another instructor (Dr. Z) who did use active learning techniques. Dave described Dr. Y's classes in a very negative manner as follows:

> They just dragged on and on, like they were hour lectures, and some of them were just brutal. Cause he was so monotone too. If he had more interactions with the students, or like give a quiz at the end, or a quiz in the middle or something like that, or gave bonus points for asking questions or something, that will be like a better way. But he will just sit there and literally read the slides… and that sucked. Like I didn't really go to class for the most part and I will just study like a week before the exam and will be fine.

However, he described Dr. Z's classes in a more positive way:

> [Dr. Z] will leave like certain notes out and you will have to go to class to fill it in or there is a quiz at the beginning about last lecture's material or the quiz at the end. That was always the best. This way you have to pay attention during the hour lecture you know, even if you didn't like it, you will pay attention… We will first start the lab out with a quiz. He will put up an x-ray and we will have 10 minutes to write up a report, which I thought was pretty cool.

Examples of active techniques provided by the participants at both institutions included oral rounds, hot seat or pass the chalk small group work, and writing practice reports in lectures and labs. Instructors at Institution B incorporated audience response systems (i-clickers) and practice exams. The following sections provide an in-depth exploration of these themes.

Active Learning Instructional Methods

Audience response system (i-clickers). Students at the institution that utilized an audience response system during lectures found that it helped them remain focused on the material and engaged in the learning process. With only one exception that related to the hassle of distributing and collecting the i-clickers, students enjoyed this and found it less stressful than the hot seats in laboratory setting: "It's fun to see where you're at because if 85% of the class knew the answer and you didn't know it's kind of like oh I guess I should start studying" (Ingrid). Several of the students utilized these in-class opportunities to see if they understood the material and to see how they were faring compared to the rest of their class.

> I did like the clickers because it allowed you to kind of test yourself but then it also allows you to see where everyone else was, and what other people were having trouble with. So, if you know a lot of your peers were having trouble with the same thing as you are, you could get together and work it out together. (Karen)

Practice quizzes. At Institution B, one of the instructors provided practice exams or self-quizzes. The students uniformly liked them and found them helpful. Karen explained, "Dr. A made PowerPoints for us to go over in class, and in lab in a way we could kind of test ourselves as we went. So these were very helpful… it was kind of a combination of a self-quiz and a review." When asked if these practice exams provided by the instructor were helpful, Ingrid responded:

> Very much so, yes, because I cheat and look at the answer if possible. You know if I can find out in 30 seconds, I will look at the answer. But with this, you had to scroll down 20 slides to get to the answer. So, I will write down what I thought it was on a little piece of paper and then check on it at the end.

Students also reported creating their own self-quizzes either informally with flashcards or by quizzing each other in open lab. Eric created PowerPoint files to use in this manner, which he then shared with his entire class.

Oral rounds/hot-seat/pass-the-chalk. Students at both institutions described an activity where instructors would either pick a student or ask a volunteer to take a case in front of a small group of students. The student would then have to describe what he/she sees on the radiograph, come up with a differential diagnosis, and indicate what he/she thinks is the appropriate clinical management for the patient. The students all thought that it was a valuable learning experience and the majority of them thought it was a fun activity. Hank explained "I mean for me I am kind of a competitive person so if I get pass the chalk I want to make sure I find what the actual finding is, so it makes you prepare for that or pay attention to what they are saying in lectures." Some students, for example Ingrid, found it quite stressful but still appreciated that it was a helpful learning experience. Ingrid indicated that she did not like

> being put on the spot so, I didn't enjoy that. My skin will start to get red, and I will start to sweat a little bit whenever we will do that. But I am sure it was good for me, and good for the class as a whole, to make sure that everyone is paying attention.

Angela indicated that the instructors tried to keep it fun and as stress free as possible by assisting the person on the hot seat. She explained, "If I was not able to see something, they [the instructor] would help with that and kind of gave hints as to what to look for" which made it more fun and not as stressful. Jessica said that she and her friends created their own oral rounds when studying for exams as it helped solidify the material. Christine expressed a desire to have more of these types of encounters: "I think if they

do that more often it will be better that way because I like just to see how they see things and how other people see it, it helps. I don't know how that helps but it just helps me to see it better."

Clinical real life cases. The participants all mentioned that the radiology instructors made an effort to use real cases when teaching the material and to include clinical information along with the radiographic information. This made it easy for the students to see how what they were studying related to what they would be doing in real life. Eric explained that it was important to understand how the radiology will apply to the real world because patients do not come in and tell you what is wrong with them; you have to figure it out with the following:

> You can't just memorize the key words that they give you and then expect to go and see a patient and have them say those key words. You need to understand what the disease actually is and especially for radiology, you need the help of a picture just because no two x-rays look exactly the same. You could have a normal knee and have it taken from five different people and all of them look totally different. And some look like they have that pathology going on and they don't, so with radiology you need to pound it in.

Eric went on to explain later in the interview how, because of the way instructors incorporated clinical information into the radiology classes throughout the curriculum, he finds it easy to work through cases in clinic and he gave the following example: "Yesterday my clinician sent me a text back asking why multiple myeloma was on my differential diagnoses list, and I was able to cite from *Yochum and Rowe* that it is more prevalent in African Americans, in this age group, with associated infections or chronic infections, and bone pain." Jessica summarized the overall sentiment of the students about how case studies were invaluable in the classrooms with the following statement,

"Well most of them incorporate some kind of story or practical experience as to how you could view things and that really helped. Case studies really helped to get it in your head and a little bit of humor was good too."

Writing in lectures and lab. Students at one school reported that one instructor provided them with written notes that were missing pieces of information. Dave noted that this forced them to "go to class to fill it in…This way you have to pay attention during the hour lecture." Participants also thought that it was valuable when instructors asked them to write radiology reports during class time and then reviewed what should have been included in the report. It is important to note that the respondents felt that not only was the activity of writing down the information useful, but receiving feedback about what they should have included was also valuable.

> Dr. Y at the beginning of the class he will put up an x-ray and then give us a blank report form and then we will have to go through the ABC's and he will want it as a professional report written… Then after we will turn in our sheets, he will then go over and go through how he will write his report and pointed out all the pertinent findings and that helped. It was nice to be able to do it yourself and then see how a guy who does this for a living actually will do it, and compare and make the changes. So I thought that was helpful by what he did for getting ready for test. (Eric)

Report writing class and search patterns. Participants at both institutions talked about their capstone radiology report writing courses at length. In this course, students were presented with radiographs with a short clinical history. The student then had to write up a radiology report, describe the findings, list a differential diagnosis, and make recommendations for appropriate patient management. "Basically a random film that they pull from the back and you have to say you know the ABCS, the findings, and then diagnosis kind of thing" (Beth). Christine was succinct with "I think writing reports

is good." Whereas Eric discussed how important this was and related it to clinical practice with the following:

> But being able to talk about the disease I think the written exams were great and it was nice because it also focused on our differential diagnoses classes that we were able to add that in. I actually was able to use that information even now, we have to write integrated cases for the clinic, so it's the case that we saw and then we give a list of differentials as to why we would exclude and include certain ones.

The students also had the opportunity to take part in oral rounds where they orally worked their way through cases in a small group with an instructor present. The students all stressed that while this was good practice, the most important aspect of both of these activities was the feedback they received from the radiologists. Karen spoke at length about how using the ABCS was essential for writing radiology reports and how this capstone course forced the students to approach reading films the way they will in real life.

> It was pretty difficult at the beginning, because we were just kind of thrown these things [radiographic cases] and that was the first time we had to piece the whole picture together. In our other classes, if we were doing tumors then we know that we were looking for tumor, and if we were doing arthritites then we know that we were looking for arthritis. Whereas this one week it could have been a foot, and then the next week it could have been a lumbar spine series. You had no idea of what kind of path [pathology is present on the radiograph]. So that was the first time that I can think of where we actually had to use our full course load, everything that we had ever gotten, into one film. Yes, I think it's easier for us to learn things when they are split up into trauma and tumors but then it's also easier to think that you know it because you could pull it out on those tests. But in real life, you are not going to get a film that will say there is a tumor on this; you are just going to get blank films.

Instructor Expectations, Examination Styles, and Resultant Strategic Studying

It was apparent at Institution A that the students viewed the radiology director as a more demanding instructor who had higher expectations for the students than other instructors did on the campus. Dave explained the difference in how he prepared for exams based on the instructor. "The harder teacher I will study more for. Dr. Y's tests were brutal. Dr. Z if you just study his notes you will be fine, but Dr. Y you have to go like up and beyond… radiology was the only one that I made flash cards for." Eric elaborated on this point:

> When the residents come and teach it they didn't expect as much from us as Dr. Y, the head of the radiology department. What they presented, Dr. Y will double the information on that. So they will seem thorough presenting it, but you needed to go and read further in Yochum and Rowe especially after they presented.

The style of the examination also affected how students prepared for the exam with written exams requiring one to know the material at a deeper level than a multiple-choice exam. Hank explained it simply with the statement that "you have to know it better in order to do it that way [do well on a written exam]." Dave elaborated this point and clarified that you need to "know your stuff a lot more when it's short answers. If it's multiple choice, you will probably be like, I don't know I could just figure it out, you know? But with short answers you either know it or don't." Frank echoed these thoughts with his answer:

> I think that written tests in general make you know a little more in depth. So I think written were more difficult and multiple choice exams tend to be a bit easier. Especially when you have the answers there, so you can just try to figure it out, sometimes it [a multiple-choice exam] is word association rather than really knowing the material itself.

At Institution A, there was a perceived disparity between the different instructors' expectations, with resultant alterations in the way the students prepared for exams. Students related that the perceived difficulty of the instructor and the style of examinations they were given changed both how they approached the material, and how well they learned the material. Students indicated that they learned the material better when the instructor gave harder exams and when they were given practical exams requiring them to interpret films rather than multiple-choice exams. Angela, for instance, explained that: "Dr. Y's exams are always pretty hard, so I knew I had to study more for his class and he always likes to challenge us, which is not a bad thing, so I made sure I knew most of the details and what he may or may not ask." Dave's response was more succinct, "the harder teacher I will study more for, Dr. Y's tests were brutal." Similarly, students indicated that, in general, practical lab exams where they were required to interpret radiographs forced them to learn the material better than the classroom exams that tested them on information without images. Gwen explained, "written you will definitely have to be a lot more sure of your answer I will say, whereas multiple choice you will do a process of elimination and come up with one or two, then make your best guess, whereas written you don't have that guess at all." Hank's answer of "because you have to know it better in order to do it that way [written exams] echoed Gwen's explanation. Beth expanded on this idea with her answer:

> I probably learned more material from the lab portion [lab exams] because for me I am more of a visual learner, and for written exams I just felt like it is more memorization and that kind of stuff. So, I benefited most from the lab portion and I always did better in lab whether it was anatomy or any other class.

Because the students felt the classroom, multiple choice format exams were easier, students often strategically studied for classroom exams, utilizing the easier multiple choice format exams to boost their overall grades in the course. Ingrid explained this strategic approach to her radiology exams as follows:

> I always knew I was a better written test taker so I mean I will study well for the written test [classroom multiple choice exam] because even if I didn't do well on the practical side of things, at least I could keep my grade up by doing well on the written examinations. So, that was part of my strategy to make sure that I did well on that side.

This strategic studying concept struck a chord with me as an instructor and as a chiropractic physician. In reviewing my journal, I discovered that I had reflected on this every time this was brought up in an interview. While I understand the need for strategically studying in order to get through professional school, and know that I did this myself as a student, as a healthcare provider this forthright acknowledgement by the students that they did it to balance out a poorer grade on the lab exams really disturbed me because of the potential risk to patients. If the way faculty teach and test the students allows them to get through a professional program with a weakness in interpreting radiographs then faculty need to change how they approach delivering the material and assessing the students' skills at the view box. To do otherwise provides a disservice not only to the student, but also to their future patients.

What Didn't Work – Group Presentations

One instructor at Institution A gave students the option of taking an exam or doing a group presentation. All of the students I interviewed at this institution chose to do the group presentation. This was particularly interesting as all of them also stated that

they did not find the project useful and they thought that taking an exam would have been a better learning experience for them as they believe they would have learned the material better in preparation for an exam. Angela "thought it was busy work" and Christine indicated, "I just haven't really found it that helpful." The students perceived that the group project was not only a poor learning experience but that it was also an unfair experience because "it's assigned so you don't get to pick a partner so sometimes people they kind of slack off, and so very much the ones that care about their grades have to do most of the work" (Christine). When asked if they thought that an exam would have been a better learning experience than a group project, the answer was generally yes. However, they qualified it with the fact that they would not have chosen a midterm over the presentation because a midterm is more work and more stressful. Christine's response was frank on this point: "It [an exam] would be a better learning experience but I wouldn't choose that… I think the mid-term for me would have been better, because that's how I learn the most. I need some challenge I guess." Beth found some value in the group project but thought that it was rather limited as it meant that she focused her energy on a single topic rather than learning all of the material. She explained it like this: "for me on the project I will probably focus on my topic and not everyone else's topic and don't really listen to them that well. But having a mid-term after that will probably help me bring everything together and actually focus on the important topics." Dave indicated that he found the case presentation to be "a little useful but a mid-term would have been more all inclusive, you know, whereas the case presentation covers just a little about that one little subject."

When the instructors involved them in hands-on activities, students uniformly perceived that they were better able to grasp the information. The instructors who utilized these techniques were viewed as effective instructors. Additionally, when instructors incorporated clinical cases and experiences into the lectures and labs, the students found the material easier to retain. This is because they could relate it to what they will be doing in "real life." The students described the use of i-clickers (a form of audience response system), quizzes in lectures relating to the material covered during the lecture, practice exams, and writing during lectures as effective instructional techniques. The sole student who disliked the use of i-clickers indicated that the reason he did not like them was that it was disruptive to hand them out and pick them up in class. Students identified aspects of the laboratory classes that required active involvement of the student as effective instructional methods, including oral rounds (identified as hot seat at Institution A, and pass the chalk at Institution B), practice exams, and report writing in labs. In particular, students identified their capstone course where they were required to write 30 radiographic reports on unknown cases as especially useful. The students at both institutions found lectures without these elements to be boring and ineffective. Students at Institution A identified the one group project they had to do during their radiology curriculum as a particularly ineffective instructional method.

Student Challenges and Overcoming the Challenges

Specific Student Challenges to Learning Diagnostic Imaging

In exploring the student experience in learning diagnostic imaging, one of the key areas of inquiry was the challenges faced in learning radiology and the ways students

addressed these challenges. When I questioned students about specific challenges they faced in order to be successful academically in their radiology classes, almost universally their answers related to finding enough time to learn the material. This overarching theme also had three sub themes that related to time management in that the students indicated that they had to spend a lot of time in order to address the challenges. These three challenges were (a) learning the vocabulary necessary for diagnostic imaging, (b) developing the 'eye' for radiology and mastering how the three-dimensional human body appears on the two-dimensional image, and, finally, (c) mastering the technology for simply looking at digital imaging.

Time. Beth's immediate response to this question was "Time. Time had a lot to do with any of the courses here, but I think one of the most time consuming in that term was radiology." Christine expanded on this idea explaining that it was difficult "…studying all those material (sic) in such a short period of time. Not only to study to memorize it because x-ray you have to understand what's going on to see it, if you just memorize it it's not going to work." Hank's response also touched on the deeper level of learning required for radiology and the time it takes to gain that knowledge: "just making the time to sit down and deep learning rather than for recognition, that's what I think is challenging academically."

Vocabulary. Lisa indicated that time was an issue for her in learning radiology. In particular "getting the verbiage down and so for me it's something I had to spend more time looking back on my notes for how things were described, looking at other, if I could find other, reports online about the specific lesion." Eric explained that while learning

the vocabulary was very time consuming, it was a very important aspect of mastering the material. His explanation about the need to spend the time to master this information was:

> Learning vocabulary…. you need to understand the terminology that they are using, and the findings that they are talking about, and it's marked up in the text books that they give you, but they don't have time to go through explaining all of these little details when you should have that knowledge beforehand. They are just telling you in the lecture what they expect you to understand and what are the very, very important parts of the reading and the different diseases that they are presenting. The stuff that they want you to know for the test, but in clinical you need to know all of it, you need to understand that stuff in order to make the call otherwise you are going to miss a lot.

Jessica explained that having the vocabulary was an important aspect to learning diagnostic imaging and that using the ABCS helped her with this process but that she felt that it should have been introduced earlier in the curriculum to help with this process.

> I liked how they kind of gave you the method, the TABCS, go look through the film and to start to pull out words and learn how to use them in a report. I think it would have been better earlier. For me it was a hard process because I don't have the words for this, they are not there. So, I would be flipping through *Yochum and Rowe* and looking online for some words to use to describe it. So, that's why I was thinking it would be easier if I saw the words all the way along.

Developing the radiology 'eye'. Frank, Ingrid, and Karen all talked about how learning to develop their ability to see the findings on the radiographs and then relate that two-dimensional image back to the three-dimensional human body was very challenging and time consuming for them. Ingrid found that she had to spend a lot of time looking at images in order to try to learn how to find things on the radiograph. She found her basic issue was "not having an eye for the x-rays and they [instructors] were always joking that you must be hallucinating, and I was like you must be hallucinating a lot, because I don't

see half of the things you see." Frank said that "even just looking at films and just knowing what was going on, on the film…and trying to figure out what it was, what exactly it was, where was it, because you have to answer both."

Using the technology. Two students, Karen and Jessica, talked about how learning to use the technology added to the amount of time it took them to learn the material. Both of these individuals began their radiology curriculum utilizing traditional analogue radiographs and then transitioned to digital imaging. While they both indicated that they think digital imaging is superior to analogue, the fact that they were in the cohort that was caught in the transition to digital created an added difficulty for them. Karen explained this issue as follows:

> …just a switch from plain film to digital or non digital to digital but it because we had only had non-digital I think the first trimester. So, it was just when we were starting to get the hang of looking at x-rays and then we switched over. Don't get me wrong, digital system is fantastic, and I don't think anyone will pick a regular film over digital, but it is just a shift. Because we had just gotten used to that, and we had to learn not only how to look at an x-ray on a screen but also all the different things you could do with it, so that was maybe a bit of an issue.

Overcoming the Challenges

Time. All students had the same solution to the challenge of needing more time to master radiology. Their answer was simply, 'we had to make the time to learn the material in order to be successful in the courses'. Most of the students indicated that they had to develop their time management skills in order to overcome the time challenge. Beth, Gwen, Hank, Ingrid, Karen, and Lisa all indicated that they needed to "find the time." Dave's answer was more succinct with a simple "late nights" and Angela indicated that she needed to "not procrastinate." The individuals who listed one of the

three subthemes of time also indicated that they had to find ways to allocate time for radiology but they also commented on a few other aspects of how they allocated their time for studying and how learning to do so altered the way in which they approached the material.

Vocabulary. Christine indicated that she:

> had to develop the way to study the material…I will read the notes one time really fast with the picture and then the material read it really fast, of course staying in the lab too. I stick with it. If it was two hours, I will go and stay there for two hours, not try not to leave early.

Similarly, Lisa indicated that she altered how she approached the course material and utilized a variety of sources to see how others used radiographic terminology in describing various lesions.

Developing the radiology 'eye'. Karen, Frank, and Ingrid all indicated that they had difficulty in developing the ability to see findings on the radiograph and then relate them to the patient. All three indicated that spending time looking at the images was the primary solution to this issue but they did offer a few additional thoughts on this. Frank indicated that he studied the images with anatomical models in his hand in order to help "visualize what was going on," and Karen echoed Frank's thoughts on the utility of anatomical models with the statement "I have a skeleton at home so that was really helpful for radiology." Ingrid was very vocal about her need to utilize anatomical models to master normal radiographic anatomy.

> Seeing it, I need to do that [use an anatomical model] because then I know where it is in the body. But, like I said my mind was on memorization, so with that I would draw the femur on a note card and then label the A, B, C, D and then point to something. And then on the back it would say greater trochanter, and so I still did more of a note card memorization, but I would

> spend the time in the lab going over it [the radiographs and anatomical models] so that I could at least try to apply how I will use it someday.

Using the technology. Jessica and Karen also indicated that they had to find the time not only to learn the material but also to get comfortable utilizing the technology necessary to view the materials. Jessica addressed her challenge of using the technology through the assistance of others. She stated "I just ask people to help me, classmates, Dr. X, Dr. Y, whoever."

The overarching challenge students faced in learning diagnostic imaging was a lack of sufficient time. Students voiced three challenges relating to this lack of time. The challenges were (a) learning the vocabulary necessary for diagnostic imaging, (b) developing the 'eye' for radiology and mastering how the three-dimensional human body appears on the two-dimensional image, and, finally, (c) mastering the technology for simply looking at digital imaging. Students overcame these three challenges through effective time management that allowed them to spend the time necessary to master both the technology and the skill of understanding what they are seeing on the radiographs – the 'radiology eye'.

Student Recommendations for Radiology Faculty and Future Students

In exploring the student experience in learning diagnostic imaging, two of the main areas of inquiry asked for recommendations that students offer for both radiology faculty and for peers regarding the teaching and learning of diagnostic imaging. Students had very thoughtful responses to these questions and identified a variety of suggestions. Two common themes were identified in the recommendations for faculty: (a) increasing active learning activities such as report writing and self-assessments/quizzes, and (b)

providing more ‘real life’ experiences such as case studies, outside speakers from imaging centers, and increasing the advanced imaging content because of the increase in utilization of advanced imaging in practice.

One student, Beth, had unusual insight into the curriculum because of her job in the radiology-learning laboratory. During the four years she worked in the lab, the college underwent a change in how it presented the radiology curriculum. She was trained in the ‘older curriculum’ wherein the material was taught to the students based on the underlying pathology. For instance, all tumors are taught in the tumor class whereas fractures and internal joint derangements are taught in the trauma course. The newer curriculum delivers the material based on body region. For instance, there is a course on lower extremity. The course addressed tumors of the leg, trauma of the leg, arthritis of the leg, and any other pathology that might occur in the lower extremity. Both curricula will cover the same material but differ drastically in how the material is categorized for the students to learn. Beth spent a fair bit of time talking about this issue and what she observed in the learning lab between the two different groups of students. She was adamant in her opposition to the regional approach to delivering the material and summarized her feelings with the following statement:

> I disagree on how they are changing it right now. And to me, I would probably have a hard time categorizing the regions instead of the conditions. It’s just a different learning experience, but I think the conditions were more important than the regions. I don’t know, to me it is, and I think other students agree as well.

Recommendations for Faculty

Increase active learning. It was apparent from the student responses that they think that an increase in interactive educational experiences would be beneficial. They want increased formative feedback in the radiology courses. Angela, Jessica, and Lisa all suggested utilizing written radiology reports throughout the curriculum as a way to help students master the skill of describing what they see on the radiographs. Lisa explained why she thought it was important to actually practice writing out the radiographic findings and why she thinks it would be good to have it integrated throughout the curriculum in the following statement:

> I still think if they incorporated more the ability to describe stuff. If you could describe a lesion then you can identify it and it makes it so much easier. And, I think that disconnecting, not having to physically do it and just looking at it on a piece of paper, going oh yah, I recognize that, that's easy to do. But you know, your patients won't come in like that.

Angela commented that by requiring students to do reports every lab, it would also make "sure that the students stay in for a decent amount of time… I think it's only to their advantage to stay for a little bit at least just to see the different films."

The participants had other suggestions for ways to increase active learning and formative feedback activities in the curriculum. Christine, Eric, Frank, Gwen, and Karen all had suggestions related to providing feedback through various forms of assessments. Eric, for example, thought that instructors should go through exams in class after the exam is completed so that students can understand what they did incorrectly and learn from their mistakes. I noted in my journal that this observation was an astute one, as feedback has been shown in the literature to be an important, if not the most important,

piece of student learning. I reflected that reviewing exams with students provides them with important feedback about where their weaknesses are in their knowledge base and that without this feedback we, as instructors, prevent them from having the opportunity to improve their skills. Frank suggested that during lectures instructors "keep doing the clicker (audience response system) questions; those were obviously very important and useful. Maybe even include one set a day just randomly during the lecture." Frank's response to this was particularly interesting as he also noted that use of the i-clickers was his most negative experience – when they did not work properly. Christine, Gwen, and Karen suggested that there be more opportunities for the students to test themselves in the labs using small group work and self-assessments or quizzes. Christine suggested that the small groups "have each one go through it (radiographs) first and then the instructor or resident go through what they see in there." All three felt it important to have more self-quizzes where the radiographic findings are written out for the student to look over after they have tried to interpret the images themselves. Dave combined a suggestion for writing reports with assessment feedback by suggesting that there be a resident or radiologist present throughout the radiology rotation to answer questions, do oral rounds with the interns, and to go through the radiographs with the interns after they complete their radiology reports.

Increase 'Real-Life' Experiences. Five participants had suggestions on how to increase the 'real-life' aspect of the courses. All of them wanted to see more images and have the instructors present more cases. In Hank's words,

> …tie in real life stuff with it. They actually did a pretty good job with that and they had little tumor stories or where someone came in with back and

hip pain, I took an x-ray and there was an aneurysm. Stuff like that sticks out.

Beth suggested that they provide more advanced imaging cases in particular "since we are going to see more MRIs nowadays." Ingrid expanded on the advanced imaging idea and suggested:

> ...just once a trimester to bring in someone from the outside to kind of show how radiology works outside of the classroom setting. It might be beneficial just to see that there is a light at the end of the tunnel and we're going to be using this and if it's (interpreting radiographs) not their strength there are people out there that would help you in the future. I mean you don't have to do it all by yourself.

Jessica had a caveat in her suggestion that more cases be presented – that the instructors always show a normal radiograph beside the abnormal radiograph. She indicated that,

> …one thing I always thought of is not just showing us abnormal. Just put it back up there with normal every time, so it's right there every time so it's easier to make a comparison. Because it sticks, you know? Oh, you see how the bone density is different? Different than what?

Recommendations for Future Students

The participants were very consistent in their recommendations for future students about how to best master the curriculum. Every answer touched on spending time, using all resources, and looking at as many images as possible. Beth's response was the most concise with a blunt "go to class, be there, own the book, and go to lab. Don't be lazy." The other participants echoed her sentiments but expanded to list other resources such as class notes, websites, and open lab times. Several students spoke specifically about classes and labs. Christine suggested that students "definitely go to class every time and make sure they stay in the lab like the whole time, go through every single x-ray they

have that they put up." Dave focused more on time with the comment "just take time with it I guess, it takes a lot of time for sure." Eric and Hank expanded on the importance of truly mastering the material, as it is important for clinical practice. Hank suggested that students "study to learn the material in order to pass the test, because if you know the material you will be fine on a test. If you just learn it well enough to pass the test you won't be able to utilize it in real life." Eric explained that learning does not stop in the classroom:

> Once you passed the class it doesn't end there, you need to keep looking at x-rays and because you forget if you not using the skill you will forget it. So even on my rotations, like the VA hospital or the private clinics where I am at, or even at school every time there was an x-ray I always wanted to go look at it. Whenever I ask for x-rays to be taken on a patient, I will like look at the knee or look at the body part before the resident tells me what's going on and see if I could do it. So just practicing, trying to keep that skill active.

I noted in my journal that Karen's response of "just do as much as you can, and just get in there as much as you can, because the more you see the more you are going to know" really summarized the students' responses to this question.

Resources in Course Syllabi

While interviews were the primary source of data collection for this study, I also reviewed all 12 syllabi for the radiology classes taught at both institutions. Two of the primary purposes of a syllabus are to serve as a contract between the student and faculty member, and to act as a learning tool by providing a list of resources available to students for the course along with explanations of how they will be assessed (Parks & Harris, 2002). I compared the syllabi with the experiences of the students as both a source of triangulation and to help make meaning of their experiences in relation to the theoretical

framework of the study. To do this I asked the question of whether the learning strategies and perceived effective instructional methods are reflective of the resources found in course syllabi.

Syllabi at both institutions contained a dearth of information that related to how students' perceived they mastered the material presented in the courses. With one exception, the syllabi did not list any online resources, even though the students indicated that they were referred to the website www.mypacs.net and to intranet sites by all of their instructors for their diagnostic imaging classes. The only resource that the students at both institutions consistently reported utilizing that was also consistently listed as a required (or recommended) resource was the textbook Essentials of Skeletal Radiology (Yochum & Rowe, 2004).

The normal radiographic anatomy course syllabi at Institution A listed a DVD on reserve in the library as a recommended resource and not a single student interviewed at Institution A was aware that it existed. Three of the five radiology syllabi at this institution listed the Radiological Learning Library as either a required or a recommended resource. This resource was widely utilized by the students interviewed on this campus. One Normal Radiographic syllabus at Institution A indicated a recommended study time of "1 to 2 hours of study time each week, the time being spent between reading and looking at radiographs in open lab" which did not correlate with the students' perception that a great deal of time needs to be spent in studying radiology in order to master the material. The Advanced Imaging syllabus listed intranet self guided case exercises that the students would be tested on during class time, and the Normal Radiographic Anatomy

I syllabus listed a similar online slide lecture on radiographic physics. These were the only references on the syllabi at Institution A that referred to online resources. Most students reported utilizing online resources, especially www.mypacs.net and Google, and indicated that their instructors recommended www.mypacs.net and utilized that website in class to some degree.

Institution B only had one syllabus that listed a resource other than course notes and required/recommended textbooks. The Skeletal Radiology II syllabus listed the radiographs in the Radiological Learning Lab and images on the university website as required resources for labs. There were no other references to online materials. This was very surprising to me because every student interviewed at Institution B related that the faculty recommended online resources and made those resources available through the college's intranet system. They also indicated that www.mypacs.net was utilized extensively in class and that the faculty had created accounts on the website specifically for each course. Gwen related, "They did a great job though in finding websites that they thought were good for images and putting them on Moodle so we could use that as a resource as well." Frank noted, "They did bring up mypacs a lot and we have an account through them for each class, which has examples there."

The syllabi at both institutions were not reflective of the learning strategies employed by the students or of the instructional methods that the students perceived as effective. Additionally, they failed to provide adequate information to the students to act as a learning tool by providing a list of resources available to students for the course.

Conclusion

Chapter IV presents analysis of data collected in this qualitative exploration of the student learning experience in diagnostic radiology education. A total of 12 students at two different chiropractic colleges in the United States were interviewed. Student responses offer insight into the learning strategies they believe both worked and did not work in learning radiology, their perceptions of the effectiveness of instructional methods used by faculty, the challenges students faced in learning radiology and how students addressed these challenges, and the recommendations that students offered for both faculty and peers regarding the teaching and learning of radiology. Additionally, syllabi from both institutions were analyzed to determine whether the learning strategies and perceived effective instructional methods are reflective of the resources found in course syllabi.

The data from the student interviews revealed that the students preferred learning experiences that are active in nature and that relate to clinical situations that they will encounter in practice. These findings reflect Lev Semyonovich Vygotsky's (1962) theory of social constructivism, experiential learning theory developed by David A Kolb (1984) and Malcolm Knowles' (1990) work on adult education, or andragogy. As reflected in these theories, the students perceived that they mastered the radiology curriculum best when they understood that it was important for them to learn this material in order to become competent clinicians. They preferred to have active learning experiences and thought that such experiences afforded them better learning than passive experiences. Additionally, students believed that when an instructor had higher expectations or harder

exams they mastered the material better than when the instructor was ‘easy’ or just utilized multiple choice format exams.

Chapter V offers conclusions and discussion about how students experience learning radiology. Recommendations for helping radiology instructors improve how they deliver radiology curriculum to students and suggestions for future research are included in Chapter V.

CHAPTER V

SUMMARY, CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

The lack of information about the student learning experience in learning diagnostic imaging was evident in the literature review in Chapter II. The lack of research in this area combined with my own experience in teaching diagnostic imaging over the last decade resulted in this exploratory study. The study utilized a qualitative phenomenological approach through in-depth interviews of 12 students using open-ended questions to serve the research purpose of identifying and understanding the experiences of students in radiology curricula and how they perceive radiology is learned.

The results of this inquiry provided insight into several areas of the student learning experience in diagnostic imaging courses at two chiropractic colleges in the United States. First, it offered a reflection of the overall chiropractic student experience in diagnostic radiology courses. Second, this study documents what students believe to be effective delivery, learning resources, and study methods for radiology. Third, common themes identified by the participants as particularly beneficial or unhelpful when learning diagnostic imaging provide a basis for further investigation into improving diagnostic radiology education. Fourth, the study's key findings allow individual instructors to reflect on how their particular course design could be altered to enhance student learning. Finally, the study provides a foundation of information that will

encourage future discourse and research into evidence-based diagnostic radiology education.

Summary of Study

The first two chapters reviewed the available literature examining undergraduate diagnostic radiology education, diagnostic radiology curriculum, and diagnostic radiology pedagogy and demonstrated that the evidence shows a wide disparity between disciplines and even between colleges within disciplines (Barlev, Lautin, Amis & Lerner, 1994; Subramaniam, Kim & Scally, 2007). This paucity of literature has been summarized with the succinct statement that "evidence-based radiology education and radiology education research are glaringly lacking" (Tay, Kamei, & Tan, 2009, p. 195). Physicians need to learn what makes an educator effective so that they can apply that knowledge to facilitate successful student learning (Collins, 2006). The literature reviewed clearly demonstrated the need for a qualitative study exploring the student learning experience in diagnostic radiology education.

Chapter III outlined the phenomenological research design of this study. The study gathered the experiences of 12 students who learned diagnostic radiology during their education at two different chiropractic colleges in the United States and who were asked to examine their beliefs about what was truly effective within the learning experience. Specifically this study investigated (a) the learning strategies followed by students that they believe both worked and didn't work in learning radiology, (b) student perceptions of the effectiveness of instructional methods used by faculty, (c) the challenges faced in learning radiology and how students addressed these challenges, (d)

the recommendations that students offer for both faculty and for peers regarding the teaching and learning of radiology, and (e) whether the learning strategies and perceived effective instructional methods are reflective of the resources found in course syllabi. This allowed me to understand what pedagogy(ies) students perceive as effective in teaching undergraduate diagnostic radiology. In Chapter IV, I presented discuss the data collected in this study and highlight the themes that emerged from the study.

This final chapter offers my conclusions by discussing each of the key findings and incorporating relevant aspects of the literature review and theoretical frameworks driving the study. These conclusions offer a foundation upon which I base my recommendations for future practice for those who teach diagnostic imaging. Finally, my suggestions for future research conclude the chapter.

Key Findings

Preference for Active Learning Experiences

Students strongly preferred learning experiences that were active in nature to those that were passive learning experiences. This was the strongest theme that emerged from this study and was reflected in the students' answers to the questions relating to three of my research questions, specifically, (a) the learning strategies followed by students that they believe both worked and didn't work in learning radiology, (b) student perceptions of the effectiveness of instructional methods used by faculty, and (c) the recommendations that students offer for both faculty and for peers regarding the teaching and learning of radiology.

This overall preference for active learning environments is seen in interviewee Dave's comment, "they were hour lectures, and some of them were just brutal. He was so monotone too. If he had more interactions with the students…that will be a better way." Students listed numerous and varied interactive activities for both lecture and laboratory settings. Lecture examples included i-clicker use, providing incomplete notes that require students to fill in blanks throughout the lecture, having students write a radiology report in lectures, giving small quizzes at beginning, middle, or end of lectures, using humor to engage students, and reviewing exams in class. Laboratory examples included providing anatomical models for use in learning normal radiographic anatomy, hot-seat/pass-the-chalk/oral rounds, radiology report writing, self-assessments, practice exams, and practice quizzes within a group environment. The solitary exception to the preference for active learning experiences was a universal opinion that group presentations are not a good learning experience. The reasons given for group presentations being a poor learning experience were not related to the actual presentation but rather the assigned presentation only covered a small portion of the material, unlike an exam that covers all the material, and issues related to disparate work ethics and associated group dynamics.

This finding is reflective of the students' self-reported preferred learning styles as multimodal, mainly visual and tactile learners, who strongly preferred active learning approaches, preferably ones that tied the learning activity to real life. This strong preference for active learning opportunities is reflective of experiential learning theory wherein the student learners are actively involved in the educational experience (Kolb,

1984). Many of the preferred learning experiences such as the small group oral rounds and practice quizzes also strike a chord with Lev Semyonovich Vygotsky's (1962) theory of social constructivism, as these experiences are social interactions wherein the students work as a group to learn the material.

Real Life Clinical Cases

Students almost universally discussed the utilization of real life clinical cases in both lecture and laboratory settings when discussing questions relating to the following research questions, (a) student perceptions of the effectiveness of instructional methods used by faculty, and (b) the recommendations that students offer for both faculty and for peers regarding the teaching and learning of radiology. Students viewed this as a vital aspect of their learning experience as it allowed them to see how they would apply this skill in their own clinical practice and made the material easier to remember as a result. One of the few non-visual learners, Jessica, suggested that instructors expand on this concept of providing real examples and provide comparative normal radiographs when showing abnormal radiographs. This desire to have their learning experiences grounded in clinical cases that they will encounter in practice reflects the internal motivation that Malcolm Knowles (1990) describes in the adult learner. He postulates that adults learn best when they understand why they need to learn something and when they can gain knowledge through active learning styles such as problem solving, role-playing, case studies, or self-evaluations. Kolb's (1984) experiential learning theory can also be seen in this finding in that Kolb believes that gaining knowledge effectively requires that learners can make meaning of an experience so that they can apply the knowledge in

future situations. By providing clinical vignettes in class, the instructors provide both a basis for students to find meaning in the topic being discussed and allow the learners to understand why it is important to them as individuals to master the material.

Search Patterns and Vocabulary

One interesting difference between the two institutions was when faculty taught students to develop a search pattern for approaching interpretation of the radiographs. This importance of this difference became apparent while asking students questions relating to four of my research questions: (a) the learning strategies followed by students that they believe both worked and didn't work in learning radiology, (b) student perceptions of the effectiveness of instructional methods used by faculty, (c) the challenges faced in learning radiology and how students addressed these challenges, and (d) the recommendations that students offer for both faculty and for peers regarding the teaching and learning of radiology.

Institution A incorporated it throughout radiology courses as a fundamental skill that was assessed from the start of the radiology curriculum and where students practice writing radiology reports to reinforce this skill in several courses. Institution B mentioned using a search pattern in its classes but did not incorporate and evaluate this skill until the final course in the curriculum when students were required to write radiographic reports for the first time. The students at Institution A reflected about how helpful the search pattern was in learning the material and students at Institution B commented that they had wished that the search pattern and report writing had started earlier in their training. Additionally, students at Institution B found mastering the

vocabulary necessary to write radiology reports more challenging as they had not been forced to practice utilizing the vocabulary throughout the curriculum; unlike the students at Institution A where they were required to utilize appropriate vocabulary in writing the reports in numerous classes. Vygotsky's (1962) Zone of Proximal Development (ZPD) describes how learners can be 'stretched' through assistance from others to master information or skills that they could not do alone. Essentially the role of the instructor is to help the learner improve his or her performance and become more effective at the given task (Atherton, 2011). By providing students with an effective search pattern, and requiring them to utilize it throughout the curriculum, the instructors were essentially utilizing the students' ZPD effectively. While the students at Institution B did master the material, they appeared to find the process more difficult than their counterparts did at Institution A.

Importance of Examinations and Strategic Studying

Students provided extensive feedback about how the style and difficulty of course evaluations drove the extent of their studying and the depth that they learned the material. Almost universally, students indicated that they learned the material better if they perceived the course evaluations would be difficult. If the instructor gave challenging exams and/or if they were given written exams rather than multiple-choice exams, the students reported that they studied to learn the material at a deeper level to ensure that they had a better grasp of the material for the examination. Similarly, students reported that they did not learn as much when they were evaluated through presentations rather

than examinations and that such group presentations were essentially busy work with little learning occurring in the process of preparing and presenting their project.

Interestingly, harder exams resulting in deeper student learning only held true if all of a given course's evaluations were perceived as difficult. While students universally indicated that they wanted to learn the material and understood that mastering diagnostic imaging was important for their future clinical practice, many of them also admitted to studying strategically for their radiology classes. Because of the very heavy course loads students experience in professional programs, they often resort to being selective and study preferentially for easier exams in order to maintain their grades if a course provides the opportunity to balance out exam grades over term of the course. If an exam is perceived as easier, students will study harder for that exam in order to boost their overall grade in the class and balance out their grades on exams that are perceived as more difficult. This finding is important for instructors to understand, because offering easier multiple-choice examinations, where they simply need to recognize data, along with written examinations where the student is required to apply their knowledge, faculty are actually doing a disservice to both the student and their future patients. Practitioners need to be able to apply their knowledge in a clinical setting. This concept of strategic learning is considered a subset of surface learning rather than deep learning and has been a source of both concern and inquiry for years in the literature (Atherton, 2011b; Biggs, 1993; Houghton, 2004; Mansouri, Soltani, Rahemi, Nasab, Ayatollahi, & Nekooeian, 2006; Ramsden, 1988). Finally, students indicated that they preferred being able to use examinations as both summative and formative evaluations wherein they are allowed to

review their exams and learn what they did incorrectly so that they can then address their areas of weakness. Institution A did not allow students to review their exams, which created resentment over the lost learning opportunity.

Syllabi Not Well Utilized

In order to answer the research question of whether the learning strategies and perceived effective instructional methods are reflective of the resources found in course syllabi, syllabi from all diagnostic imaging courses at both institutions were compared with the interview findings. This revealed that students rely on what is presented in class as resources for studying rather than what is listed in the course syllabus. Students uniformly utilized all resources offered by instructors including required textbooks, recommended websites, intranet resources, and laboratory resources. However, these online resources were usually not listed on syllabi and, in one case, a resource that was listed on a syllabus was unknown to every student interviewed. It is apparent from discussions with students that they do not use course syllabi for guidance in studying. Review of the 12 syllabi from both institutions revealed faculty have not updated their syllabi to reflect the resources they are currently providing or recommending in lectures and laboratories. Because a primary purpose of a syllabus is to serve as a learning tool by providing students with key information such as: a list of resources available for the course, explanations of how students will be assessed, information about planning and self management skills, advice on amount of time to spend outside of class, and tips on how to study and do well on exams or assignments (Parks & Harris, 2002), this finding was both surprising and disappointing. This represents a huge opportunity for

improvement in providing better learning opportunities for students, as a well-constructed syllabus can be an extremely effective tool for student centered learning (Eberly, Newton, & Wiggins, 2001).

Time

In investigating the research question 'what are the challenges faced in learning radiology and how students addressed these challenges', time was overwhelmingly the biggest challenge students faced in learning radiology at both institutions studied. Students indicated that they spend more time studying for diagnostic imaging than most of their other classes and that time management was problematic given the huge course loads they carry through the program. The areas identified as most time consuming in learning diagnostic imaging at both institutions were developing the 'eye' for radiology, learning the required vocabulary for diagnostic imaging, and mastering an understanding of how the three dimensional human body appears on the two dimensional image. Two students at Institution B also indicated that learning to utilize the technology associated with diagnostic imaging was problematic. This issue tied into several other key findings as time management affected study strategies, the amount of time students were able to spend in open laboratories, and their desire to have search strategies taught and assessed throughout the program. The issue of time management in professional programs and the resultant need for effective learning and study strategies (Lee & Pringle, 1988; Schutz, Gallagher & Tepe, 2011; Shapiro, Shapiro, & Schwartz, 2000; Wolf, 1994) in order to succeed and develop effective stress management techniques is well known in the literature.

Recommendations for Future Practice

My recommendations for future practice are intended for radiology faculty and program administrators overseeing radiology training who aspire to improve the quality of their educational offerings and improve student-learning outcomes. By focusing on student-centered learning faculty will increase the likelihood of students mastering the material thereby having better radiology skills and eventually providing quality health care to their patients. As a result, my findings in this study lead me to suggest the following to those who educate future physicians: (1) increase active learning activities; (2) provide anatomical models in normal radiographic anatomy laboratories and examples of normal radiographs in pathology laboratories; (3) incorporate radiographic search patterns and appropriate vocabulary utilization throughout all classes; (4) utilize challenging examination formats and allow students to review exams; (5) utilize clinical cases as much as possible; (6) establish safe, challenging learning environments; (7) develop syllabi that fulfill all three functions of an effective syllabus; (8) increase institutional support of scholarship in teaching and provide faculty development that models the creation of safe, challenging learning experiences; and (9) provide time management and study skill training to students in their first term of professional school.

Increase Active Learning Activities

This study found that students prefer learning activities that require them to be engaged in the learning process and that they believe these activities increase their mastery of the content. This finding is consistent with current literature in education and with the three theoretical frameworks utilized in this study, andragogy, experiential

learning, and social constructivism. As a result, I suggest that instructors seek out ways to increase effective active learning activities in both the classroom and laboratory settings.

Faculty should explore options such as audience response systems, providing students with online self-assessments and self-quizzes, incorporating short quizzes or writing assignments in lectures, and other more effective activities that lend themselves to a large group setting like a lecture. Laboratory sessions, by definition, are small group activities and are perfect for incorporating active learning strategies. The utilization of hot-seat sessions in teaching radiology is one of the few areas of radiology education that has support in the literature as an effective method of education, especially when employed in ways that are supportive of student learning rather than in a way that can be perceived as negative by the student (Chew, 2001; Collins et al., 1997; Collins, Garofalo, & Albanese, 1996; Collins, Miller & Albanese, 1997; Roberts & Chew, 2003). Instructors can incorporate these hot-seat sessions, along with other active learning activities such as report writing, group quizzes, games, and other small group activities that incorporate the aspects of andragogy, social constructivism, and active learning techniques.

Provide Anatomical Models in Normal Radiographic Anatomy Laboratories and Normal Radiographs in Pathology Classes

Another finding in this study was that many students occasionally utilize anatomical models when studying normal radiographic anatomy. Several indicated that they did not have regular access to these items even though they would have been

beneficial to have while learning normal anatomy. Others purchased their own to utilize in this manner. In particular, one of the non-visual learners indicated that the simple addition of a normal radiograph next to the radiograph with the pathology being taught would be invaluable in being able to learn to see what the instructor is pointing out on the images. These two items would be simple additions to make and would most likely assist students in mastering the material.

Incorporate Radiographic Search Patterns and Appropriate Vocabulary Utilization Throughout All Classes

Another key finding in this study was the discovery that the incorporation of a formal search pattern for reviewing radiographs throughout the diagnostic imaging curriculum along with the requirement to utilize appropriate vocabulary in practicing writing radiology reports was a valuable learning tool for students. The disparity between the two institutions regarding when students were required to incorporate this process into their educational experience was enlightening. Students at Institution A required to utilize a search pattern and write reports and were very appreciative of this focus as it helped them master the material. Students at Institution B were not required to utilize a search pattern or write reports in most of their courses. As a result, they did not practice using vocabulary to describe their findings on radiographs until their last course in their diagnostic imaging curriculum. These students uniformly thought that these skills should be incorporated into classes earlier in the curriculum. Faculty should incorporate a formal radiographic search pattern into courses throughout the curriculum

and require students to practice writing radiology reports in all courses. These two simple changes will make it easier for students to master the material.

Utilize Challenging Examination Formats and Allow Students to Review Exams

The students' revelation that they learn the material better for written examinations or for examinations that they perceive as more challenging is reflective of the literature that examines the relationship between student learning and methods of assessment (Bruno, Ongaro, & Fraser, 2007; Gijbels & Dochy, 2006; Scouller, 1998). Additionally, strategic studying (Atherton, 2011b; Mansouri, Soltani, Rahemi, Nasab, Ayatollahi, & Nekooeian, 2006) is a well-known phenomenon in the educational literature. Institutions should encourage radiology instructors to familiarize themselves with this research and employ higher-level assessments to encourage deep learning of the material though faculty development programs. Additionally, faculty should avoid creating situations where students compensate a poor performance on an image interpretation exam with low-level multiple-choice examinations, as it will result in students not adequately mastering a fundamental skill necessary for clinical practice, the ability to interpret radiographs. Students must be assessed on their ability to interpret radiographs and incorporate that information into patient management rather than on simple recognition of facts on multiple-choice exams that test them at the lowest levels of Bloom's taxonomy (Anderson & Krathwohl, 2001).

A great deal of literature supports the utilization of formative evaluation in assisting students to master a topic (Baeten, Kyndt, Struyven, & Dochy, 2010; Black & William, 1998; Gibbs & Simpson, 2004a; Gibbs & Simpson, 2004b). Nor is this a new

concept in higher education. Over 20 years ago, Hattie (1987) performed a comprehensive review of 87 meta-analyses of studies of factors affecting achievement and found that the single most important factor was feedback. Radiology faculty should allow all students to review their examinations in order for students to be able to receive feedback about what they did wrong on the exam so that they can address those weak areas of knowledge. If students are correct in their assumption that the reason they are not allowed to review exams is that exam security will be compromised, I would advise faculty that my experience with this is, that this is untrue. Radiographic interpretation examinations are extraordinarily easy to create and reuse if one simply changes the clinical presentation of the case and shuffles the order in which the cases are presented. This has been my approach in examining students and I have never had an issue with reusing cases. In discussing this finding with colleagues, I found that others have similar experiences in reusing radiographs on exams.

> It is easy to use the same cases in subsequent exams if the clinical information for the case is changed and the case order is changed. I have done this for years and the students never knew, even though they always got their tests back and we always went over the answers in front of the films. (C. Peterson, personal communication, October 3, 2011)

Utilize Clinical Cases as Much as Possible

Students identified the utilization of clinical cases in presenting material resulted in the material being more memorable and easier to study. This is an easy addition to both lecture and laboratory activities and is something that most instructors, in my experience, already do to some degree. It is a simple way to help the students master the material.

Establish Safe, Challenging Learning Environments

Students described many of their best learning experiences in terms that indicated that, while they found the radiology courses difficult, they enjoyed them and felt that the faculty were supportive of them during the learning process. Angela's statement, "I enjoyed it even though it was hard," reflects the appropriate level of challenge she found in the courses. Even the 'hot-seat' sessions in the laboratory were perceived as enjoyable although they were stressful. Ingrid explained, "as much as I didn't like pass the chalk, it was always fun, it was just a laid back atmosphere, and I always felt like I learned a lot out of them." Learning environments where students feel safe to experiment, where students are appropriately challenged, and where students have fun while undergoing the learning process result in better learning outcomes (Gulpinar, & Yegen; 2005; Hutchinson, 2003; Jeffree & Clarke, 2010; Kendall, Hesketh, & Macpherson, 2005; White, 2001). Similarly, articles identifying characteristics of effective clinical teachers document that the ability to provide a safe, nonjudgmental, and nonthreatening learning environment is important (Buchel & Edwards, 2005; Collins, 2006; Hutchinson, 2003) in achieving these effective learning experiences. Recent literature shows that medical colleges are beginning to actively incorporate the concept of safe learning environments into formal curriculum design (Chou, Johnston, Singh, Garber, Kaplan, Lee, & Teherani, 2011; Miller & Cohen-Katz, 2010).

Develop Effective Syllabi

This study revealed that the syllabi at the two institutions are not being effectively utilized by the faculty or the students. It is generally accepted in educational circles that

a syllabus serves three basic functions. It serves as a contract between the faculty member and the students; it serves as a permanent record of the course and its requirements, and most importantly for this study, it serves as a learning tool (Parks & Harris, 2002). A well-written syllabus can be a key component of student-centered learning (Eberly, Newton, & Wiggins, 2001). I recommend that the faculty and administrators responsible for radiology curricula spend time reworking their syllabi to include elements that would assist students in their courses. Not only should it contain a current and accurate list of resources that students should use inside and outside of class time, but could also contain information about planning and time management, tips on how to master the information, study strategies, common mistakes to avoid, and many other possible helpful topics (Parks & Harris, 2002). While this would be a somewhat time-consuming activity, it would provide students with a useful document. Additionally, as it appears that students at the institutions do not actually read the syllabi provided to them, it would behoove faculty to spend time reviewing it in class and emphasizing the areas to utilize as a learning tool once the syllabi include that information.

Increase Institutional Support of Scholarship in Teaching and Provide Faculty Development that Models the Creation of Safe, Challenging Learning Experiences

Most people instructing diagnostic imaging do not have any formal training in the scholarship of teaching and they simply ‘teach as they were taught’ and mimic their own instructors. This issue is not new and the idea that teaching is often the neglected area of scholarship in higher education has been discussed in the literature for decades (Boyer,

1990), and persists in current medical education realms (Chen, 2009; Shapiro & Coleman, 2000). This is particularly true in clinical education, of which radiology education is a subcategory, in that physicians fail to turn their experience into scholarship. Physicians do not "systematically assess the effectiveness of different techniques and communicate these findings in a way that allows others to benefit from that expertise" (Shapiro & Coleman, 2000, p. 896). This is, at least in part, because many institutions do not adequately recognize, or reward, faculty for scholarship of teaching (Fincher et al., 2000). Similarly, faculty training in this area is often inadequate (Hutchinson, 2003) and arguments abound that institutions should invest in improving the quality of their radiologists' teaching abilities and should recognize excellent teaching skills as an important part of their faculty members' value to the department (Gunderman, 2000; Gunderman et al., 2000; Gunderman, Kang, Fraley, & Williamson, 2002).

It was evident from the students' descriptions of their best learning experiences that when faculty attempted to create supportive, challenging learning environments, and when faculty incorporated active learning techniques into student learning experiences, it worked. However, the techniques being utilized in the diagnostic imaging classes were rudimentary, with much room for expansion and improvement. Additionally, in the case of Institution A, the faculty do not appear to realize the extreme importance of timely, formative feedback to the student learning experience.

Both Institutions A and B utilize formal faculty development programs that include information on effective teaching methods (Administrators at Institutions A & B, personal communication, May 2011). Faculty training in this area is becoming more

common and is often done through lectures, seminar series, short courses, and workshops. Unsurprisingly, sessions that receive the most positive feedback from participants, and appear to have the greatest impact had some interactive practice sessions (Steinert, Mann, Centeno, Dolmans, Spencer, Gelula, & Prideaux, 2006). This again reflects the need to create an effective learning environment for learners, in this case the faculty members attending the training. Institutions must create safe, challenging, active-learning experiences for faculty to learn to utilize these techniques. Otherwise, how can we ask them to embrace these concepts when we do not model them for the faculty when we are educating them about these techniques?

Colleges must also create an overarching atmosphere that encourages the scholarship of teaching by creating an infrastructure that fosters and rewards these types of activities (Fincher et al, 2000). Additionally, institutions should provide opportunities for faculty to participate in faculty development opportunities that will allow them to take part in learning experiences that model the type of safe, effective, and challenging learning environments that they should be providing to their students.

Provide Time Management and Study Skill Training in First Term of Professional School

Several students indicated that they had to learn how to study and how to manage their time effectively in order to be successful in their courses at both institutions. Additionally, several students indicated that this was not something that they had to do in their high school and undergraduate careers. I reflected in my journal that this was something I struggled with in professional college as well, a need to spend significant

amounts of time studying, and I had no idea how to study effectively. It would be worthwhile for administrators at professional colleges to consider providing training and guidance in this area during the first few weeks of students' professional school experience.

Recommendations for Future Research

While reviewing the data gathered in this study and identifying common themes in the transcripts as I strove to address my research questions, I inevitably began to identify new questions that need to be asked as researchers pursue excellence in radiology education. As a result, I suggest that future research address the following questions: (1) do students with weaker grades in diagnostic imaging experience radiology education in the same way as the population of students in this study? (2) Do students with weaker grades in diagnostic imaging have different learning styles than those with strong grades and does it relate to the pedagogical approach utilized in the curriculum? (3) How do the various active learning techniques identified as 'effective' by the students in this study compare to each other? (4) Is there an ideal time to incorporate a radiographic search pattern in the curriculum? Finally, (5) how does student assessment affect both short- and long-term knowledge retention?

Repeat Study with Students with Poor Grades

A limitation of this study was that only students with grades of B or better in the diagnostic imaging courses were interviewed based on the theory that those with better grades mastered the material better than those with lower grades. This raises the question "is the student experience in learning radiology different for those with low grades than it

is for those with high grades?" If students who mastered the material better as reflected in their course grades utilized different material, study techniques or had different obstacles to overcome than their counterparts with lower grades, then those differences could shed light on areas to focus future research studies. It would be worthwhile to explore if differences exist between the two groups, and if differences occur, to examine why they are different, and if that difference is the cause of the grade disparity.

Research on Active Learning Techniques

While this study found students preferred active learning techniques, it did not delineate which, if any, of the identified techniques were more helpful than others in mastering the material. Additionally, it raised questions in my mind about whether the active learning techniques affected short-term information retention, long-term retention, or both. Comparisons between cohorts of students could be utilized to test various active learning techniques as these courses are generally taught two or three times a year. The simple addition of a specific active learning technique in one group, while keeping all other factors the same, would allow for analysis of the classroom data to see if there is a significant effect on student learning outcomes with the addition of the technique.

Research on Search Pattern Instruction

Students identified utilizing a formal search pattern as a valuable learning tool. Study into how and when to incorporate this tool into the curriculum should be undertaken. Should students be asked to learn this skill in their normal radiographic anatomy class when they are struggling to understand basic fundamental concepts of how

to look at an image, how to find specific anatomy on the image, and understand what the various radiographic densities they see in the image mean in relation to the human body. Would asking them to master this additional skill at this early stage help or hinder them? Would it be better to incorporate the search pattern after they have learned what normal looks like on a radiograph?

Research on Exam Styles

The findings in this study suggest that exploring the relationship between examination styles and student mastery in diagnostic imaging is needed. The realization that students are utilizing the ability to do well on a multiple-choice examination to compensate for poor radiographic interpretation skills is disturbing at best. If diagnostic imaging is considered be a fundamental clinical skill, then it should be tested as a clinical skill rather than with multiple-choice exams aimed at fact recognition. Can the assessment of students be changed and thereby cause them to learn material at a deeper level? Will the use of purely interpretive written exams result in better student outcomes and better patient care? This is an area of radiology education only a few preliminary studies are found in the literature (Marchiori, Adams, & Henderson, 1999; Marchiori, Henderson, & Adams, 1999; Peterson, 2004), but the need for further research is evident.

Limitations and Conclusion

The previous sections of this chapter outlined key findings, recommendations for practice based upon the findings, and suggestions for future research. While a limitation of this study is its small scope with interviews of only 12 participants, my research found several key themes across the participants. These included a preference for active

learning experiences and for real life clinical cases to be incorporated into classes, a desire for search patterns and vocabulary to be integrated into all diagnostic imaging classes, the importance of examination style in relation to student depth of learning and strategic studying, that course syllabi are not being utilized adequately by faculty or students, and that time management is the single largest obstacle students face in learning radiology.

A relative dearth of articles examines the pedagogy of teaching radiology to undergraduate medical/chiropractic students. What little literature exists in radiology education is often contradictory in nature with the only consensus being that radiology education is important at both the undergraduate and resident level. To date no definitive studies have examined how to teach radiology successfully to either undergraduates or residents or how to assess it effectively as a clinical competency. The students in this study provided valuable information that correlated with three well-accepted theoretical frameworks for learning – social constructivism, andragogy, and experiential learning theory – and provided for seven recommendations for future practice, which could lead to improved student learning outcomes in diagnostic imaging curricula thereby improving patient care by increasing the skill set of graduates. By striving to improve radiology education for students, not only will students succeed in courses but they will also become better clinicians to their future patients.

APPENDIX A

HOURS IN CHROPRACTIC COLLEGE CURRICULA

DEDICATED TO RADIOLOGY

Hours of Radiology in Curriculum

Chiropractic Program	***Physics & Positioning***	***Diagnostic Radiology***	***Total Hours***
Canadian Memorial Chiropractic College (T. Pringle, personal communication, January 26, 2012)	98	236	334
Cleveland Chiropractic College Kansas City (M. Whitehead, personal communication, August 13, 2010)	60	315	375
Cleveland Chiropractic College Las Angeles (M. Whitehead, personal communication, August 13, 2010)	60	315	375
D'Youville College (J. Taylor personal communication, August 8, 2010)	64	361	425
Life University (B. Fox, personal communication, January 23, 2012)	132	308	440
Life University West (JC. Carter, personal communication, August 7, 2010)	64	225	289
Logan College of Chiropractic (N. Kettner, personal communication, August 10, 2010)	90	210	300
National University of Health Sciences (W. Bogar, personal communication, August 9, 2010)	75	210	285
New York Chiropractic College (JN. Poirier, personal communication, August 7, 2010)	60	210	270
Northwestern Health Sciences University (R. DeVries, personal communication, August 20, 2010)	75	210	285
Palmer College of Chiropractic West (D. Scuderi, personal communication, August 17, 2010)	110	308	418
Palmer College of Chiropractic Davenport (D. Marchiori, personal communication, February 12, 2012)	165	210	375

Palmer College of Chiropractic Florida (D. Marchiori, personal communication, February 12, 2012)	216	144	360
Parker Chiropractic College (S. Norton, personal communication, August 19, 2010)	90	240	330
Sherman College of Chiropractic (L. Orndorff, personal communication, January 24, 2012)	180	276	456
Southern California University of Health Sciences (M. Eurich, personal communication, August 19, 2010)	90	285	375
Texas Chiropractic College (J. Thompson, personal communication January 23, 2012)	60	285	345
University of Bridgeport (T. Perrault, personal communication January 2, 2012)	90	306	396
University of Three Rivers (JM Grenier, personal communication, August 8, 2010)	90	360	450
Western States Chiropractic College (B. Harger, personal communication, January 23, 2012)	99	220	319
Average	**114.4**	**264.5**	**378.9**

APPENDIX B

INVITATION TO BECOME A LIAISON

Date

Name,
Title
Institution
Address

Dear _____:

I am writing to invite you to participate as an administrative liaison for a study examining student experiences in the radiology curriculum of their chiropractic education that I am conducting for my doctoral dissertation at Loyola University Chicago. This qualitative study explores the experiences of eight fourth-year students at each of two different chiropractic colleges regarding their perspectives on how they learned diagnostic radiology and what contributed to this learning. Specifically, this study investigates a) the learning strategies followed by students that they believe both worked and didn't work in learning radiology, b) student evaluations of the effectiveness of instructional methods used by faculty, c) the challenges faced in learning radiology and how students addressed these challenges, d) the recommendations that students offer for both faculty and for peers regarding the teaching and learning of radiology, and e) whether the learning strategies, and instructional methods that worked are reflective of those described by faculty in course syllabi.

My intent is to gain insight into this topic by interviewing eight fourth-year students at your institution; four women and four men, including two students of color.

If you are willing to act as a liaison for my study, I will ask you to help identify and contact the student sample from your institution and to obtain copies of syllabi from the radiology courses at your institution. To that end, I will ask you to send students the materials I provide you, including an Invitation to Participate, and a Synopsis of the Research Study. Students will indicate their willingness to participate by contacting me directly. The information gathered during interviews with students and through the use of course syllabi will only be used for the purpose of this research. Your identity, the identity of your institution, and those students who volunteer to participate will not be revealed. The enclosed Synopsis of the Research Study and copy of the IRB approval from Loyola University Chicago will provide you with more detailed information.

Thank you for considering my request to participate in this research project. If you are interested in participating, please contact me via email at klinake@luc.edu. I look forward to hearing from you soon.

Sincerely,
Kathleen Linaker
Email: klinake@luc.edu
Phone: 678-581-9897

APPENDIX C

LETTER TO COOPERATING INSTITUTION

Date
Name
Title
Institution
Address

Dear Ethics Committee Chair:

I am writing to inform you of my desire to conduct a study at your institution for my doctoral dissertation at Loyola University Chicago that examines student experiences in the radiology portion of the chiropractic curriculum. This qualitative study explores the experiences of eight fourth-year students at each of two different chiropractic colleges regarding their perspectives on how they learned diagnostic radiology and what contributed to this learning. Specifically, this study investigates a) the learning strategies followed by students that they believe both worked and didn't work in learning radiology, b) student evaluations of the effectiveness of instructional methods used by faculty, c) the challenges faced in learning radiology and how students addressed these challenges, d) the recommendations that students offer for both faculty and for peers regarding the teaching and learning of radiology, and e) whether the learning strategies, and instructional methods that worked are reflective of those described by faculty in course syllabi.

I seek approval from your institutional research board for my study. My intent is to gain insight into this topic by interviewing eight fourth-year students at your institution; four women and four men, including two students of color.

The information gathered during interviews with students and through course syllabi will only be used for the purpose of this research. The identity of your institution and those students who volunteer to participate will not be revealed. The enclosed Synopsis of the Research Study and copy of the IRB approval from Loyola University Chicago will provide you with more detailed information.

Would you please contact me via email at klinake@luc.edu to discuss how I can provide the information your ethics committee requires in order to review my request to conduct research on your campus? I look forward to hearing from you soon.

Sincerely,
Kathleen Linaker
Email: klinake@luc.edu
Phone: 678-581-9897

APPENDIX D

STUDENT INVITATION TO PARTICIPATE

Date

Dear _____:

I invite you, as a fourth-year chiropractic student, to participate in a research study examining your experiences in the radiology curriculum of your chiropractic program. As a doctoral student in the Higher Education program at Loyola University Chicago, I am investigating how students experience radiology as it relates to their training and study over their years in the chiropractic program.

My intent is to gain insight on this topic through personal interviews with eight fourth-year interns at two different institutions. I am inviting you to participate because you are currently a fourth-year student at (*institution name)*. Should you accept the invitation to participate, you will be agreeing to be interviewed by me for approximately 60-90 minutes. The interview will be audio taped, later transcribed, and I will ask you if you are willing to review the transcription to ensure accuracy. Confidentiality is ensured and your input will not be shared with your institution. Your participation will not impact any of your grades or academic standing at your college. I will use a pseudonym for your identity in the study so your name will not appear in my analysis, nor will it be known to any reviewers of this study. The attached synopsis of the research study provides further detail of the study.

Should you decide to participate in this research by agreeing to be interviewed, you will receive a $20 gift card to Amazon.com at the interview as a token of my appreciation for your time and willingness to participate. To ensure the confidentiality of the study, please respond directly to me at klinake@luc.edu and not to [liaison name here], if you are willing to participate in this study.

Thank you for your consideration. If you have any questions, please do not hesitate to contact me.

Sincerely,

Kathleen Linaker
Email: klinake@luc.edu
Phone: 678-581-9897

APPENDIX E

SYNOPSIS OF THE RESEARCH STUDY

Researcher Background

My name is Kathleen (Kat) Linaker and I am a Ph.D. Candidate in the program in Higher Education in the School of Education at Loyola University Chicago. I received a Doctor of Chiropractic degree from Northwestern University of Health Sciences and I am currently the Executive Director of Chiropractic Programs at D'Youville College in Buffalo, New York.

Research Purposes

This qualitative study explores the experiences of eight fourth-year students at each of two different chiropractic colleges regarding their perspectives on how they learned diagnostic radiology and what contributed to this learning. Specifically, this study investigates a) the learning strategies followed by students that they believe both worked and didn't work in learning radiology, b) student evaluations of the effectiveness of instructional methods used by faculty, c) the challenges faced in learning radiology and how students addressed these challenges, d) the recommendations that students offer for both faculty and for peers regarding the teaching and learning of radiology, and e) whether the learning strategies, and instructional methods that worked are reflective of those described by faculty in course syllabi. This knowledge can then be applied to future curricular revisions and utilized as the groundwork upon which to conduct future research.

Participant and Institutional Selection

Two chiropractic colleges provide the student sample for this study. Students must be in their last year of study with all radiology courses completed with a grade of B or better. For the student sample, I seek to interview four women and four men including two students of color, from each institution.

Expectations of Participants

Consent to participate in this study is sought from all students. Student participants are asked to meet with the researcher for a 60 - 90 minute interview. The interview will be audiotaped for later transcription and returned to the participant for review.

Potential Participant Benefits

Students will be given the opportunity to reflect on their journey through their radiology studies and this study helps institutions understand how students experience learning radiology and how they believe they mastered the material. These insights will help faculty and administrators deliver a better learning experience for future students.

Potential Participant Risks and Ensuring Confidentiality

A potential risk exists if any personally identifiable data are accidentally revealed. For this reason, strict confidentiality of all records will be maintained and participants will be identified only through the use of pseudonyms. All data will be stored in a secure area and all raw data, including interview transcripts, will be destroyed within two years after completion of the study.

Treatment of Results

To ensure the accuracy of data collected, participants will be given the opportunity to review the transcript of their personal interview. Additionally, a summary of the dissertation will be made available for any interested participants.

APPENDIX F

LETTER TO DECLINE PARTICIPANT

Date

Name
Address

Dear _____:

Thank you for responding to my invitation to participate in a research study for my doctoral dissertation examining the experiences of students in the radiology portion of the chiropractic curriculum. I greatly appreciate your willingness to participate. However, I do not require your participation at this time.

Please accept my gratitude for your willingness to assist me in this research endeavor.

Sincerely,
Kathleen Linaker
Email: klinake@luc.edu
Phone: 678-581-9897

APPENDIX G

SIGNED CONSENT OF PARTICIPANTS

Project Title: Shades of Grey: An Exploration of the Student Learning Experience in Diagnostic Radiology Education
Researcher: Kathleen Linaker
Faculty Sponsor: Dr. Terry E. Williams, Associate Professor, Loyola University Chicago

Introduction: You are being asked to participate in a dissertation research project being conducted by Kathleen Linaker, a doctoral student in the Higher Education program at Loyola University Chicago.

You are being asked to participate because you are a fourth-year student at (*insert institution name).* Approximately eight fourth-year students will participate in this study at your institution. Please read this form carefully and ask any questions you may have before deciding whether to participate in this study.

Purpose: This qualitative study explores the experiences of eight fourth-year students at each of two different chiropractic colleges regarding their perspectives on how they learned diagnostic radiology and what contributed to this learning. Specifically, this study investigates a) the learning strategies followed by students that they believe both worked and didn't work in learning radiology, b) student evaluations of the effectiveness of instructional methods used by faculty, c) the challenges faced in learning radiology and how students addressed these challenges, d) the recommendations that students offer for both faculty and for peers regarding the teaching and learning of radiology, and e) whether the learning strategies, and instructional methods that worked are reflective of those described by faculty in course syllabi.

Procedures: If you agree to participate, you will be asked to grant me a personal face-to-face interview regarding your background and your experiences in your radiology classes. The interview will take place on your campus, and will take approximately 60-90 minutes. The interview will be recorded using a digital audio-recorder and transcribed later. A third party may transcribe the audio recordings, however, the transcriptionist will be asked to sign a confidentiality agreement. To ensure confidentiality, the name and identity of both you and your institution will not be used. Pseudonyms will be used in all publications and presentations. I will send you a complete transcript of your interview. You will have a two-week period to review the transcript for accuracy and completeness, and to return to me with any corrections or additions. All data, including the digital recordings, will be stored in a locked secure location and will be destroyed within two years of completion of the study.

Risks/Benefits: Your harm or discomfort as a participant is no more than what you may encounter in daily life. There is a potential risk for breach of confidentiality, however to minimize this risk, all communication will occur either via the PI's Loyola e-mail account, U.S. Postal Mail or via face-to-face communication. All participants, as well as their institutions, will be given pseudonyms. There are no direct benefits to you from

participation, but your willingness to share your experiences will contribute valuable insights and knowledge about chiropractic student experiences in radiology education. This knowledge can then be applied to future curricular revisions and utilized as the groundwork upon which to conduct future research. A summary of the findings of this study will be distributed to participants upon request.

Confidentiality: All information that identifies individuals, institutions and other persons/places will be assigned pseudonyms and will be kept secured by the researcher. All consent forms will be stored separately from the interview transcripts to keep participant identities confidential. All data will be kept in a secure, locked location and will be destroyed within two years of completion of the study.

Voluntary Participation: The interview is completely voluntary and you may refuse to answer any questions at any time or withdraw from participation completely without penalty. Furthermore, you may interrupt to ask questions concerning the research or research procedures at any time.

Questions: If you have questions about this research study, you may contact the researcher, Kathleen Linaker, or faculty sponsor, Dr. Terry Williams at the contact information listed below.

Researcher
Kathleen Linaker
Ph.D. Candidate
Higher Education Program
Loyola University Chicago
(678) 581-9897
6105 Long St., Clarence Center, NY 14032
klinake@luc.edu

Faculty Sponsor
Terry E. Williams, Ph.D.
Associate Professor
School of Education
Loyola University Chicago
Lewis Towers, Room 1138
820 N. Michigan Ave., Chicago, IL 60611
twillia@luc.edu

If you have questions about your rights as a research participant, you may contact the Compliance Assistant in Loyola University's Office of Research Services at (773)508-2689.

Statement of Consent: Your signature below indicates that you have read the information provided, have had an opportunity to ask questions, and agree to participate in this research study. You will be given a copy of this form for your records.

Participant Signature Date

Researcher Signature Date

APPENDIX H

INTERVIEW PROTOCOL

1. Tell me what your experience has been like being a student learning radiology. How do you think you learn best? Please describe for me the characteristics of your optimal learning style?
    A. Trigger items - – visual/auditory/tactile/kinesthetic
2. As you completed your radiology courses, what various strategies did you follow to help you learn the course material? Which approaches seemed to work best for you and which ones were least helpful/effective for you? Why?
    A. Items to ask about to trigger full descriptions
        i. Study habits – self, group etc – did you try different approaches
        ii. Resources used – why these and not others
        iii. Different for different classes?
        iv. Different for different instructors?
        v. Is this different from how you approach classes other than radiology?
        vi. Academic self-efficacy – how do you view your ability to successfully engage in and complete course-specific academic tasks? Was it different prior to starting your radiology classes?

3. To what extent do you feel your instructors used a teaching approach/style that matched well with your learning style/needs while learning radiology? Were some instructional approaches more helpful to you? Less helpful to you? Why? Are you aware of any resources available to you for learning radiology that your instructor did not recommend? If so, did you use them? Why/why not?
    A. Items to ask about to trigger full descriptions
        i. Lectures – style – if various styles thoughts on the differences
        ii. Labs – active passive
        iii. Self-assessments or other self-guided learning materials provided
        iv. Assignments
        v. Exams – how assessed – did it affect how you studied – what was it like to try to learn the material for the exams

4. Overall, as you think back on your radiology courses, what specific challenges did you face that you had to overcome in order to be successful academically? How did you address these challenges?

5. Overall, what do you think was your very best learning experience in the radiology curriculum and why? What was your poorest learning experience and why?

6. What specific recommendations do you have for radiology faculty regarding how best to convey radiology education to students?

7. What specific recommendations do you have for students who are about to begin their radiology coursework regarding how best to master the curriculum?

APPENDIX I

TRANSCRIPTIONIST CONFIDENTIALITY AGREEMENT

I, _____, agree to transcribe the interviews for the
(Insert Printed Name)
doctoral research of Kathleen Linaker entitled "Shades of Grey in Radiology Education: An Exploration of How Students Experience Learning Radiology." I will maintain strict confidentiality of all data files and transcripts. This includes, but is not limited to, the following:

- I will not discuss the transcripts with anyone but the researcher.
- I will not share copies with anyone except the researcher.
- I agree to turn over all copies, both paper and electronic and any other media, both current and future, of the transcripts to the researcher at conclusion of the contract.
- I will return the audio files to the researcher upon conclusion of the contract.
- I will ensure that all electronic copies of the transcripts are purged from my computer and back-up files.

I have read and understood the information provided above.

_____ _____
Transcriber's Signature Date

_____ _____
Researcher's Signature Date

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VITA

Kathleen Linda Linaker was born and raised in Millet, Alberta, Canada. She attended the University of Alberta in Edmonton, Alberta where she earned a Bachelor of Science in 1994. She then attended Northwestern Health Sciences University in Bloomington, Minnesota earning a Doctor of Chiropractic in 1997. She practiced for a number of years and then returned to school, where she completed a three-year radiology residency at National University of Health Sciences in Lombard, Illinois and successfully earned her Diplomate status with the American College of Chiropractic Radiologists in 2002.

Dr. Linaker then remained on faculty at National University of Health Sciences and began her Ph.D. at Loyola University Chicago. She continued to maintain both a clinical and radiology practice until 2005 when she moved to Marietta, Georgia to assume the position of Director of Clinical Radiology at Life University.

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She is currently the Executive Director of the Chiropractic Department at D'Youville College in Buffalo, New York. This dissertation reflects her interest in both

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