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Perceptions of Effective Teaching Strategies and Assessments of Critical Thinking in Radiographic Clinical Practice

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Abstract

The following dissertation represents research concerning radiologic science clinical coordinators and program director's perception of student critical thinking skills, teaching strategies and assessment. The survey used in the study was based on Gosnell's (2010) model that evaluated critical thinking skills in radiography program director perceptions. Results from the research offers a contribution to the field of radiography in general and specifically in clinical practice. The survey was sent electronically through Qualtrics to 523 clinical coordinators employed at JRCERT accredited institutions. A solid 31.74% response rate was reached with a slightly skewed delineation of facility representation (hospital 18.9%, community college 38.41% and university 39.02%). Quantitative data was gathered over a six-week period and analyzed by descriptive statistical analyses, and ANOVA. Data showed that clinical coordinators generally agreed that critical thinking must be included in programmatic curricula and that it is an essential skill for radiographers. There was also agreement among clinical coordinators on effective and non-effective teaching strategies and assessment tools. Hands-on and situational judgements ranked highest in effective teaching methods while hands-on learning and higher cognitive questioning ranked highest in methods actually used while portfolios ranked lowest in both categories. Image critique, clinical competency and situational judgements ranked highest in assessment tools used. Standardized testing ranked lowest as a preferred method of assessment. Qualitative data was gathered through the use of interviews of program directors within the United States. Analyses showed little significance in attributes of graduates dependent on the terminal degree of the program or the education level of the instructor. Interview responses added to establishing characteristics of critical thinking within radiography and the overall perception of teaching and assessing critical thinking. Further research that evaluates

specific critical thinking teaching and assessment highlighted within this study would greatly benefit the field of radiography.

Keywords: critical thinking, clinical education, radiography

Dedication

With humble gratefulness I dedicate this dissertation to my Lord and Savior Jesus Christ. He provided everything I needed to finish my work. When I was weak, he was strong, when I was in need, he provided and when I celebrate, he is honored.

I would like to express my deepest, though inadequate, thank you to my family. My husband Ken, daughter Rachel, sons Nathan and Daniel have been an ongoing inspiration for me. My children were young when I began this journey four years ago and they are now 20, 17, and 14. Their memories are filled with me sitting at my computer working on papers. I hope that I have given them a foundation of hard work and reaching your goals. Through the years they have brought me peace and resolve, I owe them so much for all they have given me. Ken has supported me in all that I have taken on. His love and kindness are his finest attributes and I hope that one day I can show him how much it has meant.

Dad and mom are two of the most sacrificial people I have ever met, and I am fortunate to have them on speed dial. They never fail to be encouraging and supportive. Not a week goes by that mom does not ask me what she can do for me that week. Dad always knows exactly what to say to lift me up and push me onward. I know that they pray for me constantly and that is all I could ever ask for. Their example of God's love, hard work, and dedication has been a blessing my entire life.

My friends and my church have also been a source of encouragement and peace. I am blessed and I owe so much to so many. My father's favorite saying is "Because He lives, the best is yet to be." I am thrilled to have completed this journey and am excited for what is yet to be in my life.

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Chapter 1: Introduction

Radiologic science is an allied health profession that is focused on diagnostic imaging with radiation (ARRT, 2016). Since the invention of x-rays in 1895 by Wilhelm Roentgen, the field has grown into one of the largest allied health science careers in the world. According to the American Registry of Radiologic Technologists there are 325,000 registered technologists (ARRT, 2016). In 2016, the American Society of Radiologic Technologists (ASRT) had 150,000 members and an operating budget of 20 million dollars.

Clinical education is a vitally important component of any radiographic technology program for radiology training (Gosnell, 2010). When students begin a program, they are usually given only a week or two of didactic introduction, followed soon after by the start of clinical rotations. Even though the Joint Review Committee on Education in Radiologic Technology (JRCERT) does not mandate the number of hours for clinical training, most programs schedule approximately 1,700 clinical hours in two years. This is one of the highest totals of clinical hours for any allied health program or nursing.

This emphasis is placed on clinical education because students are able to apply classroom learning with real-life situations and patients (McInerney & Baird, 2015). In two years, a student must learn the positions of all 207 bones in the human body (ARRT, 2016). In addition, every patient presents different variables to work around, such as pediatric and geriatric patients, patients with altered mental status, and patients with trauma that prohibits normal positioning guidelines (Long, Rollins, & Smith, 2015). Thus, the student must be able to use alternative positioning techniques. In addition to positioning, students learn communication skills during clinical practice. At the hospitals where they complete their clinical rotations, they must

communicate not only with patients but also with other students, technologists, administration, and ancillary staff.

In the classroom, students are taught how radiation is created and how to adjust the technical factors associated with producing radiation (Sedden & Clark, 2016). Students must have a thorough understanding of how radiation affects the body, and how to set each variable to deliver the appropriate amount of radiation depending on a patient's body habitus and the body-part thickness, from toe to skull. In addition, they must understand the importance of radiation protection for themselves, other technologists and patients. All of this information is learned in the classroom and is practiced in clinical education.

Clinical coordinators are program faculty members who oversee clinical rotations and the development of students in clinical practice. They provide rotation schedules and visit clinical sites to grade competencies and communicate with the clinical instructors. They also conduct classes, work hands-on with students while at clinical sites, assign homework, and give written examinations. All of these elements can work together to create a learning environment for critical thinking if the coordinator is diligent and skillful in implementing critical thinking.

It is vital that a radiologic technology student possess critical thinking skills to practice as a registered technologist. JRCERT identifies critical thinking and problem-solving as priority learning outcomes in the Standards for an Accredited Education in Radiographic Technology. Programs must include teaching strategies that will train students to become lifelong critical thinkers.

Background, Context, History and Conceptual Framework for the Problem

Critical thinking is the ability to interpret, analyze, evaluate, reflect, and apply knowledge to a situation (Castle, 2006). There is a concerning deficit of critical thinking in current college

students and graduates (Beachboard & Beachboard, 2010; McInerney & Baird, 2015). While there are many theories on why critical thinking has waned in today's college student, the fact remains that critical thinking needs to be implemented in pedagogy. The conceptual framework for this study is based on the concepts of learning critical thinking skills and assessment practices, as well as the perceptions that clinical coordinators have regarding critical thinking in student clinical education. With clinical education being such an integral part of the learning experience for radiographers, it is imperative that these skills are taught in conjunction with physical competencies.

Critical thinking is a skill that can be learned. Student motivation to learn is a crucial component of teaching (Tanenbaum, Tilson, Cross, Rogers, & Dowd, 1997). Some of the ways that instructors can facilitate learning is inquiry and problem-based techniques and questioning or open discussions. In addition, it is important that students are aware of their own learning style, to optimize retention of material (Ward, 2009). Learning outcomes are the culmination of the learning process. Assessing learning outcomes needs to use a true measure of what the student has retained rather than simply what they have memorized. Traditional teaching and assessing causes students to be passive learners (Covill, 2011). Learning-oriented assessment provides students a deeper foundation for learning, by providing consistency throughout the individual courses (Carless, 2014).

Statement of the Problem

The scope of practice demands that radiographers possess the ability to think critically (ASRT, 2016). The implications of inadequate critical thinking skills can be devastating on patient outcomes (Martino & Odle, 2008). Current trends represent a lack of critical thinking in today's college students. The problem addressed by this study is that, if radiography students do

not have the critical thinking skill level and preparedness upon graduation, their effectiveness as an allied health provider could suffer.

Purpose of the Study

The purpose of this dissertation study is to evaluate clinical coordinator's perceptions of student growth in critical thinking, as evidenced in clinical practice. In addition, the purpose is to examine how clinical coordinators implement critical thinking skills within curricula as well as tools for assessment.

Research Questions

Research question 1. What aspects of the definition of critical thinking skills are most pertinent to clinical coordinators?

Research question 2. What are components of teaching critical thinking, as perceived by clinical coordinators?

Research question 3. Which teaching method or learning activity is most often used by clinical coordinators to teach critical thinking in clinical practice?

Research question 4. What are the assessment tools and teaching methods utilized by clinical coordinators to assess critical thinking in clinical practice?

Research question 5. What are clinical coordinator's perceptions of the critical thinking attributes of graduates, based on the degree awarded?

- Null hypothesis: There will be no difference in clinical coordinators' perceptions of the critical thinking attributes of graduates, based on the degree awarded
- Alternative hypothesis: There will be a difference in clinical coordinators' perceptions of the critical thinking attributes of graduates, based on the degree awarded

Research question 6. What are clinical coordinator's perceptions of the critical thinking attributes of graduates, based on the degree held by the clinical coordinator?

- Null hypothesis: There will be no difference in clinical coordinators' perceptions of the critical thinking attributes of graduates, based on the degree held by the clinical coordinator
- Alternative hypothesis: There will be a difference in clinical coordinators' perceptions of the critical thinking attributes of graduates, based on the degree held by the clinical coordinator

Research question 7. What are program directors' perceptions of students' critical thinking readiness for employment upon successful completion of the radiologic technology program?

Research Method

The researcher used a survey based on a questionnaire by Gosnell (2010). According to Singh (2007), surveys are one of the most statistically accurate ways to collect quantitative data. The reliability of questions used in Gosnell's survey was at an acceptable rate of 0.899 based on Cronbach (Gosnell, 2010). Using Qualtrics (2016), it was determined that a sample size of 218 participants was needed from a distribution of 500 surveys with a variance of 5. The random sampling was conducted using the Microsoft Excel random sampling application, with a participant list provided by JRCERT. The survey used in this study was modified to address the purpose. Specific modifications are discussed in Chapter 3.

Data from research question one was analyzed using differential statistical analyses, and by qualitative analyses of clinical coordinator and program director perceptions of the definitions of critical thinking. Differential statistical analyses were used for research question two.

Research question three was analyzed using differential statistical analyses for frequencies of teaching methods or learning activities in the curriculum. Research questions four was analyzed using differential statistical analyses on clinical coordinators' assessment tools and attributes of graduates. A two-way ANOVA was conducted for research question five and six, to determine if there were differences based on the degrees awarded and degrees of instructors. Analysis was conducted using SPSS at a significance level of .05.

Interviews were conducted with program directors of JRCERT accredited programs to add qualitative data in order to substantiate findings from the survey. The primary focus of the interview questions was to discern the interviewees' perceptions of the readiness of students for employment in the radiologic technology field. Interview questions are an essential aspect of providing viability and human characteristics in research (McCusker & Gunaydin, 2015). The optimal number of interview participants is 10; due to the rich and thick design of the interviews, this number is considered appropriate to add significant qualitative data to supplement the survey responses. The researcher conducted a random sampling from the list of JRCERT accredited schools. Twenty-five program directors were randomly selected and contacted via email by the researcher to participate in an interview. Programs were divided into five regions of the United States, and random sampling was conducted on each region using the Microsoft Excel random sampling application.

Interview answers were analyzed individually for emergent themes. Adams and Lawrence (2015) stressed the importance of categorizing and organizing for a thematic analysis. Each time a similar identifiable descriptor was used in an answer, it was assigned a category. This allowed emergent themes to guide the results, which increased validity and reliability.

Cooper, Hedges, and Valentine (2009) suggested that developing a solid coding protocol lends transparency and replication.

Significance of Study

Radiographers are at the forefront of patient care. They must possess critical thinking skills to optimize patient outcomes (Magno, 2010). Studies have shown that current college students lack critical thinking. This study will highlight areas in which clinical coordinators can increase critical thinking skills in radiologic science students.

It is important to establish the perception and definition that clinical coordinators have of critical thinking, so that the processes they use to teach and assess can be evaluated in comparison to their perceptions. This study will show that patient outcomes are dependent on the critical thinking skills of radiographers. Identifying gaps in teaching critical thinking will assist instructors to better equip students to become autonomous radiologic technologists. Program director interviews will supplement the results by addressing their perception of overall student critical thinking.

Definition of Terms

Clinical instructors. This term is defined as radiologic technologists who work with radiology students to teach positioning and techniques on real patients in a hospital setting.

Competency-Based clinical education. This term is defined as a progressive approach to the technical and professional development of a student. Students begin this process by observing an examination or groups of examinations. After didactic and laboratory instruction and documented laboratory proficiency in a procedure, the student then proceeds to the participation stage of the competency-based clinical education system (PCCC.edu, 2013).

Critical thinking. This term is defined as the ability to observe, synthesize, reflect, reason, evaluate, and act on a problem or issue (Ennis, 1985; Facione, 1990; Halpern, 1998).

Disposition. This term is defined as a person's inherent qualities of mind and character (Merriam-Webster, 2016).

Inquiry-Based learning. This term is defined as a pedagogy which best enables students to experience the processes of knowledge creation, with the key attributes being learning stimulated by inquiry, a student-centered approach, a move to self-directed learning, and an active approach to learning (Spronken-Smith, 2013).

Learning outcomes. This term is defined as what a student is expected to be able to do as a result of a learning activity (BYU, 2016).

Learning styles. This term is defined as an approach by which students prefer to learn (Wilson, 2011)

Problem-Based learning. This term is defined as solving complex and authentic problems that help develop content knowledge as well as skills in problem-solving, reasoning, communication, and self-assessment (Stanford.edu, 2001).

Radiologic technologist. This term is defined as medical personnel who perform diagnostic imaging examinations. They are educated in anatomy, patient positioning, examination techniques, equipment protocols, radiation safety, radiation protection, and basic patient care (ASRT, 2016).

Traditional college student. This term is defined as someone who begins college immediately after high school, enrolls full time, lives on campus, and is ready to begin college-level classes (Deil-Amen, 2011).

Assumptions

Creswell (2014) defines assumptions as facts that cannot be verified but are assumed to be true. In this study, it is assumed that the responses will be truthful and reflect practice at the relevant institution. It is assumed that participants will provide honest responses to the best of their knowledge. It is a general assumption that clinical coordinators have access to email in order to receive and respond to the survey. It is assumed that radiography programs that are accredited by JRCERT are similar in practices and outcomes.

Limitations

One of the limitations of the study was the sample size, which will affect generalizability: 523 surveys were sent, with responses anticipated from 218. Another limitation of the study is the method utilized. Accurate survey responses rely on truthfulness of the participant and a substantial sample size. Additional limitations of the study were interpretation and coding of the data. A specific challenge with coding is that inferences from the data will not necessarily fit into established categories. The assumptions may not correlate with the emergent patterns. Once the raw data was collected, they were linked to the research questions via categories and identifiable patterns (Glaser, 2013).

Modification of the survey without a pilot study was another limitation. The Gosnell (2010) survey was originally used to determine program directors' perceptions of critical thinking. Since this study evaluated clinical coordinator perceptions, the survey was modified to include questions pertinent to clinical education.

Delimitations

Delimitations of the study were that only JRCERT-accredited radiography programs within the United States are eligible to participate in the study. JRCERT sets the standard for

radiologic science programs and having only JRCERT-accredited programs will allow more equitable findings.

Summary

Critical thinking skills are essential in radiographic technology. Each patient requires that the technologist understands basic positioning skills and supplements this knowledge with critical thinking. JRCERT recognizes the need for critical thinking and requires programs to implement, by their own discretion, effective teaching strategies to promote critical thinking. Clinical education, as a vital and collaborative partner with didactic education, is an ideal place to insert practical application of these skills. Chapter 2 contains a literature review that reinforces the gravity of teaching critical thinking and identifies teaching strategies and apparent gaps in research. Chapter 3 describes the methodology utilized for this study.

C**hapter 2: Literature Review**

Critical thinking involves the ability to observe, synthesize, reflect, reason, evaluate, and act on a problem or issue. While there are many differing opinions on the exact wording of a definition, most researchers include many of the above concepts (Ennis, 1985; Facione, 1990; Halpern, 1998). Critical thinking is the act of thinking in a disciplined way, using cognitive skills for an outcome that is not merely based on knowledge but on the application of that knowledge (Behar-Horenstein & Niu, 2011; Ennis, 1993; Fahim & Masouleh, 2012; Flores, Matkin, Burbach, Quinn, & Harding, 2012; Paul, 2005).

It is important to conceptually understand and interpret material for critical thinking to take place (Schaber & Shanedling, 2012). Critical thinking should evoke the potential to challenge self-knowledge (Niu, Behar-Horenstein, & Garvan, 2013). It requires disciplined thinking and is an active process of reflection, interpretation and operation (Paul, 2005). Critical thinking involves metacognition leading to a desirable outcome (Magno, 2010). For a person to become proficient, critical thinking must be practiced and implemented (Smith & Stitts, 2013).

Radiologic science is an allied health profession that is focused on diagnostic imaging with radiation (ARRT, 2016). As a legitimate health care profession, it is vital that radiologic technologists possess critical thinking skills. This allows them to produce optimal radiographs for the radiologist to interpret. During clinical rotations, students work beside registered radiologic technologists to supplement what they learn in the classroom and laboratory. However, the hands-on experience is typically where students encounter real patients in critical situations.

Clinical education plays an important role in preparing radiography students. During this time, students learn how to communicate with patients, other students, technologists, physicians,

administration staff, and other ancillary clinicians. Studies indicate that new students benefit greatly by interacting, working, and learning from experienced technologists (Larsson, Aspelin, & Lundberg, 2013). This type of setting provides interactions that could not be obtained in the classroom (Sedden & Clark, 2016). Students take what they have learned in the classroom and apply the knowledge as a tangible learning outcome in the clinical setting.

A study by Castle (2009) demonstrates that 30% of students display good critical thinking skills while 60% had average skills and 10% displayed poor critical thinking skills in the areas of investigation, discrimination, judgement, inference, evaluation, and analysis. There is little literature that investigates clinical coordinator's perceptions of critical thinking in radiography students, or the tools used to teach and assess critical thinking.

Conceptual Framework

The conceptual framework of this study is based on clinical learning and assessment in radiography. The JRCERT (2008) and the ASRT (2007) recognized a need to incorporate critical thinking skills into programs and thus create standards with specific learning outcomes. There is limited direction available on how the learning outcomes should be reached, and generally this is determined by individual radiography programs.

There are many studies that offer research on the benefits of teaching critical thinking skills (Behar-Horenstein & Niu, 2011; Ennis, 1985, 1993; Facione, 1990; Fahim & Masouleh, 2012). However, few studies are specific to critical thinking in radiologic technology pedagogy within clinical practice. This study will evaluate clinical coordinators' perceptions of student growth in critical thinking, as evidenced in clinical practice, will examine how clinical coordinators implement critical thinking skills within curricula, and will examine tools for assessment.

One key component that must be considered before any teaching strategies are successful is student motivation. Students can lose motivation within 10–15 minutes from the beginning of a lecture (Tanenbaum et al., 1997). If the student knows that they are responsible for performing a task, they tend to pay more attention.

New-generation learners have revealed a deficit in pedagogical strategies. Historically, higher education learning has consisted of lecturing, note taking, and examinations. This approach to teaching is antiquated for today's college student. Methodologies must be re-evaluated and re-organized to maintain viability and produce autonomous citizens of society. There is an emerging disconnect between delivery of instruction and learning comprehension.

Two teaching strategies used to promote critical thinking are problem-based and inquiry-based teaching methods. Similar to active learning, problem-based and inquiry-based learning allow the student to participate in the learning experience. The facilitator, or instructor, provides a problem for discussion, allowing a student-centered approach. A study by Spronken-Smith, Walker, Bathelor, O'Steen, and Angelo (2012) showed that inquiry-based learning created an overwhelmingly positive learning experience for students, including increases in grades, retention, and enthusiasm.

Questioning, specifically with open-ended questions, prompts students to use critical thinking skills to participate in discussions. This technique can follow Bloom's taxonomy to lead students to higher cognitive thinking: questions can begin on Bloom's lower levels and work towards higher levels in a technique described as convergent (Tanenbaum et al., 1997).

In an attempt to reach the majority of students within the class, learning styles can be an important asset to instructors. Understanding how students optimally learn can guide curricula towards increased learning. This process can be time consuming for instructors, but it places the

responsibility of learning on the student by discovering their own learning style and designing a study routine to promote that particular style. Within radiography, Shaver (2000) showed that students prefer the tactile/kinesthetic style of learning that is experienced in clinical practice.

Instructors are the facilitators of knowledge and must be prepared to redesign pedagogy to suit today's college student. Paul (2005) showed that, even though instructors wish to include critical thinking skills, few feel comfortable with implementing this in their teaching. Failure to teach critical thinking in health care can lead to detrimental results for patient outcomes (Facione & Facione, 2008).

Learning outcomes are the culmination of the learning process. Assessment of learning outcomes needs to be a true measure of what the student has retained, not simply what they have memorized. Traditional teaching and assessment causes students to be passive learners (Covill, 2011). When students become learning oriented they tend to create a deeper knowledge base. When a learning-oriented style is consistent throughout individual courses, students tend to become active learners (Carless, 2014).

Critical Thinking

Critical thinking is what allows a person to make decisions based on both latent and active variables. It is beneficial to differentiate between thinking and critically thinking. Thinking can take many forms. In the movie Camelot, a young King Arthur asks, "Even when you are not thinking a thought, aren't you still thinking?" (Lerner & Logan, 1967). The human mind is never at rest; thoughts and impulses are a constant.

Even though some people can multi-task, the mind is still only concentrated on one item at a time. When multi-tasking, the mind can switch back and forth quickly between thoughts. Cognitive control handling takes place in the pre-frontal cortex (Miller & Cohen, 2001). All of

the functions are not yet completely understood, but it is known that the pre-frontal cortex is able to take actions, reflections, stimulations and impulses, and categorically use them for cognition. According to Johnson, Blum, and Giedd (2009), the pre-frontal cortex continues to mature well into the twenties. Considering that most college students are between 18 and 23 years old, the assumption can be made that their pre-frontal cortex has not fully developed. This concept is important in understanding their ability for judgement. Multi-tasking or over-stimulation cause the neuroreceptors to act differently. Studies have shown that with persistent increasing stimuli associated with multi-tasking, the pre-frontal cortex is at risk of damage if there is not a mechanism of relief (Takeuchi et al., 2013).

In today's society, and specifically for "digital natives" (Prensky, 2012) who have grown up with the apparent ability to multi-task, the number of incoming stimuli is great. However, even though their minds physically handle stimuli differently than the previous generations, the tradeoff is that the receptors are not being trained to focus intently on one stimulus at a time. An analogy of this concept is ping pong. If I am playing ping pong with one other person and one ball, I can concentrate on that ball and, after a while, even anticipate where the other person is going to hit the ball. What if another person joins the game and I must concentrate on two balls coming towards me? I might have some success if they hit the balls at different times towards me. However, problems will occur when I am playing with five, six or 10 other people: I might be able to hit the balls, but not with any concentration or accuracy.

The human mind is constantly thinking. It has the ability to reflect on experiences and to anticipate upcoming events. Thinking is an active conscious and unconscious cognitive process. Critical thinking takes the practice of thinking a step further. Thinking critically causes a person to face a dilemma, challenge or problem, and to pull from experience, knowledge, wisdom and

reflection, to make a disciplined decision for a desired outcome. It is the application of the variables in order to make a cognitively autonomous judgement. The lack of formation of the pre-frontal cortex is exhibited in functioning executive processes which direct goal-oriented decisions (Johnson et al., 2009).

Today's Students

There is a disconnect in the perceptions of higher education instructors and students. The focus of this study is the generational learning variance experienced by the present-day traditional college student. The terms "digital native" and "digital immigrants" were introduced by Prensky (2012), who emphasized that the current educational organization is an antiquated system for today's students. In 1983 Howard Gardner developed the theory of multiple intelligences, which is still widely accepted as a foundation of each person's optimal method of learning. Though Gardner's theory is relevant, Prensky's division of learners, digital immigrants and digital natives must also be considered.

Digital natives are students from kindergarten to college who were born in the digital age; their lives run parallel to technology. In contrast, digital immigrants are those people who have had to learn technology as it was introduced. For example, a person in their 50s can probably remember the rotary dial telephone, and they have also experienced cordless phones and bag phones, and now the current cellular phones with the capabilities of a computer. The digital native does not have these experiences to reflect upon. Many children today have cellular phones at an early age and their knowledge of how to use them is superior to adults (Strasburger & Hogan, 2013). There is a misunderstanding between instructors and students (Cox, 2011), and this generational divide represents the complexity that instructors face in trying to connect with students.

One noticeable change in students is the lack of critical thinking skills. There are several variables that could be responsible for this trend. Technology has played a major role in dulling critical thinking skills (Wolpert, 2009). Technology has made great advancements in knowledge and makes daily life more convenient, but the tradeoff is that it has decreased the need to think critically. The implications of this in in education have been noted (Flores et al., 2012). Since the current retirement age is 65, the majority of digital-immigrant instructors will be retired within approximately thirty years. At that point, the only college instructors will be digital natives. There will continue to be challenges in reflective ability of students due to the ongoing advancements in technology. When the current digital natives become leaders, their students will experience the same generational disconnect. However, this does not account for today's lack of critical thinking skills in tomorrow's leaders.

A working definition of critical thinking skills should be established. The published definitions of critical thinking are diverse and limited only by the imagination. For this paper, the definition will be limited to the act of thinking and using cognitive skills in a disciplined way for an outcome that is not merely based on knowledge but the application of that knowledge (Behar-Horenstein & Niu, 2011; Ennis, 1993; Fahim & Masouleh, 2012; Flores et al., 2012; Paul, 2005).

Student Motivation

The motivation of the student plays a key role in achieving success in the classroom. Students do not always know this, so the instructor must make it clear that the curriculum depends on their involvement. Servant leadership is a productive method to accomplish motivation of students (Barbuto, 2000; Crippen, 2010). Students typically have become accustomed to instructors elevating themselves, but, when the instructor becomes merely a facilitator, the student discovers that they can be accountable for their own learning. Students are

not always comfortable with this concept, which relates to the fact that they lack certain critical thinking skills. They must rethink how to think (Clayton, 2003). Research shows that students are more participatory when a lecture is accompanied by hands-on learning (Sedden & Clark, 2016).

Dahl and Smimou (2011) explained that students often display increased motivational patterns when they are challenged with goals of performance. Another interesting finding is that motivation produces two specific concepts: "Higher levels of interest and intrinsic motivation enable student performance; Higher levels of value motivate students" (Dahl & Smimou, 2011, p. 586). Therefore, if students perceive that the result is worth the work, they tend to be more motivated.

One way in which students can be motivated is through active learning techniques, such as interactive classroom instruction, group interaction, and peer instruction (Welsh, 2012). Active learning involves activities that cause students to participate, and to think about, and learn from, their actions (Weigel & Bonica, 2014). In a study by Welsh (2012), 70% of 492 students surveyed perceived active learning to be important or very important. In another study of 78 students, 64% considered that active learning increased their understanding of material (McClanahan & McClanahan, 2000).

The techniques used for active learning include journaling, reflection, brainstorming, group activities, and eliminating some lecture material in exchange for time to incorporate active-learning activities (McClanahan & McClanahan, 2000). Some of the ways that action learning can be applied are identifying a problem, planning towards a solution, taking action, observation, and reflection on the implications (Smith & Stitts, 2013). Inserting questions within discussion also maintains student attention and forces them to participate (Tanenbaum et al.,

1997). However, when using a questioning method, the instructor must form the questions so they are not too broad, as this can cause student confusion; yet also ensure questions are not too narrow, as this can cause students to hesitate to answer (Tanenbaum et al., 1997). These processes can be also compared with acquiring critical thinking skills. Active learning takes place in the frontal area of the brain, which provides stimulation for a pleasurable learning experience, whereas passive learning takes place in the rear of the brain. This area requires more effort to learn and does not allow for deep retention or reflection (Zull, 2002).

Instructional Strategies

Problem-Based learning. As with active learning, problem-based and inquiry-based learning allow the student to participate in the learning experience. The facilitator, or instructor, provides a problem for discussion that allows a student-centered approach. Students work through the problems in pairs or groups. The problem is the vessel that guides the discussion (Vander Kooi & Palmer, 2014). Spronken-Smith et al. (2012) showed that inquiry-based learning created an overwhelmingly positive learning experience for students, including increases in grades, retention and enthusiasm. In addition, problem-based and inquiry-based learning instills qualities of critical thinking in the students (Friedman et al., 2009). Feedback, both to and from students, increases their accountability and offers them a vested interest in the outcomes (Tanenbaum et al., 1997).

Questioning. Tanenbaum et al. (1997) determined that questioning is one of the best ways to promote critical thinking. Questions can begin from the lower levels of Bloom's taxonomy and progress to the higher levels. Lower-level cognitive questions are used to open class discussions and ignite student's interest. Tanenbaum et al. (1997) described higher-level cognitive question examples as being convergent and divergent. Questions are initially broad and

work towards narrow (convergent), or they begin narrow and work towards broad (divergent). Teacher-directed questions can be a solid foundation for stimulating critical thinking in students (McKeachie, 2002).

Learning Styles

A controversial approach to increasing critical thinking outcomes is learning styles. Robert Gardner developed multiple intelligences to define how people optimally learn. Not every student learns in the same way (Hunt, Wiseman, & Touzel, 2009); in fact, the traditional method of teaching is not the ideal method of learning for the majority of students (Griggs et al., 2009). By knowing how a person learns best, an instructor can develop pedagogies and assessments to emphasize the learning process. There are several free learning-style assessments online to evaluate a student. For example, the Birmingham Grid for Learning presents students with a questionnaire and, when this is completed, provides an evaluation of their learning styles as well as a definition of them.

There has been great controversy when discussing learning styles. Proponents subscribe to the fact that people learn best when they recognize and "learn" how they learn. In opposition to Gardner's multiple intelligences, Sternberg, Grigorenko, and Zhang (2008) claimed that learning styles are measured by "either ability-based or personality-based" traits (p. 486). Students must be aware of how they learn. Instructors must also consider the different learning styles of students. Someone who is a visual learner with a personality-based style may need visual presentations, whereas a logical learner with an ability-based style may succeed with charts. The leaders who emerge in the classroom tend to be interpersonal with a personality-based style. It is essential that instructors and students understand how the different styles lead to the success of the outcomes.

There are two generally recognized schools of thought regarding learning styles: inherent and learned (Cheema & Riding, 1991; Sadler-Smith, Allinson, & Hayes, 2000). If a student has an inherent learning style, and they understand their particular style, the student can easily adapt to any type of teaching pedagogy. A student with a learned style can alter their style to fit the teaching pedagogy (Sadler-Smith et al., 2000). Both of these have implications that place learning on the student, meaning that the student must be aware of their learning style and make a conscious decision to learn. Otherwise, what takes place is memorization and regurgitation.

Opponents of learning styles consider instead that people learn due to ability or personality (Sternberg et al., 2008). However, there is an argument that learning styles are simply the way in which students prefer to study and has nothing to do with ability (Hatami, 2012). Some researchers view learning styles as an inherited trait while others consider them to change in different circumstances. In fact, it is suggested that students' learning styles can change from class to class depending on what is expected of them (Oxford, 2011). In one study, researchers discovered that, when teaching styles were matched to student learning style, there was no effect (Pashler, McDaniel, Roher, & Bjork, 2009).

Bloom's Taxonomy

For educational purposes, Bloom's taxonomy provides an outline of higher order thinking (Kennedy et al., 1991). With the publication of Bloom's taxonomy, education decisively incorporated critical thinking skills into higher-level thinking. The first two tiers of Bloom's taxonomy require little critical thinking because they are based on knowledge (Adams, 2015). Critical thinking begins in level three and higher, with applying and analyzing. Adams (2015) acknowledged that these cognitive functions are the result of higher-order, or critical, thinking. At this level, students begin differentiating between just learning material and practical

application. However, opponents of this school of thought argue that it is too vague for tangible practices (Ennis, 1985). Nevertheless, if Bloom's hierarchy is approached with specific regard to particular classroom instruction, or clinical practice, the advantages could prove beneficial from an educational perspective.

Some criticisms of Bloom's taxonomy stem from its conceptual generalizations, especially curricular (Marzano, 2006). Marzano pointed out that Bloom had a significant impact on theory and practice, but not as much impact on curriculum and evaluation. In 1940, Ralph Tyler introduced the Tyler model, which continues to serve as an objective-centered method of evaluation (Marzano, 2006). Tyler based his model on: 1) defining learning objectives; 2) establishing learning experiences; 3) organizing learning experiences; and 4) evaluation of experiences (Pinar, Reynolds, Slattery, & Taubman, 1995).

Further defining of critical thinking skills requires a division of approaches. In 1993, Robert Ennis correlated critical thinking with Bloom's taxonomy, stating that from an educational approach the top three tiers (analysis, synthesis, and evaluation) could be applied. It has been suggested that the comparison was too general for authentic validity in education (Ennis, 1985). Nevertheless, critical thinking skills have historically had a foundation in education, philosophy and psychology. For increased efficacy in the classroom, instructor experience is an important tool (Sternberg, 1986; Lai, 2011). This model is directed by years of tangible outcomes, but the legitimacy is difficult to measure since it is independently represented (Lai, 2011).

Educational Domains

In evaluating best practices in critical thinking, Lai (2011) emphasized that there are three domains to consider: philosophical, psychological, and educational. Within the concept of

critical thinking, the philosophical and educational domains align in that they propose what and how a person is capable of thinking. Ennis (1985) argued that critical thinking relies on reflection and the initiative to decide and act on what is right. Lipman (1988) supported this school of thought by adding that critical thinking, by definition, requires a criterion of good judgement based on reflection of past experiences, meaning that active thinking can be observed or taught. On the contrary, psychological theories resonate with how a person actually thinks as opposed to what they are capable of thinking. This allows only for innate and reflective critical thinking skills. The three domains do agree that critical thinking is making inferences (Facione, 1990), analyzing (Halpern, 1998), problem solving (Ennis, 1985), and deductive reasoning (Ennis, 1985; Facione, 1990).

The argument for a philosophical domain is based on the teachings of Socrates and Plato (Lewis & Smith, 1993), urging that critical thinking relies on what a person is capable of thinking. This school of thought promotes reasoned thinking for the good of mankind. It is a disciplined and learned process (Paul, 2005). In contrast, the psychological approach is dependent on how a person actually thinks (Sternberg, 1986). This is evident in Halpern's (1998) evaluation of metacognitive applications to critical thinking skills. Ironically, although the philosophical and psychological theories have differing approaches, they also have similarities. As with the educational approach, the philosophical and psychological approaches rely on a pattern that transcends conventional thinking. Lipman (1998) gives a comparison of "ordinary thinking" versus "critical thinking" (p. 40). The descriptors on the list of ordinary thinking processes are all based on beliefs or preferences, whereas critical thinking descriptors are based on reasoning and logical application (Lipman, 1998).

There is evidence that critical thinking is subject to disposition. There are two distinct variables, one being that a person *can* critically think and other being that the person is *motivated* to do so (Ennis, 1985). There are studies that argue critical thinking is habitual (Facione, 2000). If this is true, then it is important to note that a habit is something that must be continually practiced, or it wanes. Other researchers add that to critically think requires criteria (Lipman, 1988). The validation of this point is that a criterion defines the boundaries of critical thinking and can be used as a measuring tool. By assigning criteria within the domain of education, students become responsible for their own outcomes (Lipman, 1988). One important argument to consider is that many researchers believe that critical thinking skills cannot be transferred across domains (Ennis, 1989; Lai, 2011), and can only be mastered within specific realms. Proponents of generalized critical thinking skills believe that disposition and criteria serve as the basis for guidance within any domain (Halpern, 2001; Lipman, 1988).

Current Trends in Critical Thinking

Current trends in educational critical thinking depend on the disposition of the student as well as the criterion provided by the instructor. Research shows that critical thinking does slightly improve during college at a linear relationship to major-related domains (Huber & Kuncel, 2016). Findings from the study also demonstrate that the type of instruction utilized by the instructor had a significant effect on student critical thinking learning. If the criterion is in place but the student does not possess the disposition, it is up to the instructor to implement methods to promote motivation. Studies suggest that students and parents tend to focus on the end goal of higher education instead of developing learning strategies (Dahl & Smimou, 2011; Lee & Lim, 2012). It has also been observed that, by altering the classroom dynamic towards an obtainable goal, student disposition seemed to improve. Motivation is important to student

development and outcomes (Sedden & Clark, 2016), and students are separated into those who are motivated by grades or some other extrinsic force and those who require motivation by the instructor.

Self-motivators are easily teachable and an instructor needs only to act as a facilitator for learning. When students are exposed to hands-on learning, projects, and inquiry-based learning, they tend to become more motivated and accountable for their learning outcome (Sedden & Clark, 2016). Inquiry-based learning provides students with objectives (criteria) but allows them to participate in the learning process by being part of the lesson, rather than in the traditional method of teaching where the instructor lectures and the students take notes, memorize, and then regurgitate the material in an examination.

In inquiry-based learning the student is encouraged to become an integral part of the subject being taught. Students are asked open-ended questions so that they initiate and sustain learning. Active learning, problem-based learning and concept mapping are all methods of inquiry-based learning that initiate student engagement (Orique & MacArthy, 2015; Vander Kooi & Palmer, 2014; Welsh, 2012) Traditional methods of teaching cause students to be passive participants in learning (Covill, 2011); however, there is also an argument that traditional lecture methods can be beneficial if the instructor is exceptional at lecturing.

In addition to the importance of student disposition to critical thinking, it is essential that the instructor provides criteria for critical thinking skills. Studies show that less than 10% of college professors include any type of critical thinking objectives within their instruction (Paul, Elder, & Bartell, 1997; Schaber & Shanedling, 2012). Another study showed that instructors who did attempt to teach critical thinking skills lacked understanding of critical thinking themselves (Gellin, 2003). This includes a lack of tools to measure critical thinking outcomes. Implementing

critical thinking should begin with creating a classroom environment in which critical thinking is explained, welcomed, and expected. Students need to be informed from the beginning that active learning is anticipated (Konings, Brand-Gruwell, & Merrienboer, 2005). One way in which active learning can be implemented is team-based learning: allowing students to work in groups or pairs allows them to consider others' ideas and also be accountable for their own. A downside to this is that if a student does not possess the motivation for learning, they can rely on other students to carry the burden of completing projects (Lee & Lim, 2012). The instructor must provide measurement tools for each student independently. Classroom discussion and open-ended questions also provide opportunities for students to express their thoughts (Spronken-Smith et al., 2012). However, it is important for students to learn to explain their answers. College is considered the time when students begin defining who they are and what they believe, independent of parental influences. Holding them accountable for their views is one way to enforce critical thinking skills (Carlson, 2013).

Instructors and Critical Thinking

In a study by Paul (2005), instructors at 38 public and 28 private colleges were interviewed to assess their critical thinking skills. The majority of the instructors (89%) claimed that critical thinking skills were an important objective in the structure of their lessons; however, only 19% gave a clear definition of critical thinking and 9% actually utilized components of critical thinking in their daily classes (Paul, 2005). Without concrete methods in place to teach critical thinking, how can students be expected to learn how to think critically? Paul (2005) also observed that, for courses such as biology and math, instructors simply did not foster critical thinking. Instead, they taught biology, not biological thinking; or math, not mathematical thinking. Instructors could not link the concepts with critical thinking.

For graduates to compete in the workforce, critical thinking skills are vital. Employers seek employees who are equipped with critical thinking skills (Law & Kaufhold, 2009); Sternberg (2013) found that 93% of employers placed critical thinking skills as a top priority for new employees. In 2012, IBM ranked critical thinking skills in their managers and senior officials as one of the most important factors in success (Collier, 2013). Employers in the healthcare field desire employees to be equipped with critical thinking skills, because healthcare workers must often make quick decisions based on a patient's condition and lack of critical thinking skills can be detrimental for patient outcomes (Biswas, 2011). Ramifications for graduates without advanced critical thinking skills can affect personal, company, and generational outcomes (Flores et al., 2012). Leaders, by definition, are expected to lead others, therefore future leaders need to have the ability to analyze, evaluate, synthesize, and make decisions based on critical thinking.

Student Perspective

Another important aspect to consider is students' perceptions of learning. Today's traditional college student is considered a digital native (Prensky, 2012). In their world, convenience is expected, expediency is the norm, and accessibility is presumed. They have been exposed to standardized testing since elementary school and tend to have the perception that short-term memorization skills will equip them for what lies ahead. Instructors of higher education that are digital immigrants (Prensky, 2012) are faced with the dilemma of instilling critical thinking skills in four short years or, possibly, in one semester.

Radiologic Technology

Radiologic Science is an allied health profession that is focused on diagnostic imaging with radiation (ARRT, 2016). Other modalities within radiologic science include computerized tomography, magnetic resonance imaging, sonography, nuclear medicine, special procedures, cardiac catherization, mammography, and radiation therapy.

Historical perspective. X-rays were invented in 1895 by Wilhelm Roentgen. Since then, the field of radiologic technology has grown into one of the largest allied health science careers in the world. Once a student has graduated from an accredited school, they must take the national registry exam and pass with a score of at least 85. After they are a registered radiologic technologist, they must maintain 24 continuing education credits every two years (ARRT, 2016). There are 625 radiologic technology programs in the United States. Most schools offer an associate of allied health science degree, while 34 offer bachelor degrees in radiologic science (ARRT, 2016).

Once a graduate passes the registry exam they are equipped to pursue jobs in hospitals, doctors' offices, outpatient diagnostic centers, and surgery centers. Within a hospital, a technologist will perform radiographic procedures on emergency room patients, in-patients, and out-patients. They are also required to operate radiographic equipment in surgical cases and use portable x-ray machines and C-arms. The diversity of patients and afflictions requires the technologist to make quick decisions on positioning. In many instances, patients are not able to be positioned exactly as the technologist learned (Long et al., 2015). For example, for an elbow radiograph, technologists learn to perform the anteroposterior projection with the arm extended, in the same plane and with the hand supinated (Long et al., 2015). However, if a patient has an injury that prohibits them from extending the arm, the technologist must make an immediate

decision on an alternative positioning technique. This is vitally important so that the radiologist can interpret the radiograph and give a true reading.

In most programs, the student has completed general education requirements including English, History, Humanities, Mathematics, Medical Terminology, and Anatomy & Physiology I and II. In the bachelor degree programs, they must also complete courses in several other areas, including research and microbiology. Once they have finished the general education requirements, they can apply to the program. Many programs require applicants to participate in observation hours in a radiology department to familiarize themselves with all aspects of radiology.

There are typically 150–200 applicants to a radiology programs in the U.S. (ASRT, 2016; ETSU.edu, 2017). While each program sets their own admission criteria, usually grade point averages are an important benchmark. Other considerations that are sometimes used are an interview with the radiography faculty and an essay.

The national average number of students accepted to a program is 30 per year (ARRT, 2016). Once the students are selected to a program, they must complete a background check, a physical examination, immunizations and CPR certification. These requirements are in place because they will be working in a hospital setting and will be exposed to numerous bacteria. When classes begin, students start their clinical rotation by completing training in student and patient safety, professionalism and procedures. They must also be introduced to the Health Insurance and Portability and Accountability Act (HIPAA), a federal law protecting the privacy of patient information. Health care providers are expected to follow HIPAA guidelines or face significant fines and imprisonment. Students must be aware of relevant laws, because they are held accountable for patient privacy.

Clinical education is an important part of student training. Students spend an average of 1,800 hours at their clinical site in the two years. During this time, they complete rotations in radiography, computerized tomography, fluoroscopy, surgery, and portables. They will also complete rotations on evenings and weekends where patient injuries are increased and tend to be more traumatic. Students also complete four elective rotations. During clinical rotations, students spend time with registered technologists, learning hands-on with patients. The students are required to complete competencies in all areas of positioning. The competencies are graded by the clinical coordinator or clinical instructor by looking at the images with the students.

Once students have completed a set number of examinations under direct supervision, they must perform mandatory competencies of procedures. A registered technologist observes them and completes a check-off sheet of their performance. If the student passes the examination, they are then able to perform the examination without direct supervision. Students must pass 60 mandatory competencies in two years. In addition to the mandatory competencies, there are two proficiency competencies each semester. Proficiency competencies are for procedures that students have previously completed, but with more stringent criteria to ensure that students are indeed competent to perform the exam. Students must also complete eight mastery competencies in their last two semesters. Mastery competencies are performed on patients who are not able to be positioned under normal circumstances and in situations that require critical thinking skills. This could include trauma patients, mentally disabled patients, or any other non-routine patient.

Once a competency is completed, the clinical coordinator or clinical instructor retrieves the images and performs an image review with the student. During the image review, the clinical coordinator or clinical instructor looks at each image in the exam. For example, a two-view chest

examination consists of a postero-anterior and a lateral view. The student is expected to explain about the patient, how they set up the room, how they specifically positioned the patient, and what technical factors and radiation protection procedures they used. In addition, they must name the anatomy, pathology, mistakes in positioning, and what they could have done to improve the image.

Clinical Application

The revisions of the *Standards for an Accredited Education Program in Radiologic Technology* by JRCERT in the 1990s sought to implement critical thinking within programs. The revisions promoted identification of critical thinking and problem-solving skills that were important specifically to the field of radiography. Radiography educators are challenged with the task of developing a curriculum that promotes critical thinking while keeping pace with the advances in technology within the field of radiology (Larsson et al., 2013). Students are exposed to state-of-the-art equipment which, although beneficial for patient outcomes, deprives students of some aspects of critical thinking. Radiography has experienced significant technical change over the past 40 years, from dipping films in solution for development to the use of equipment that sets the appropriate techniques and even positions the room for the exam to be completed. Computerized tomography of the head region can now be scanned in less than one minute, whereas until recently the procedure took 30 minutes to complete. There are also 3-D imaging techniques that simulate an arteriogram without invasive procedures; all the parameters are pre-set by a physicist so that the technologist must simply know which buttons to push. While these advancements are remarkable, radiography educators must find ways to teach students critical thinking skills in an environment that does not promote them.

McInerney and Baird (2016) suggested a method called reflective cycling. Based on Dewey's theory, the cycles allow students to assess a situation, reflect, plan, reason, and take action (McInerney & Baird, 2016). The cycling method follows a similar approach as Bloom's taxonomy, in that students begin reflection at lower cognitive levels where information is obtained and they start understanding dynamics situations, and they then move to the higher cognitive levels, where they practice analysis, synthetization, and evaluation. However, Castle (2006) argued that students must possess reflective ability before they can move to the higher cognitive levels. For this to happen, students need experiences to draw from, and they need instruction. It is the responsibility of educators to provide situations for learning (McInerney & Baird, 2016).

At the beginning of clinical education, few students have worked in a radiography department or hospital. Most begin at the lower-level cognitive function of remembering and understanding. During the first few weeks of clinical instruction they begin socialization with staff members and other students. This is complemented by classroom instruction so that students begin building their foundation of cognitive learning (Larsson et al., 2013). Memorization will not help them with achieving the higher order cognitive skills that will be required of them to perform their professional responsibilities. Radiographers must continuously utilize critical thinking throughout their career, therefore students should have an environment and curriculum that promote these skills (Turner, 2005). The aim is to integrate traditional classroom education, laboratory simulations, and hands-on clinical experience.

One idea for incorporating critical thinking skills in a curriculum is to use a student workbook for image collection or presentation. This allows students to take some of their images and critique them (McInerney & Baird, 2016). The purpose is for students to evaluate their work,

make suggestions for improvement, and present their findings. It can also be beneficial for students to present in front of their peers. Studies show that this can be an effective and positive reinforcement as well as a learning objective (Elshami & Abdalla, 2016; Holmstrom & Ahonen, 2016). This type of activity promotes the highest level in Bloom's taxonomy: create.

Case studies are a well-documented approach to learning. This involves students choosing a patient case and performing an evaluation. Since most colleges have online learning capabilities, case studies can be presented online or in front of peers (Holmstrom & Ahonen, 2016). One program specifically for radiography is the student-oriented learning about radiography (SOLAR). This is a case-oriented approach to radiographic learning (Baird & Wells, 2001), in which students can access case scenarios and maintain a record of their answers and evaluations. The program is set up to teach communication, patient care, imaging procedures, interpretation, and quality control (Baird & Wells, 2001; Holmstrom & Ahonen, 2016). However, Holmstrom and Ahonen (2016) also mentioned that students had difficulty with the technology skills required for the program.

Studies have shown that students respond positively to problem-based learning in radiography (Castle, 2006; Holmstrom & Ahonen, 2016). This type of learning pushes students to analyze and evaluate and has the potential to increase critical thinking skills to the higher cognitive level. During their time in clinical rotations, students begin developing information that they can use for reflective practices. Research has also indicated that students learn through problem-based teaching, but that, when they participate in peer evaluation with problem-based learning, they focus and work harder to achieve their end goal (Lee & Lim, 2012).

Peer mentoring can also be a useful technique for increasing critical thinking. In a study by Meertens (2016), students who had a better understanding of material were encouraged to

mentor those students with poorer understanding. The report showed an increase in self-confidence and interpersonal skills. Attendance was not mandatory, but students who attended found that there was less pressure than mentoring with a faculty member, and that they enjoyed the relaxed atmosphere (Meertens, 2016).

Another approach in teaching critical thinking is discussions and questioning. If the instructor acts as a facilitator, asking open-ended questions and prompting discussions, students tend to react in a positive way (Tanenbaum et al., 1997). This type of teaching allows students to lead the discussion, whether it be with the class or in groups. According to McKeachie (2002), teacher-directed questions with a student-centered approach is one of the most useful types of teaching.

Motivation of the student is a key component of successful training. As previously described, students complete a rigorous process prior to the beginning the program, so low motivation is not usually an issue. The students who are placed in the program are required to complete many hours of observation (ARRT, 2016); thus, they have a good idea of what is expected of them on a normal day in radiography. This process was implemented to increase the retention rates of programs. Sedden & Clark (2016) provided insight into maintaining student motivation, proposing that student accountability is a major factor in motivation. Student accountability can be accomplished by expecting students to self-evaluate, providing feedback, communicating, and defining assignments. Students tend to focus more intently on assignments when they understand the expected outcomes (Holmstrom & Ahonen 2016; Sedden & Clark, 2016).

Clinical instructors. Clinical instructors are a vital part of clinical education, providing daily support and supervision of students at the clinical site. Clinical instructors are generally

employees of the clinical affiliate (hospital) and are sometimes also paid by the educational institution. Clinical instructors must be registered technologists in good standing, and be approved through the educational institution (ARST, 2016). Clinical sites must also be approved as a clinical affiliate (ASRT, 2016). Clinical sites and clinical instructors have a vested interest in student outcomes, because current students could be future employees and co-workers (Sedden & Clark, 2016).

Assessment

Assessment is an important part of teaching critical thinking. Traditional evaluations by testing is not always the optimal type of assessment. Specifically, multiple-choice answers do not properly assess what the student actually knows. Elshami and Abdalla (2016) defined two forms of assessment: summative assessment, which is an overall assessment of the student's performance that takes place at the end of the course; and formative assessment, which takes place throughout the course. Clinical education provides both summative and formative assessment. It is crucial that radiography students be aware of their progress throughout the course.

Castle (2009) offered a list of attributes against which radiography students should be assessed, including interpreting, analyzing, evaluating, explaining, and inference. He also stated that students should be assessed on these intermittently during the course, as a process for improvement of skills. Learning-oriented assessment provides students with a deeper foundation of learning, by providing consistency throughout the individual courses (Carless, 2014). This model introduces students to the tasks and course requirements, and students are evaluated on development and engagement during the course. They can determine how they are progressing

prior to the end of the course. Feedback for students allows them to make improvements in areas that they may be lacking (Carless, 2014).

The latest revision of the *Standard* emphasizes competency-based evaluation and effective student learning through hands on learning and increasing of critical thinking so that graduates will be prepared to enter the work force as competent radiographers (JRCERT, 2014). Guidelines are also provided by JRCERT concerning what students must be taught. Specific lists are given and must be covered during the program. JRCERT also requires specific outcomes be measured and reported.

Summary

Critical thinking is becoming increasingly important in higher education. There are solid reasons for this, but it is up to higher education instructors to introduce these skills into students prior to graduation. The conceptual framework of this discussion is based on critical thinking by students, embedding critical thinking skills in curricula, and motivating students to take responsibility for their learning.

Radiography students are at the forefront of healthcare so the need for critical thinking skills is vitally important. Classroom instruction, laboratory simulation and clinical education complement one another to provide a well-rounded education. However, critical thinking must be at the core to produce graduates who are capable and ready to enter the workforce.

Implementing inquiry-based learning, problem-based learning, peer mentoring, open discussions, and case study scenarios are just some of the ways that critical thinking can be incorporated into radiography clinical education. Students must be motivated and diligent in learning. Collaborative teaching in the classroom, laboratory, and clinical sites must take place for students to be prepared as radiologic technologists.

Chapter 3 will cover the methodology for data collection, and will include the problem purposes, research questions, population and sample, instrumentation, procedures, limitations, design, and expected findings.

Chapter 3: Methodology

Critical thinking is the ability to observe, synthesize, reflect, reason, evaluate, and act on a problem or issue (Ennis, 1985; Facone,1990; Halpern, 1998). Research has shown that the current population of millennial-age undergraduate students lacks critical thinking skills (Fahim & Masouleh, 2012; Hassan & Madhum, 2007; Smith & Stitts, 2013). Additionally, radiologic science students are not acquiring the critical thinking skills during clinical practice (Gosnell, 2012).

There is a need to understand if graduates in radiologic science are able to enter the career field equipped with the essential skills required for the career (Flores et al., 2012). Important information can be gained by researching the development and use of critical thinking in clinical practice (Castle, 2004; Davison & Mannelin, 2003; Gosnell, 2012; McInerney & Baird, 2016; Meertens, 2016).

The purpose of this dissertation study is to examine clinical coordinators' perceptions of student growth in critical thinking, as evidenced in clinical practice. In addition, the purpose is to examine how clinical coordinators implement critical thinking skill within curricula as well as tools for assessment. In this chapter, the sampling and measurement tools, and data collection methods and analysis, will be discussed. Data on critical thinking skills was obtained from surveys sent to clinical coordinators within the United States, and interviews were conducted with program directors within the United States.

Data gathered for the study are quantitative and qualitative. This mixed method of research adds validity and reliability to the conclusions. Internal and external validity is important in this type of study. Adams and Lawrence (2015) warned that external validity requires that findings should be able to be applied to the general public and not just study

participants, and that the more diverse the sample, the greater the validity. Levy and Ellis (2006) suggested that surveys and questionnaires tend to have increased reliability when they use previously tested instruments. In this study, the survey instrument was developed for nursing students by Gordon in 1995 and modified by Gosnell in 2010 for use with radiologic technology students. Likert scale responses allow evenly spaced intervals of answers, providing the ability to conduct mathematical analysis of the data. Qualitative data from interviews adds rich information to complement the quantitative data (Adams & Lawrence, 2015). By establishing content analysis, answers from the interviews were categorized, scored, and recorded for frequency.

The focus of this study was the teaching strategies used by clinical coordinators to help students develop critical thinking skills. The study examined clinical coordinators' perceptions of students' critical thinking skills in clinical practice. The study also considered program directors' perceptions of students' overall critical thinking skills at a JRCERT school. Limitations of the study were also discussed. This study determined instructional pedagogy, specifically pertaining to the development of critical thinking skills, for radiography students in an accredited program.

During the two years in a radiography course, there is an emphasis on fostering the development of critical thinking skills. JRCERT identified critical thinking and problem-solving learning outcomes as priorities in the Standards for an Accredited Education in Radiographic Technology. Programs must include teaching strategies that will train students in becoming lifelong critical thinkers. This skill is essential for frontline healthcare workers such as radiologic technologists.

Some of the methods for teaching critical thinking are inquiry- and problem-based learning, reflective journals, image review, open-ended questions, group projects, and case

scenarios. Empirical research has confirmed that these strategies can increase student learning (Covill, 2011; Friedman et al., 2010; Lynch, 2007; Spronken-Smith et al., 2012).

As part of a mixed-methodology research study, clinical coordinators and program directors were asked to participate in a survey and/or an interview about the critical thinking skills of their radiography students. Data for the case study were collected by surveying clinical coordinators and interviewing program directors.

Problem Purposes

The scope of practice demands that radiographers possess the ability to think critically. Radiographers are often in emergency situations that require alternative positioning techniques to obtain radiographs (Long, et al., 2015). The implications of inadequate critical thinking can be devastating on patient outcomes. The radiographer is the liaison between the patient and the radiologist: the radiologist rarely sees or speaks to the patient, so they rely on information from the radiographer, in the form of radiographs and patient history, for their report. Subsequently, the radiologist's report is sent to the ordering physician so that a diagnosis can be made.

No two patients are identical and few patients are representative of a typical textbook patient. For this reason, the technologist must constantly make adjustments to positioning and technical factors to achieve optimum radiographic quality. The purpose of this research was to determine the extent to which radiography students are equipped with critical thinking skills in clinical practice.

Research Questions

Research question 1. What aspects of the definition of critical thinking skills are most pertinent to clinical coordinators?

Research question 2. What are components of teaching critical thinking, as perceived by clinical coordinators?

Research question 3. Which teaching method or learning activity is most often used by clinical coordinators to teach critical thinking in clinical practice?

Research question 4. What are the assessment tools and teaching methods utilized by clinical coordinators to assess critical thinking in clinical practice?

Research question 5. What are clinical coordinator's perceptions of the critical thinking attributes of graduates, based on the degree awarded?

- Null hypothesis: There will be no difference in clinical coordinators' perceptions of the critical thinking attributes of graduates, based on the degree awarded
- Alternative hypothesis: There will be a difference in clinical coordinators' perceptions of the critical thinking attributes of graduates, based on the degree awarded

Research question 6. What are clinical coordinator's perceptions of the critical thinking attributes of graduates, based on the degree held by the clinical coordinator?

- Null hypothesis: There will be no difference in clinical coordinators' perceptions of the critical thinking attributes of graduates, based on the degree held by the clinical coordinator
- Alternative hypothesis: There will be a difference in clinical coordinators' perceptions of the critical thinking attributes of graduates, based on the degree held by the clinical coordinator

Research question 7. What are program directors' perceptions of students' critical thinking readiness for employment upon successful completion of the radiologic technology program?

Population and Sample

The population for this study was clinical coordinators and program directors currently teaching in a JRCERT-accredited program in the United States. There are currently 703 institutions employing clinical coordinators and program directors that are eligible for participation. Surveys were sent to 523 randomly selected clinical coordinators. With a confidence level of 95% and a 5% margin of error, the ideal sample size was 218 responses to the survey (Qualtrics, 2016).

The researcher randomly selected and contacted twenty-five program directors from different locations within the United States to participate in the interview. To ensure random sampling, program directors were sorted by the region of the United States and assigned a number within that region. Microsoft Excel was used to generate a random sample without bias. An email request was sent to JRCERT (see Appendix B) requesting names and email addresses of clinical coordinators at accredited institutions. The list included programs that offer certificate, associate and bachelor degrees. The request to JRCERT was granted (see Appendix C).

Data Collection and Instrumentation

A survey was developed, based on a questionnaire used by Gosnell (2010) (see Appendix F). According to Singh (2007), surveys are one of the most statistically accurate ways to collect quantitative data. Since the answers from the survey are in Likert scale numbering, data were sorted using chart methods. Gosnell's survey was adapted from a questionnaire from Gordon (1995) that was used to survey nursing students.

The Gordon survey investigated critical thinking of nursing students and was validated by a critical thinking expert panel. The correlation coefficient was 0.96 which is well within acceptable limits of reliability. The original survey was modified for use with radiography students. Gosnell completed a pilot study to clarify and update terminology. The stage one survey was changed according to Dillman's tailored design method (Dillman, 2000). Stage two was based on a five-point Likert scale and questions were modified in accordance with research questions. The reliability of questions was at an acceptable rate of .899 based on Cronbach (Gosnell, 2010). The survey used in this study was modified to address perceptions of clinical coordinators as opposed to program directors.

The Gosnell survey included items that measured the administrators' broad goals for student acquisition of critical thinking because her survey was designed to be completed by program directors. Since this study focuses on clinical coordinator perceptions and students in clinical practice, survey items that were considered program-based and not student learning outcome based critical thinking were eliminated. In section one of this survey, the following statements were removed from the Gosnell survey:

- Radiologic science programs generally do a good job teaching critical thinking
- Critical thinking is a generalizable skill (can be applied to many different activities)
- Clinical reasoning and critical thinking are synonymous
- Critical thinking is an abstract cognitive activity
- Critical thinking is a linear process
- Critical thinking and following protocol are synonymous
- Critical thinking is best acquired in liberal arts, non-health professions courses
- Critical thinking is a rational process

- Critical thinking is synonymous with decision making processes, and
- Problem solving and critical thinking is synonymous.

An open-ended question which asked the clinical coordinators to state their definition of critical thinking was added.

Section two and three in the Gosnell survey were addressed in the program director interview portion of this study so they were not included in this survey. Some teaching methods and learning activities in sections four and five in the Gosnell survey were directed toward program directors. They included the following which were also eliminated from the survey:

- Socratic questioning
- On-line discussions
- In class discussions
- Traditional lectures
- Concept mapping
- High order multiple choice test items

However, added to the section were Hands-on learning and Inquiry-based learning due to the nature of clinical education. Eliminated from this section was Specific course assignments in section six of the Gosnell survey. Section seven in the Gosnell survey was eliminated altogether because it did not address the purpose of this survey.

In section eight, wording was changed to determine clinical coordinator perceptions of attributes of their graduates. The following attributes were eliminated:

- Empathizing
- Inductive reasoning
- Sensing

- Speaking or writing
- Defending an opinion
- Applying reflective skepticism
- Judging evidence to be more or less important
- Interrogation
- Cross-examining
- Managing others
- Reading
- Exploring ethical issues impacting a solution
- Interpreting data on a table or graph
- Performing routine procedures
- Conducting research in a discipline
- Implementing a plan
- Thinking about thinking
- Recognizing cues
- Judging the credibility of a source
- Additionally, section sixteen was eliminated since it did not apply to this research.

A request was sent to Susan Gosnell to use her survey (see Appendix A) and permission was granted through personal correspondence from the instrument creator. Clinical coordinators were sent an email, using the addresses obtained from JCERT, and asked to participate in the survey (Appendix D). The Gosnell questionnaire was sent electronically to clinical coordinators.

Twenty-five program directors were randomly selected using Microsoft Excel and asked to volunteer to participate in an interview (see Appendix E). Six program directors agreed to

participate in the interview. The primary focus of the interview questions was to discern the perceptions of the readiness of students for employment in the radiologic technology field. Open-ended questions were designed to clarify what skills are needed for employment as a radiologic technologist and whether these skills are noticeable in recent graduates (Appendix G).

Interview questions are an essential aspect of providing viability and human characteristics in research (McCusker & Gunaydin, 2015). Design of the interview questions was derived in part from a study by Ott (2015). Initial interview questions are listed on Appendix H.

According to Leedy and Ormod (2015), interviewees ensure the validity of a study by confirming that their answers were recorded correctly. To this end, it is imperative that answers are transcribed with accuracy and diligence, with no additions or subtractions (Gorgi, 2009). Christensen, Johnson, and Turner (2011) also predicted improved reliability and trustworthiness of the interview process when participants are allowed to review their recordings and validate the information. Trustworthiness is an important component of the interview process, leading to in-depth and honest answers from the interviewees (Cope, 2014).

Cope (2014) considered that one way to promote trustworthiness is to prolong engagement. To maintain the integrity of the trust between me and the interviewees, I spent as much time as needed during the interview explaining the purpose and objectivity of the questions. Interviews took place via telephone and were transcribed with participants' permission. Transcripts were sent to the program directors for validation with a 100% confirmation.

Data Collection Procedures

An application for approval for the research was submitted to the Concordia Institutional Review Board (IRB). Emails were sent to clinical coordinators asking them to participate in a

survey (Appendix D). The survey included 523 randomly selected JRCERT programs. Eligible programs included those offering bachelor and associate degrees, and certificates. Clinical coordinators who chose to participate were given a Qualtrics link that directed them to the survey. By clicking the link to the survey, the participants gave their implied consent to participate.

Emails were sent to 25 program directors of JRCERT programs in the United States, asking them to participate in an interview (see Appendix E). The invitation emails (see Appendix G) were limited to 25, in the hope that half would participate. Six program directors agreed to participate in the interview.

Data Analysis Procedures

Quantitative data gathered from the surveys were used to answer research question one; this was supplemented by qualitative data of word frequency in the interviews, and by the clinical coordinators' perceptions of pertinent aspects of the definition of critical thinking. Research questions two, three and four were addressed with descriptive statistical analysis. Data were analyzed for research questions five and six using a two-way analysis of variance (ANOVA), which, according to Rosner (2006), is the most accurate way to compare more than two variables. Independent variables for question five are the level of degrees earned by students including bachelor, associate, and certificate. Independent variable for question six is the degree level of the clinical coordinators including bachelor, masters, and doctoral. Dependent variable for question five and six is the perception of attributes by the clinical coordinator. Each research question is addressed within the survey questions and, since the survey is based on a Likert scale, statistical analysis of the data can be undertaken. Research question seven was based on qualitative data gathered from interviews of the program directors.

Coding for the interviews is a way to identify common themes within the data. It was important to develop a coding protocol that will lead to transparency and replication of the study (Cooper et al., 2009). Themes that are pertinent to the study include increased critical thinking, teaching strategies, clinical experience, autonomous thinking, reflection, preparation, and inquiry-based thinking. Each interview answer was assigned a descriptor. According to Saldaña (2009), this allows the researcher to explore the essence of the replies in an organized manner. Each time a similar descriptor was used by the interviewees, it was placed in a category. This type of coding produced emergent themes. Thematic analysis allows emergent themes to be categorized and organized for analyses (Adams & Lawrence, 2015).

Once the interviews were completed, any identifiable key words were highlighted and any key words that shared a common thread throughout the interview process. Key words were categorized into their frequency of use.

Delimitations and Limitations of the Research Design

The researcher delimited the study population to clinical coordinators and program directors from JRCERT-accredited programs and who work directly with radiography students. These criteria will allow as much consistency as possible.

One of the limitations of the study was the method utilized. Accurate survey responses rely on truthfulness of the participant and a substantial sample size. The researcher distributed five-hundred and twenty-three surveys and received 166 responses. Another limitation is the lack of a pilot study of the survey after modifications. Additional limitations of the study were interpretation and coding of the data, and assumptions that did not coordinate with the emergent patterns. Once the researcher collected the raw data, they were able to be linked to the research questions via categories and identifiable patterns (Glaser, 2013).

Trustworthiness

According to Guba (cited by Krefting, 1990), truth value is one of four characteristics of trustworthiness in qualitative research. To reach a truth value, certain criterion must be achieved within the research. DeVault (2017) recognizes that trustworthiness is the collaboration of credibility, transferability, dependability and confirmability. Internal validity helps to establish credibility and leads to trustworthiness (Shenton, 2004). Triangulation and member checks enrich the credibility and add trustworthiness to the data. Triangulation of the data was accomplished by overlapping responses of clinical coordinators and program directors. Dependability and validity of data was further established by triangulation of data from the survey and interviews. According to Carlson (2010), member checking allows validation of data. Doyle (2007) advised that, to increase trustworthiness, it is important to provide hard copy transcripts for review. The researcher sent electronic transcripts to the interviewees and asked each one to verify accuracy of the transcription to ensure accuracy of the data.

The researcher should not set a priori parameters but should allow the emergent themes to lead the results. Key words and statements were used to code data for this purpose. Interview questions included how critical thinking is incorporated into the program. Data from the surveys explained how critical thinking is included in clinical practice. The overlapping of data provided possible transferability, increasing reliability. Collaboration of data provided a general overview of critical thinking for the entire program.

Expected Findings

Findings were expected to show the common teaching strategies used by clinical coordinators during clinical practice; perceptions that clinical coordinators have about critical

thinking skills of radiography students in clinical practice; and perceptions that program directors have of the overall level of critical thinking skills of radiography students.

The survey of clinical coordinators allowed insight into their perceptions of how critical thinking skills should be taught, whether they use those strategies, and whether they believe that they have increased student's critical thinking during clinical practice. Interviews from program directors enhanced the study by including their perceptions of the students' overall critical thinking skills.

Ethical Issues of the Study

To alleviate possible bias, the researcher distributed surveys that allowed participants to respond anonymously. All participants were required to complete an informed consent form from the Concordia Institutional Review Board prior to participation. The researcher informed participants that they could withdraw from the study at any time without penalty. Since the survey was anonymous, no identifying information was used. Participants were informed that codes, not real names, would be used for the study. The results will be kept in a locked cabinet for a period of 3 years and then destroyed.

Summary

The methodology for this study was described in Chapter 3 and included research questions, purpose, population, instrumentation, data collection, analysis, design, limitations, expected findings, and ethical issues. The study is designed to address the question of increased critical thinking skills in radiography students during clinical practice. Chapter 4 includes analysis of the statistical data obtained from the survey and emergent themes from the interviews.

Chapter 4: Results and Findings

This study was designed to assess clinical coordinators' perceptions of the critical thinking skills of radiography students. The findings are based on clinical coordinators' definition of critical thinking, clinical coordinators' perception of critical thinking teaching strategies, and how critical thinking teaching strategies are implemented in clinical coordinator pedagogy. Additionally, data were collected to determine radiography program directors' perceptions of critical thinking skills in current radiography students.

Survey participants included clinical coordinators from JRCERT-accredited schools in the United States. A list of email addresses was obtained from JRCERT (see Appendix C), containing details for 558 clinical coordinators teaching at certificate, associate and bachelor degree programs. Of the 558 emails that were distributed through Qualtrics, one was eliminated since it was sent to me and 33 were not received because the email addresses were inaccurate; this left a total of 525 distributions. I received one email from a participant stating that she had not been a clinical coordinator for eight years, and one duplicate email, bringing the total to 523. One hundred and ninety-seven participants began the survey and 166 completed, for a response rate of 31.74%. The survey instrument used was adapted from Susan Gosnell (2010) which she was granted permission to use from a survey used for nursing students. Dr. Gosnell changed the questions to suit radiography program directors. The survey questions used in this study were altered for radiography clinical coordinators.

Demographic Data

The respondents included clinical coordinators teaching at hospitals/medical centers (18.90%), public community colleges (38.41%), private colleges or universities (21.34%), public

colleges or universities (17.68%), and other institutions (3.66%). Table 1 presents the demographic breakdown of participants.

Table 1

Summary of Coordinator Demographics

#	Answer	Count	%
1	Hospital/Medical Center	31	18.90%
2	Public Community College	63	38.41%
3	Private College/University	35	21.34%
4	Public College/University	29	17.68%
5	Other	6	3.66%
	Total	164	100%

Additionally, the United States was divided into five regions, with the following response rates: Northeast (24.84%): Maine, Vermont, New Hampshire, New York, Massachusetts, Connecticut, Rhode Island, Pennsylvania, Ohio, Indiana, Illinois, Wisconsin, Michigan, Maryland, Delaware, New Jersey, W. Virginia and District of Columbia; Southeast (31.68%): Kentucky, Tennessee, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama and Mississippi; Central (26.09%): Louisiana, Arkansas, Missouri, Iowa, Minnesota, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma and Texas; Northwest (4.97%): Washington, Oregon, Montana, Wyoming, Idaho, Colorado and Alaska; Southwest (12.42%): California, Nevada, Utah, Arizona, New Mexico and Hawaii. Table 2 presents the response rates from the five regions.

Table 2

Summary of Regional Divisions

#	Answer	Count	%
1	Northeast	41	24.70%
2	Southeast	52	31.33%
3	Central	44	26.51%
4	Northwest	9	5.42%
5	Southwest	20	12.05%
	Total	166	100%

For each of the research questions analyzed, which had a quantitative and a qualitative component, the researcher provided both quantitative and qualitative results.

Research Question One

What aspects of the definition of critical thinking skills are most pertinent to clinical coordinators?

Quantitative results for RQ1. This question was addressed with survey section one. The section included seven sub-items with five Likert scale responses: Strongly Disagree, Disagree, Neither Agree or Disagree, Agree, and Strongly Agree. Sub-item one, *Critical thinking is a vital skill for radiographers in clinical practice*, displayed a high level of agreement among clinical coordinators (N = 165, M = 4.92 and SD = .474) with *Critical thinking in radiography may be conceptually different than critical thinking in other health care disciplines* (N = 164; M = 4.18 and SD = .843). Clinical coordinators also had similar opinions concerning *Critical thinking is a series of decisions made by the radiographer in the clinical setting* (N = 165; M = 4.42 and SD =

.766). Responses to *Critical thinking must be included in radiologic science clinical educational programs* were (*N* = 165; *M*= 4.81 and *SD* = .601). *Graduates of your program have well-developed critical thinking skills when entering their first radiography job* were (*N* = 165; *M* = 4.00 and *SD* = .741).

Qualitative results for RQ1. There was a wide spread in responses when asked if a standard definition for critical thinking is needed in radiologic science. Clinical coordinators agreed that *Critical thinking skills could be learned* (*N* = 166; *M* = 4.06 and *SD* = .722). However, this finding was not substantiated in the interviews. In fact, during the interviews of program directors, half of the interviewees believed that critical thinking could not be taught. Program directors thought that if students enter the programs with the ability to think critically, they could be made aware of critical thinking skills pertaining to radiography and enhance those skills. However, if a student did not possess critical thinking ability upon beginning the program, directors did not witness an increase in that ability, regardless of teaching strategies. Table 3 lists the percentage of responses in agreement to the perceived definition of critical thinking, as well as the mean, and standard deviation of responses.

Table 3

Percentage of Coordinator Responses on the Definition of Critical Thinking in Radiography

Critical Thinking Definition	Percentage in Agreement	Mean Median SD
Critical thinking is a vital skill for radiographers in clinical practice	98.2	4.92 5.00 .474
Critical thinking must be included in radiologic sciences clinical educational programs	96.3	4.81 5.00 .601
Critical thinking in radiography may be conceptually different than critical thinking in other health care disciplines	85	4.18 4.00 .843

Critical thinking is a series of decisions made by the radiographer in the clinical setting	92.2	4.42 5.00 .766
Critical thinking can be learned	84.3	4.06 4.00 .722
A standard model or definition for critical thinking is needed in radiologic sciences	70.5	3.94 4.00 .954
Graduates of your program have well-developed critical thinking skills when entering their first radiography job	81.9	4.00 4.00 .741

As a supplement to survey question one, clinical coordinators were asked to provide a definition in their own words of critical thinking skills. Overwhelmingly, the words ability or able were included in the definitions. Additionally, during the interview process, program directors consistently used the term ability, with comments such as the "ability to adapt to different situations", "ability to think on demand", "ability to analyze mistakes" and "ability to assess situations and come up with alternative solutions". Table 4 indicates the words used with the highest frequency in the survey and interviews for definitions of critical thinking by program directors and clinical coordinators.

Table 4

Word Frequency of Surveys and Interviews

Word	Times used	Percentage
Ability/able	108	6.42
Situation	64	3.80
Problem	36	2.02
Analyze/analyzing	21	1.25

Research Question Two

What are the components of teaching critical thinking, as perceived by clinical coordinators?

Quantitative results for RQ2. Evaluation was completed through survey section two, using Likert scale ranking for eleven components of critical thinking teaching strategies. The components of critical thinking listed were clinical case studies, reflective journaling, situational judgements, role playing, case-based learning, inquiry-based learning, problem-based learning, hands-on learning, collaborative learning, portfolios, and higher-level cognitive questioning. Table 5 provides the results for these components.

Table 5

Percentage of Clinical Coordinator responses on the Perceived Effectiveness of Teaching Strategies of Critical Thinking

Critical Thinking Teaching Strategies	Percentage of Agreement
Clinical case studies	85.6
Reflective journaling	56.6
Situational judgements	92.8
Role playing	86.8
Case-based learning	84.9
Inquiry-based learning	80.1
Problem-based learning	93.4
Hands-on learning	98.8
Collaborative learning	85.0
Portfolios	33.1
Higher-level cognitive questions	82.5

Clinical coordinators felt that hands-on learning was by far the most important teaching strategy for teaching critical thinking in clinical practice, with 98.8% agreeing (Table 5). Problem-based

learning were the second-most common teaching strategies listed by clinical coordinators (93.4% agreeing).

Research Question Three

Which teaching method or learning activity is most often used by clinical coordinators to teach critical thinking in clinical practice?

Quantitative results for RQ3. Based on section two, the same critical thinking components were listed, and the clinical coordinators were asked to respond with the percentage of their curriculum that the components are utilized in teaching critical thinking. The results are summarized in Table 6.

Table 6

Percentage of Curriculum Dedicated to Critical Thinking Components

Critical Thinking Components	Never used	Less than 10%	10%—24%	25%—49%	50%—74%	75%—100%
Clinical case studies	3.6	25.9	23.5	16.3	13.9	12.0
Reflective journaling	25.5	31.3	17.5	6.0	6.0	5.4
Situational judgements	3.6	11.4	19.9	18.1	25.3	16.9
Role playing	6.6	16.9	19.3	16.3	25.9	13.3
Case-based learning	6.0	19.9	21.7	13.9	20.5	13.3
Inquiry-based learning	9.6	17.5	16.3	10.2	24.7	10.2
Problem-based learning	5.4	9.6	15.7	16.9	26.5	20.5
Hands-on learning	.6	.6	1.8	3.6	19.9	69.3
Collaborative learning	.6	11.4	18.1	13.9	31.3	19.9
Portfolios	48.8	19.3	10.8	5.4	6.0	4.8
Higher-level cognitive questions	3.0	10.8	18.1	15.7	22.3	22.9

Hands-on learning was the teaching strategy most utilized by clinical coordinators, with 69.3% of responses stating that it was used in 75%–100% of the curriculum. The second-most utilized teaching technique is higher-level cognitive questions, at 22.9%. In the five middle categories, the frequency used were all within 12.1% of each other. Figure 1 shows the percentage of curriculum utilized with each teaching strategy.

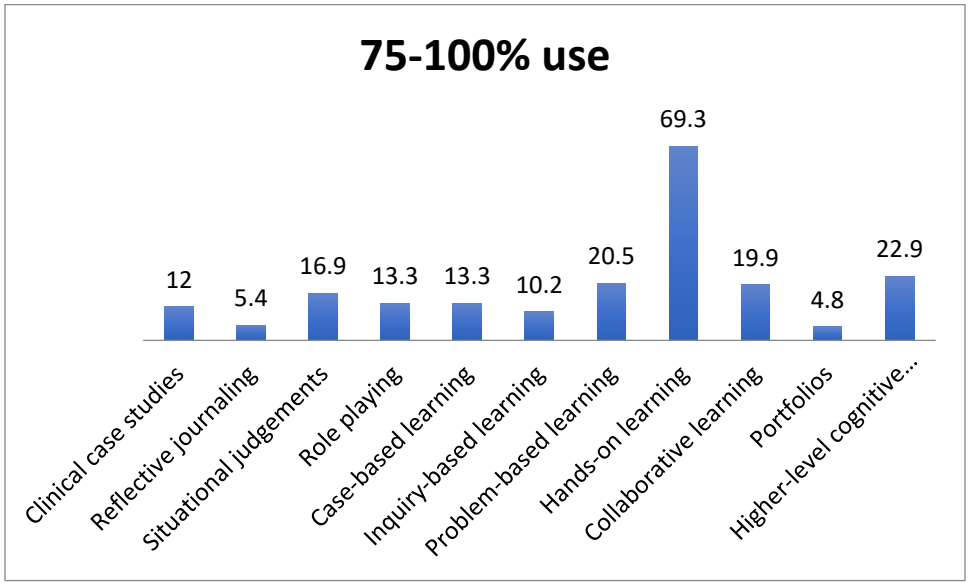

Figure 1. Percentage of Curriculum Utilized for Teaching

Research Question Four

What are the assessment tools and teaching methods utilized by clinical coordinators to assess critical thinking in clinical practice?

Quantitative results for RQ4. Survey section four used Likert scale responses on the assessment tools used for critical thinking in clinical practice. Table 7 presents the results for all twelve assessment tools. Results show that Image Critique Performance was an important tool for assessment of critical thinking (N = 165; M = 4.3 and SD = .719). Clinical Competency (N =

165; *M* = 4.30 and *SD* = .719) and Situational Judgement Test Items (*N* = 164; *M* = 4.22 and *SD* = .733) were also important tools for assessment.

Table 7

Percentage of Agreement on Effective Clinical Assessment Tools

Clinical Assessment Tools	Percentage of Agreement
Course exam results	61.4
ARRT exam results	58.4
Clinical competency results	90.4
Image critique performance	94.6
Situational judgement test items	90.3
Portfolios	20.5
Reflective journals	32.5
Clinical case study performance	68.7
Employer surveys	63.3
Student surveys	47.5
Standardized test results (such as WGCTA or CCTST)	10.2
Other assessment measures	17.4

The three lowest scoring items for assessment of critical thinking skills were portfolios, reflective journals, and standardized testing respectively. Overall, clinical coordinators scored reflective journals as a moderate method of assessment. Most clinical coordinators did not think that standardized testing is a good measure for critical thinking. Figure 2 represents the distribution of responses that agree on the assessment tools.

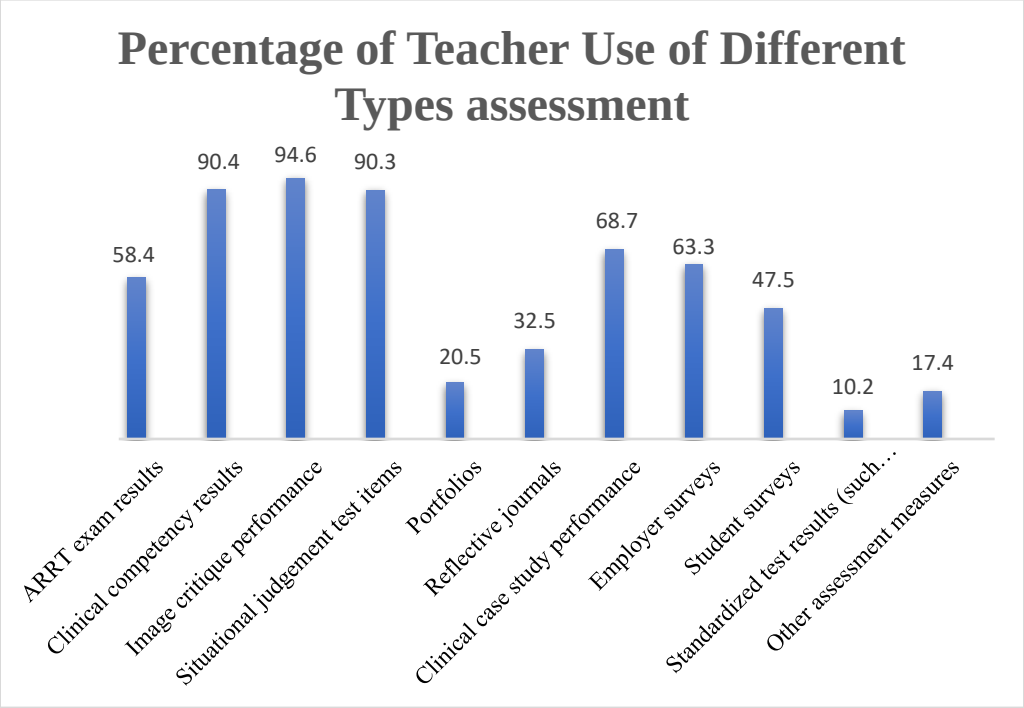

Figure 2. Distribution of Teacher Assessments

Responses to the situational judgement tool shows similar scores to image critique performance except for an increase in the lower categories.

Research Question Five and Six

What are clinical coordinators' perceptions of critical thinking attributes of graduates, based on the degree awarded?

What are clinical coordinator's perceptions of the critical thinking attributes of graduates, based on the degree held by the clinical coordinator?

Quantitative results for RQ5 and 6. For research questions five and six the dependent variable was the same, clinical coordinators' perceptions of critical thinking attributes of graduates, but the independent variables were different and multi-tiered, namely the degree awarded and the degree held by the clinical coordinator. Consequently, a two-way analysis of

variance was conducted. In a two-way analysis of variance each participant must have scores on three variables, two factors (independent variables) and a dependent variable.

A 3 X 3 ANOVA was conducted to evaluate the effects of academic degree of coordinator (the highest degree attained by coordinators) and graduate student degree, on the coordinator perceptions of critical thinking skills acquired by clinical students in the program. The means and standard deviations for coordinator perceptions of critical thinking skills as a function of the two factors academic degree of coordinator and degree of student are presented in Table 8. The ANOVA indicated no statistically significant interaction between academic degree of coordinator and degree of student, $F(3, 149) = 1.005$, $p = .392$, partial $\eta^2 = .020$. It also showed no statistically significant main effects for academic degree of coordinator $F(3, 149) = .549$, $p = .649$, partial $\eta^2 = .011$ and $F(2, 149) = 2.874$, $p = .060$, partial $\eta^2 = .037$. Consequently, both of the following null hypotheses failed to be rejected:

- There will be no difference in clinical coordinators' perceptions of the critical thinking attributes of graduates, based on the degree awarded
- There will be no difference in clinical coordinators' perceptions of the critical thinking attributes of graduates, based on the degree held by the clinical coordinator

Table 8

Means and Standard Deviations for Coordinators' Perceptions of Critical Thinking Skills acquired by Clinical Students in the Program

Coordinators' academic degree	Students' degree awarded	Mean	SD
Doctorate degree	Certificate	n/a	n/a
	Associate	4.0357	.05051
	Baccalaureate	3.8571	.30305
Master's degree	Certificate	4.2857	.46605
	Associate	4.0837	.52135
	Baccalaureate	4.0776	.41197
Bachelor's degree	Certificate	4.2946	.36906
	Associate	4.1276	.44997
	Baccalaureate	3.5000	.20203

Graduate attributes examined were deductive reasoning, problem solving, following protocols, planning, using clinical judgement, thinking creatively, motivating others, using higher cognitive thinking, communicating verbally, exercising reflective reasoning, adapting protocols based on the analysis of the situation, reasoning to make decisions, and a growing sense of accountability for patient outcomes. In all categories, *agree* was the response with the highest response rate (Table 9).

Table 9

Percentage of Respondents on Graduate Attributes of Critical Thinking

Critical Thinking Attribute	Percentage of Agreement
Deductive reasoning	89.2
Problem solving	95.8
Following protocols	97.6
Planning	83.8
Using clinical judgement	94.6
Thinking creatively	96.7
Motivating others	68.6
Using higher cognitive thinking	83.7
Communicating verbally	90.9
Exercising reflective reasoning	72.9
Reasoning intuitively	78.3
Adapting protocols based on analysis of a situation	85.5
Reasoning to make decisions, diagnose problems, and project outcomes	86.2
Growing sense of responsibility for patient outcomes	83.7

There was a trend observed of placing a higher perception on the attributes of graduates from a certificate program. In 13 of the 14 attributes listed, certificate graduates ranked higher than associate or bachelor degree graduates. In following protocols, associate degree graduates ranked first, whereas in using higher cognitive thinking and communicating verbally, bachelor degree graduates ranked above associate degree graduates. Subsequently, descriptive analysis

was conducted on programs that awarded terminal degrees of certificate, associate and bachelor. Table 10 provides the results of the descriptive analysis.

Table 10

Descriptive Analysis of Degree Awarded by Program Level

Student Terminal Degree	Mean	Standard Deviation	N
Certificate	4.27	.609	17
Associate	4.12	.676	118
Bachelor	3.99	.669	30

Based on the findings of research question five, descriptive analyses were conducted on attributes of graduates as perceived by clinical coordinators with bachelor, masters and doctoral degrees. Table 11 provides the results of the analyses.

Table 11

Descriptive Analysis based on Degree of Clinical Coordinator

Clinical Coordinator Education Preparation	Mean	Standard Deviation	N
Doctorate	3.89	.348	5
Masters	4.09	.685	105
Bachelor	4.15	.659	54

A two-way ANOVA (see Appendix J) was conducted on both sets of data to determine if there was a significant difference in coordinators' perceptions of student attributes depending on the

clinical coordinator's qualification and the terminal degree of the program. One test was conducted to decrease the possibility of error. There was no significant effect of coordinator qualification or terminal degree on the perceived attributes of graduates at the $p<.05$ level for the three conditions.

Research Question Seven

What are program directors' perceptions of students' critical thinking readiness for employment upon successful completion of the radiologic technology program?

Qualitative results for RQ7. Interviews were conducted with program directors in six states: Vermont, California, Wyoming, Connecticut, Iowa, and Ohio. There were several emergent themes from the interviews. Each program director indicated that the majority of their students' critical thinking skills increased by the end of the program.

The questions used for the interviews were

- Describe in your own words how you define critical thinking.
- What, if any, teaching strategies do you currently utilize to teach critical thinking to radiography students?
- How do you assess critical thinking in your students?
- Have you had any formal training in teaching critical thinking?
- On a scale of 1–10 (1 being the lowest and 10 being the highest) please rate the student's critical thinking skills when they begin the program.
- On the same scale, please rate your students critical thinking skills when they exit the program.
- What is your overall assessment of your students' preparedness with critical thinking to be successful radiographers?

One emergent theme was that critical thinking is the ability to analyze a situation and make a decision based on reflection and assessment. In radiography, this can involve a trauma situation

or a patient who is not able to perform normal positioning protocol due to altered mental status or injury.

Teaching strategies also contained similar emergent themes. Program directors utilize case studies, scenarios and role playing. One interviewee uses a simulation lab with manikins so that the students can practice before they perform radiographs on actual patients. The manikin's actions can be controlled, which allows the students to encounter many situations in which they would need to think critically.

Assessment procedures varied slightly but again there were emergent themes. Four of the six program directors do not think that there is a solid tool for assessment of critical thinking. The other two program directors use some type of verbalization of answers, writing assignments, and relying on clinical performance evaluations for assessment of critical thinking.

When providing an overall evaluation of students' critical thinking skills and preparedness for employment, each program director did feel as though their students were prepared. Employer surveys were one way that they were able to judge the preparedness of their students. One interesting comment was that "the students will succeed where they end up"; for example, some students will do well in a trauma one emergency department, whereas another student might be more suited to a doctor's office. This program director stated that student's critical thinking skills will dictate where they will succeed.

Hands-on learning is the most utilized method of teaching and assessing in clinical education. The majority of clinical coordinators used hands-on and situational judgements which allows the student to be an active participant in learning. Portfolios and reflection journaling were not thought to be helpful for students in clinical education. Clinical coordinators did not feel as though a standardized test was adequate for determining if there had been an increase in

critical thinking skills. Program director interviews helped to establish a clearer definition for critical thinking skills pertaining to radiography.

Chapter 5: Conclusions

The purpose of this study was to determine clinical coordinators' definition of critical thinking skills and the critical thinking attributes of radiography students in clinical practice. Additionally, the study evaluated clinical coordinators' teaching strategies and assessment measures based on their definition of critical thinking. A survey, developed by Susan Gosnell, was administered to clinical coordinators across the United States. Eligible participants were those at JRCERT-accredited radiography schools. The survey used a 5-point Likert scale and queried participants' perceptions of critical thinking in general and in their students. As a supplement, program directors were interviewed to determine their definition of critical thinking skills, assessment of teaching and overall perception of critical thinking skills in radiography students.

Radiography is a health care field that is dependent on critical thinking skills in the practitioners. Radiography students spend part of their time in traditional classrooms learning about x-rays and how to position patients to obtain an optimal radiograph for physician diagnoses. Additionally, they spend time in a laboratory simulating patient positions. Students are required to spend a certain amount of time in clinical education, performing examinations that they have learned in class and the laboratory.

Many patients are not "text book" examples, and the radiographic technologist must think critically in order to perform examinations. Didactic learning works in collaboration with the clinical experience for students of radiography. In a trauma situation, a radiographer must be equipped with critical thinking to obtain diagnostic radiographs for accurate interpretation by the radiologist. Even technologists that work in non-trauma facilities, such as outpatient or a doctor's office, are presented with challenges such as handicapped, geriatric, pediatric, overweight

patients or patients that have altered mental status, that prohibit normal patient positioning. It is imperative that radiographers can adjust positioning for patients of all sizes and conditions; inability to do so will hinder patient diagnoses.

The Joint Review Committee on Education in Radiography (JRCERT) is the accrediting body for radiologic science schools. During the two years that students spend in a radiologic science program, they are required by JRCERT to complete clinical rotations in the areas of diagnostic, fluoroscopic, surgical, and computed tomography; and elective rotations in areas such as magnetic resonance imaging, nuclear medicine, sonography, mammography, and interventional radiography. Students are supervised by a registered technologist until they have completed competencies on mandatory procedures. The students interact with actual patients from different populations and conditions. Clinical education is where the student applies the knowledge they have learned in the classroom.

Summary of Results

The first research question addressed in the study was designed to establish the perception of critical thinking skills of clinical coordinators by asking: *What aspects of the definition of critical thinking skills are most pertinent to clinical coordinators?* Because of the diversity of answers, it was difficult to pinpoint an exact definition. A 5-point Likert scale survey was used, listing characteristics of critical thinking from the definition that was previously established. Responses were measured with Strongly Disagree, Disagree, Neither Disagree or Agree, Agree and Strongly Agree. Along with the survey responses, a word frequency program was utilized to provide a clearer interpretation.

Research question two was: *What are aspects of the components of teaching critical thinking as perceived by clinical coordinators?* Again, a 5-point Likert scale response was

utilized for eleven components of critical thinking teaching: clinical case studies, reflective journaling, situational judgements, role playing, case-based learning, inquiry-based learning, problem-based learning, hands-on learning, collaborative learning, portfolios, and higher cognitive questioning.

Research question three queried: *Which teaching method or learning activity is most often used by clinical coordinators to teach critical thinking in clinical practice?* This was addressed by a survey response indicating the amount of teaching time committed to using the eleven components listed in question two. The results were measured by percentage of curriculum dedicated to instructional methods based on their responses from part two of the survey.

Research question four stated: *What are the assessment tools and teaching methods utilized by clinical coordinators to assess critical thinking in students?* A Likert scale response was utilized to determine the assessment measures employed by clinical coordinators. Assessment measurements were course exams, ARRT exam results, clinical competency, image critique, situational judgements, portfolios, reflective journals, clinical case study, employer surveys, student surveys, standardized testing, and other assessments.

Research question five asked: *What are clinical coordinators' perceptions of critical thinking attributes of graduates, based on the degree awarded?* With the results of the Likert scale responses, A two-way ANOVA was conducted to determine if perceived attributes differed depending on the terminal degree awarded to the student. Attributes examined were deductive reasoning, problem solving, following protocols, planning, using clinical judgement, thinking creatively, motivating others, using higher cognitive thinking, communicating verbally,

exercising reflective reasoning, adapting protocols based on the analysis of the situation, reasoning to make decisions, and a growing sense of accountability for patient outcomes.

Research question six stated: *What are clinical coordinator's perceptions of the critical thinking attributes of graduates, based on the degree held by the clinical coordinator?* The two-way ANOVA conducted for research question five was also utilized for question six to determine if the perceived attributes of graduates by clinical coordinators was based on degree level held by the clinical coordinator.

Research question seven was: *What are program directors' perceptions of students' critical thinking readiness for employment upon successful completion of the radiologic technology program?* This was evaluated through interviews with program directors. During the interviews, program directors were asked to give their definition of critical thinking and then describe if, and how, they teach and assess critical thinking. They were also asked if they have detected an increase in the critical thinking skills of their students during their program of study.

Discussion of Results

There was a strong agreement between clinical coordinators that critical thinking is vital in clinical practice, with an average response 4.92 on the 5-point scale. This was an important baseline to establish that clinical coordinators across the United States agreed on the importance of critical thinking in the field of radiology. Equally important was the strong agreement that critical thinking is a series of decisions made by the radiographer in the clinical setting. Results of a radiographer's decisions can have direct consequences on patient outcomes.

Clinical coordinators agreed (4.81 out of 5) that critical thinking must be included in radiologic science clinical educational programs. This could be due to the fact that JRCERT requires the teaching of critical thinking within programmatic curricula (JRCERT, 2017),

however, they do not describe in detail how to implement critical thinking. An interesting result is that, even though clinical coordinators think that critical thinking is vital and should be included in clinical education curriculum, they only rated their graduates' development of critical thinking skills at 4.00 out of 5, suggesting that, even though clinical coordinators believe critical thinking should be included, they do not see these skills being fully developed.

During the program directors' interviews, four of the six interviewees stated that critical thinking could not be taught, only enhanced. They believed that students are either born with the skill or not. In contrast, clinical coordinators believed that critical thinking could be learned (4.00 out of 5). It should be noted clinical coordinators did not have an opportunity to elaborate on their responses in the survey. Wang and Zheng (2016) concluded that the ability to teach critical thinking should be defined by teaching the skills of thinking critically. Skills are the potential to do something; therefore, if critical thinking is a series of skills, then they can be taught. An alternate conclusion could be that possibly the teaching techniques used do not reach this set of students or the students do not apply themselves.

A word frequency analysis was conducted on the interviewees' and survey respondent's definitions of critical thinking. The words *ability* and *able* were used 108 times (6.42% of responses). Other frequently used words were *situation* (64 occurrences; 3.80%), *problem* (36 occurrences; 2.02%) and *analyze* (21 occurrences; 1.25%). A previously established definition was that critical thinking is the ability to interpret, analyze, evaluate, reflect, and apply knowledge to a situation (Castle, 2008). Three of the top four words used by interviewees and survey respondents are found in this definition, therefore results from the word frequency corroborate that definition.

Clinical coordinators were asked to indicate what they perceived as important teaching components of critical thinking in clinical practice. Eleven components were presented, with hands-on learning and situational judgements ranking highest. Hands-on learning is an imperative strategy in teaching radiography students. In clinical practice, the student must participate in patient care and positioning, which is impossible without physically interacting with patients. A radiographer didactically learns and watches positioning but must perform the exams on their own before they truly understand how to position a patient. Situational judgements such as role playing and simulation of patient scenarios are also important elements for critical thinking. This type of critical thinking strategy places the student in a patient-centered situation and allows them to reflect and act based on reflective judgement.

Hands-on learning was the most frequently used method of teaching critical thinking skills to radiography students (69.3%); only 1.2% of clinical coordinators use hands-on learning less than 10% of the time. This result is consistent with how JRCERT determines clinical practice achievement. This is not surprising, due to the nature of learning radiography in clinical practice. The second-most frequently used teaching technique is higher cognitive questioning (22.9%). Within the educational domain, Bloom's taxonomy provides that higher cognitive questions can lead to an increase in critical thinking by creating a divergent path.

The third-most frequently used teaching method by clinical coordinators is problem-based learning (20.5%). This is an important component, because literature shows it to be a vital resource in teaching critical thinking (Spronken-Smith et al., 2012). Problem-based learning presents the student with a problem and prompts them to work through the problem individually or in a group. The use of problem-based learning in radiography allows the student to identify

the problem, or obstacle such as patient condition, and work through ways to acquire an optimal radiograph.

The teaching strategy that was used the least was portfolios. Although portfolios can be beneficial in certain didactic courses, clinical coordinators did not perceive that they would assist in increasing critical thinking in clinical education.

The preferred assessment tool used by clinical coordinators was Image Critique Performance (4.3 out of 5). Image critique is the process of evaluating an image upon completion of an exam, prior to releasing the patient. The student must be able to look at the image and decide if all required elements are present. They must evaluate the image for anatomy, technique, and proper positioning. Critiquing an image is a process that is developed over time and enhances critical thinking in the student.

Clinical Competency was the assessment tool that clinical coordinators perceived as having the second-highest importance. Clinical education is based on a student's ability to perform exams on their own. Once a student has been instructed in the classroom and laboratory and has participated with technologists in several procedures on patients, they are expected to complete the procedure. The technologist grades them on their performance and, if they pass, they are competent to begin performing the procedure by themselves on patients.

Portfolios, reflective journaling and standardized testing as measurements of assessment, scored low in clinical coordinator assessment tools. The literature review identified reflection, which is the act of reflecting on a situation and applying that knowledge, as one way to increase critical thinking (McClanahan & McClanahan, 2000). Clinical coordinators did not perceive that it is beneficial in clinical education. Standardized testing scored in the lowest percentile. The California Critical Thinking Skills Test is the standardized test that is generally regarded as the

highest standard for critical thinking assessment. The California Critical Thinking Skills Test is used by many universities and colleges as an exit exam to evaluate graduates' critical thinking. However, opponents argue that it is impossible to utilize a standard testing tool to measure individual knowledge. Clinical coordinators overwhelmingly agreed that standardized testing was not a useful way of assessing critical thinking in clinical practice.

Following protocol and using clinical judgement were the two attributes that clinical coordinators perceived to be highest in their radiography students upon graduation. The mean response for *strongly agree* for all attributes was 26.6 (standard deviation 9.23) and the mean for *agree* for all attributes was 59.7 (standard deviation 7.23). This indicates that more than half of the participating clinical coordinators observed these two attributes of critical thinking in their graduates.

A two-way ANOVA analysis showed that there was no significant difference in clinical coordinators' perceptions of students' attributes dependent on the degree awarded to the student upon completion of the program. Overall, clinical coordinators that teach in a certificate program ranked their students higher than those from associate or bachelor degree programs in 13 out of the 14 attributes of critical thinking. There are at least two possible explanations for this trend. First, certificate programs are clinical based, meaning that the student remains at the hospital for clinics and classes. Since hands-on training was the preferred instruction and assessment method for teaching critical thinking skills, students from certificate programs could be better prepared to enter the workforce as a radiologic technologist. Second, educators with higher-level degrees might have higher expectations of students. This is a question that needs further investigation in a separate study.

During the interviews with radiologic science program directors, the overall theme was that critical thinking skills are lacking in today's college students. Some students possess some ability to think critically, but those students need to be directed towards critical thinking in the field of radiology. Students who do not appear to have the ability to think critically tend to have a difficult time developing the required skills. One program director indicated that students who lack critical thinking skills can still succeed in radiography, but they be would likely to flourish in a setting that does not require increased critical thinking.

During the interviews, the program directors had a solid understanding of critical thinking, and purposefully include aspects in their curricula in an attempt to prompt students towards critical thinking. They also have tools for measuring critical thinking skills. However, most of the program directors agreed that critical thinking is a skill that cannot be taught, and that it can only be enhanced, which is in direct conflict with the clinical coordinators who have the most clinical contact with the students.

Discussion of the Study in Relation to the Literature

Critical thinking is the act of thinking in a disciplined way, using cognitive skills for an outcome that is not merely based on knowledge but on the application of that knowledge (Behar-Horenstein & Niu, 2011; Ennis, 1993; Fahim & Masouleh, 2012; Flores et al., 2012; Paul, 2005). Based on this definition, clinical coordinators and program directors across the United States agree that critical thinking is the ability to think in a disciplined way for an outcome, requiring training, reflection, and application of knowledge. Radiologic science is a health care field that demands that a radiographer possesses the ability to think critically, due to unpredictable patient presentations and pathologic condition.

Hands-on training was the overwhelming choice by clinical coordinators for teaching critical thinking skills to radiography students. Although problem-based learning was not the highest-ranked choice for clinical coordinators, research shows that problem-based learning and hands-on learning are similar in their approach (Welsh, 2012). Both methods cause the student to be an active learner. Tanenbaum et al. (1997) stated that students' interest in learning increases when they actively participate in, and are accountable for, their learning. Radiography students' clinical experience is greatly increased by hands-on and problem-based learning. Additionally, problem-based learning creates a positive reinforcement experience for increasing student learning and retention (Spronken-Smith et al., 2012). Sedden and Clark (2016) explained that clinical education is a vital adjunct for classroom learning.

Clinical coordinators' responses indicated that situational judgements were an important component of teaching critical thinking. Although situational judgements were not specifically mentioned in the literature review, interactive classrooms were addressed. An interactive classroom promotes student participation in identifying a problem and working towards a solution. Smith and Stitts (2013) stated that action learning includes problem identification, planning, action, observation, and then reflection on the implications. These are also characteristics of situational judgements. Despite this, clinical coordinators did not find reflection as a highly useful teaching method.

Higher cognitive questioning was also found to be an important teaching strategy for clinical coordinators. Bloom's taxonomy provides an outline of using higher cognitive questioning, by beginning at lower-level questions and progressing towards a higher level. This method increases critical thinking by leading the student to higher levels of applying and analyzing situations (Adams, 2015). In radiography, the student begins with basic questions

about positioning and anatomy and then progresses to analyzing the images and applying the knowledge. This is termed divergent thinking, because it begins broad but narrows down to higher-level thinking (Tanenbaum et al., 1997), which is extremely useful for radiography students.

Clinical coordinators ranked portfolios as the least common teaching strategy. Portfolios is a method that involves students building a folder of cases, then evaluating the cases, determining outcomes and writing reports (case studies). One assumption is that clinical coordinators perceive that this teaching strategy would be best utilized in a classroom course. Portfolios can be a useful technique, and there is a program specifically for radiography called Student Oriented Learning About Radiography (SOLAR) (Baird & Wells, 2001). This is a case-based portfolio in which students participate online to learn about patient cases and determine a clinical action plan. Clinical coordinators may not have ranked this method high because it is not hands-on learning.

Two of the approaches that clinical coordinators utilize for student assessment are clinical competency and image critique performance. Both methods are based on student motivation. Dahl and Simmons (2011) stated that student motivation is increased when they are challenged with individual performance. If a radiography student is assessed based on their performance in clinical competencies, they tend to be more motivated to both perform at a higher standard and to retain the information. Image critique places the students in a position of face-to-face interactions with the clinical coordinator. This type of assessment causes the student to be more motivated and prepared. Interactive learning is an important assessment tool (Welsh, 2011) and increases student understanding of the material (McClanahan & McClanahan, 2000).

Survey results showed that clinical coordinators responded favorably regarding the critical thinking attributes displayed in their students. The two highest-ranked attributes that they perceived in their students were following protocol and using clinical judgement. Following protocol is an assumed attribute for a student, and students in radiologic science programs are generally confined to stringent rules and policies in clinical education. Violation of policies usually leads to severe consequences, including point deductions from their final grades and/or dismissal from the program. Clinical coordinators recognized that the attribute of clinical judgement is important in graduates. Clinical judgement is an attribute of critical thinking and is imperative for a radiologic technologist to possess.

Limitations

One of the limitations of this study was the lack of participation of clinical coordinators and program directors. This was limited in part by the time of year the survey was conducted. Many institutions have a break during summer semester, so the response rate was low due to some clinical coordinators and program directors not receiving the emails. The anticipated number of respondents was 218, however the actual number of participants was 166 (typical survey response rate). Another limitation of this study was the survey. The survey questions did not accurately and thoroughly answer the original research questions, so the research questions had to be altered for the data gathered. Additionally, a pilot survey could have been conducted due to the modification of the original survey for program directors.

Implications of the Results for Practice, Policy, and Theory

The conceptual framework of this study was built on the attributes of teaching and assessing critical thinking in today's college students. First, the theory was established that students need to be taught in a different way than previous students. Prensky (2012) explained

that today's student is a digital native who has grown up parallel to technology, so their understanding is different than most instructors. However, technology has caused digital natives to have a deficit in the ability to think critically. Research has shown that critical thinking was a skill that could be taught and learned (Covill, 2011; Paul, 2005); however, during the interviews in this study, program directors did not believe that critical thinking was a skill that could be learned, and they believed that it could only be enhanced if a student already possesses an ability to think critically.

One of the key components of the conceptual framework was that motivation could drive student success. Motivation is what propels a student to become an active participant in learning. Dahl and Simmons (2011) explained that students must be challenged to be motivated to higher goals. Students will reach for the bar that is set for them. Instructors that utilize teaching methods such as hands-on, problem-based, or inquiry-based learning, equip the student to become an autonomous thinker with the ability to reflect, analyze, and make a decision. These are all qualities of critical thinking. It is possible that critical thinking is an innate ability that needs enhancing. Alternatively, it could be that a student could learn the process of critical thinking by applying the attributes of critical thinking to each situation, similar to the application of a mathematical formula. In either case, motivation is required.

Student learning is only half of the equation for critical thinking. Instructors must be willing and equipped to teach critical thinking. Paul (2005) stated that only 19% of professors could clearly define critical thinking and only 9% utilized teaching strategies for critical thinking. Of the clinical coordinator surveyed in this study, 113 indicated that they developed their critical thinking perceptions through informal discussions with health professionals. It is

important for instructors to have a foundation of critical thinking knowledge in order to teach critical thinking effectively.

Recommendations for Further Research

Further research could include analyzing the effectiveness of teaching strategies or assessment measurements used by clinical coordinators in clinical education for increasing critical thinking skills. It could be beneficial to conduct a qualitative study on a number of clinical coordinators' distinct methods of teaching and assessing. Research to assess students at the beginning of a program and again at the end to see if critical thinking skills were increased would be beneficial. The research would need to be a case study, because standardized testing was not considered reliable or valuable as a measuring tool for critical thinking by clinical coordinators in clinical education. A study conducted during the academic year could yield a higher participation rate by clinical coordinators.

Another area for future research is quantitative analysis of the growth in critical thinking skills after the use of different teaching strategies. Critical thinking is a concept that has many implications, and it is especially crucial within radiography. Additional research could be conducted to find out career outcomes of students that complete bachelor degree programs versus associate degree or certificate programs.

Additionally, the enhancement of critical thinking could be addressed by continuing education for health care educators. Specifically, refining teaching strategies that included components of critical thinking within curriculum. Increasing awareness of critical thinking teaching and assessment methods could benefit the field of radiography and student outcomes.

Conclusion

This study increases the body of knowledge in critical thinking for radiologic science clinical education, by providing information pertinent to teaching methods and assessment measures. Clinical coordinators and program directors helped to establish aspects of the definition of critical thinking unique to radiography. By doing this, a benchmark was established which future radiography instructors will be able to refer.

Clinical coordinators overwhelmingly agreed that critical thinking teaching strategies involve hands-on learning and situational judgements, combined with higher cognitive questions. Clinical coordinators also agreed that the most effective method of assessing critical thinking in radiography students in clinical practice is clinical competencies and image critique, which validates the effectiveness of current methods used by clinical coordinators. Even though portfolios were not generally perceived as a benefit for students in clinical practice, a portfolio with digital image critique could be a useful teaching tool. Additionally, clinical coordinators do not think that standardized tests, such as the California Critical Thinking Skills Test, are appropriate measurements for critical thinking in clinical education.

Although research shows that today's college student lacks critical thinking, clinical coordinators tended to agree that their graduates possess the needed attributes of critical thinking upon graduation. Program directors also agreed that their student's critical thinking skills increased during their programs. Additional expansion on these results to evaluate specific areas of teaching and assessing critical thinking could further the field of radiography and help to increase student enhancement and preparation. This study increases the body of knowledge in critical thinking for radiologic science clinical education, by providing information pertinent to teaching methods and assessment measures.

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Appendix A: Request to Use Survey Instrument

Dr. Gosnell,

I am a doctoral candidate with Concordia University-Portland, Oregon. I am currently working on my dissertation titled *Clinical Coordinator Perceptions of Teaching Critical Thinking Skills to Radiologic Technology Students During Clinical Practice*. I am requesting permission to utilize your survey form your dissertation adapted form Gordon (1995).

Please let me know if you need any additional information and if there is any cost associated with using it.

Thank you for your consideration.

Appendix B: Request to JRCERT

Good afternoon,

I am the Clinical Coordinator for the Radiologic Science Program at East Tennessee State University. I am in the dissertation phase of my doctoral degree. I would like to send a survey via Survey Monkey to all of the clinical coordinators of JRCERT radiography programs in the U.S. Would it be possible to obtain a list of clinical coordinator names and emails? If there is a cost for this, please let me know.

Thank you in advance for your consideration of this request.

Appendix C: Permission From JRCERT

Good morning Christy,

The attached MS Excel file contains e-mail addresses for 559 clinical coordinators from JRCERT accredited radiography programs.

Good luck with your survey!

Teresa Cruz
Finance Manager

Appendix D: Email for Request to Participate in Survey

Dear Clinical Coordinator,

You have been selected to participate in a survey for evaluating the critical thinking skills of radiography students in a JRCERT program. There is no reward or penalty for participating or not. Data gathered from the survey will be included in my dissertation process. The survey should take no longer than 15 minutes and is completely anonymous. By following the link, provided from Qualtrics, you are in agreement to participate in the survey.

Sincerely,

Christy Raby
Doctoral Candidate
Concordia University- Portland, Oregon

Appendix E: Email for Participation in Interview

Dear Sir or Madame,

I would like to invite you to participate in an interview for critical thinking skills of radiography students. There is no reward or penalty for participating or not. This interview is part of my dissertation process to assess critical thinking skills of students while in our program. The purpose is to address areas that might need improvement and also to highlight areas of success. The interview will only take a short time and can be completed by phone or in person. If you will be willing to participate please contact me at the following email.

Sincerely,

Christy Raby [Researcher email redacted]

Appendix F: Survey

I. Please specify the degree to which you agree or disagree with the following statements:

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1. Critical thinking is a vital skill for radiographers in clinical practice					
2. Critical thinking must be included in radiologic sciences clinical educational programs					
3. Critical thinking in radiography may be conceptually different than critical thinking in other health care disciplines					
4. Critical thinking is a series of decisions made by the radiographer in the clinical setting					
5. Critical thinking can be learned					
6. A standard model or definition for critical thinking is needed in radiologic sciences					
7. Graduates of your program have well-developed critical thinking					

(Continued)

skills when entering their first

radiography job

8. Please provide your definition of critical thinking:

II. To what extent do you agree or disagree that each of the following teaching methods and learning activities are effective for the development of critical thinking in your students in clinical practice?

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1. Clinical case studies					
2. Reflective journaling					
3. Situational judgements					
4. Role playing					
5. Case based learning					
6. Inquiry based learning					
7. Problem based learning					
8. Hands on learning					
9. Collaborative learning					
10. Portfolios					
11. Higher level cognitive questions					

Other methods used:

III. What percent of your curriculum for clinical education utilizes each of these teaching methods and learning activities?

	Never Used	Less than 10%	10%–24%	25%–49%	50%–74%	75%–100%	Unsure
1. Clinical case studies							
2. Reflective journaling							
3. Situational judgements							
4. Role playing							
5. Case based learning							
6. Inquiry based learning							
7. Problem based learning							
8. Hands on learning							
9. Collaborative learning							
10. Portfolios							
11. Higher level cognitive questions							

IV. To what extent do you agree or disagree that each of the following are appropriate assessment measures of critical thinking in your students?

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1. Course exam results					
2. ARRT exam results					
3. Clinical competency results					

(Continued)

4. Image critique performance

5. Situational judgement test items

6. Portfolios

7. Reflective Journals

8. Clinical case study performance

9. Employer surveys

10. Student surveys

11. Standardized test results (such as WGCTA or CCTST)

12. Other assessment measures used

Other assessment measures used (please specify)

V. Please specify the degree to which you agree or disagree that the following attributes of critical thinking are overall exhibited in graduates of your program

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1. Deductive reasoning					
2. Problem solving					
3. Following protocols					
4. Planning					
5. Using clinical judgement					
6. Thinking creatively					
7. Motivating others					

(Continued)

8. Using higher cognitive thinking

9. Communicating verbally

10. Exercising reflective reasoning

11. Reasoning intuitively

12. Adapting protocols based on

analysis of a situation

13. Reasoning to make decisions,

diagnose problems, project outcomes

14. Growing sense of responsibility

for patient outcomes

Specify the type of organization that sponsors your educational program:

- o Hospital/Medical Center
- o Public Community College
- o Private College/University
- o Public College/University
- o Other _____

Please indicate the terminal degree awarded to graduates of your program:

- o Certificate
- o Associate Degree
- o Baccalaureate Degree
- o Other _____

Please indicate the size of your program according to the annual enrollment of first year students:

- Less than 10
- 10-20
- 21-30
- 31-40
- Greater than 40

How did you develop your personal perception of critical thinking? Select all that apply:

- Formal coursework in graduate school
- Informally through discussions with health professions faculty
- Informally through discussions with non-health professions faculty
- By attending conferences, workshops or seminars in critical thinking
- By reading professional journals
- Other _____

Please indicate your highest level of completed educational preparation:

- Doctoral degree
- Master's degree
- Bachelor's degree
- Associate degree
- Other _____

How many years have you been teaching in a radiologic sciences program?

- Less than 5 years
- 5-9 years
- 10-14 years
- 15-19 years
- 20-24 years
- 25 or more years

Which part of the country is your educational institution located?

- Northeast
- Southeast
- Central
- Northwest
- Southwest

Appendix G: Interview Questions

1. In your own words how you define critical thinking?
2. What teaching strategies do you currently use to teach critical thinking to radiography students?
3. What ways do you assess critical thinking in your students?
4. Have you had any formal training on teaching or assessing critical thinking?
5. On a scale from 1-10 (1 being low and 10 being high) how would you rate your students critical thinking skills when they begin the program?
6. On the same scale, how would you rate your students' critical thinking skills when they finish the program?
7. Overall, do you think that your students possess necessary critical thinking skills to be successful radiographers?

Appendix H: Descriptive Analyses

Agree or disagree	*N*	Minimum	Maximum	Mean	Std. Deviation
Critical thinking is a vital skill for radiographers in clinical practice	165	1	5	4.92	.474
Critical thinking must be included in radiologic sciences clinical educational programs	165	1	5	4.81	.601
Critical thinking in radiography may be conceptually different than critical thinking in other healthcare disciplines	164	1	5	4.18	.843
Critical thinking is a series of decisions made by the radiographer in the clinical setting	165	1	5	4.42	.766
Critical thinking can be learned	165	1	5	4.06	.722
A standard model or definition for critical thinking is needed in radiologic sciences	165	2	5	3.94	.954
Graduates of your program have well-developed critical thinking skills when entering their first radiography job	165	2	5	4.00	.741
Valid *N* (listwise)	164				

Appendix I: ANOVA

Multivariate Tests[a]

	Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.926	121.186[b]	14.000	136.000	.000	.926
	Wilks' Lambda	.074	121.186[b]	14.000	136.000	.000	.926
	Hotelling's Trace	12.475	121.186[b]	14.000	136.000	.000	.926
	Roy's Largest Root	12.475	121.186[b]	14.000	136.000	.000	.926
Q16	Pillai's Trace	.277	1.003	42.000	414.000	.470	.092
	Wilks' Lambda	.744	1.010	42.000	404.207	.458	.094
	Hotelling's Trace	.317	1.017	42.000	404.000	.446	.096
	Roy's Largest Root	.201	1.980[c]	14.000	138.000	.023	.167
Q13	Pillai's Trace	.195	1.056	28.000	274.000	.393	.097

	Wilks' Lambda	.811	1.073[b]	28.000	272.000	.371	.100
	Hotelling's Trace	.226	1.091	28.000	270.000	.349	.102
	Roy's Largest Root	.189	1.850[c]	14.000	137.000	.037	.159
Q16 * Q13	Pillai's Trace	.358	1.335	42.000	414.000	.085	.119
	Wilks' Lambda	.678	1.349	42.000	404.207	.078	.122
	Hotelling's Trace	.425	1.362	42.000	404.000	.072	.124
	Roy's Largest Root	.250	2.469[c]	14.000	138.000	.004	.200

Appendix J: Statement of Original Work

The Concordia University Doctorate of Education Program is a collaborative community of scholar-practitioners, who seek to transform society by pursuing ethically-informed, rigorously- researched, inquiry-based projects that benefit professional, institutional, and local educational contexts. Each member of the community affirms throughout their program of study, adherence to the principles and standards outlined in the Concordia University Academic Integrity Policy. This policy states the following:

Statement of academic integrity.

As a member of the Concordia University community, I will neither engage in fraudulent or unauthorized behaviors in the presentation and completion of my work, nor will I provide unauthorized assistance to others.

Explanations:

What does "fraudulent" mean?

"Fraudulent" work is any material submitted for evaluation that is falsely or improperly presented as one's own. This includes, but is not limited to texts, graphics and other multi-media files appropriated from any source, including another individual, that are intentionally presented as all or part of a candidate's final work without full and complete documentation.

What is "unauthorized" assistance?

"Unauthorized assistance" refers to any support candidates solicit in the completion of their work, that has not been either explicitly specified as appropriate by the instructor, or any assistance that is understood in the class context as inappropriate. This can include, but is not limited to:

- Use of unauthorized notes or another's work during an online test
- Use of unauthorized notes or personal assistance in an online exam setting
- Inappropriate collaboration in preparation and/or completion of a project
- Unauthorized solicitation of professional resources for the completion of the work.

Appendix J: Statement of Original Work (Continued)

I attest that:

1. I have read, understood, and complied with all aspects of the Concordia University- Portland Academic Integrity Policy during the development and writing of this dissertation.
2. Where information and/or materials from outside sources has been used in the production of this dissertation, all information and/or materials from outside sources has been properly referenced and all permissions required for use of the information and/or materials have been obtained, in accordance with research standards outlined in the *Publication Manual of The American Psychological Association*

Christian L Raby

_____

Digital Signature

Christian L. Raby

_____

Name (Typed)

January 6, 2018

_____

Date