RELATIONSHIPS AMONG RADIOLOGIC SCIENCE EDUCATORS' YEARS OF TEACHING EXPERIENCE, TECHNOLOGICAL SELF-EFFICACY, AND DIGITAL TECHNOLOGY USE IN THE CLASSROOM

by

Jessica Anne Church

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Philosophy

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2023

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ABSTRACT

The purpose of this quantitative, correlational study was to examine the relationships among radiologic science educators' years of teaching experience, technological self-efficacy, and digital technology use in the classroom. The underuse of technology in higher education is an issue. Students use technology every day and radiologic science students, in particular, are expected to use it proficiently in training and practice. It is important that these students are exposed in the classroom, as technologies beneficial to learning are available. It is also important to determine the role of years of teaching experience in educators' beliefs about their abilities to use technology and their actual use of it in the classroom. To investigate this issue, a sample of 300 radiologic science educators was surveyed. Seventy-nine educators responded to a sociodemographic questionnaire, the General Self-Efficacy Scale, and questions from the Roney Technology Use Scale. Data were collected and analyzed for correlations. There was no significant relationship between years of teaching experience and technological self-efficacy ($r(77) = .16$, $p = .15$) or between years of teaching experience and digital technology use in the classroom ($r(77) = .20$, $p = .08$). The relationships were, however, slightly positive, suggesting that educators with teaching experience have moderate beliefs in their abilities to use technology and moderate levels of technology use in the classroom. Suggestions for future research include study of the role of age as it relates to teaching experience, didactic versus clinical instructors, and barriers that affect radiologic science educators' technology use.

Keywords: radiologic science education, self-efficacy, technology

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List of Abbreviations

American Registry of Radiologic Technologists (ARRT)

Joint Review Committee on Education in Radiologic Technology (JRCERT)

CHAPTER ONE: INTRODUCTION

Overview

The purpose of this quantitative, correlational study was to examine the relationships of years of teaching experience, technological self-efficacy, and digital technology use among radiologic science educators. Chapter One provides an overview of the issue of digital technology underuse in higher education. Included in the background are the historical, societal, and theoretical frameworks for the study. The problem statement examines the literature on the issue. Further, the purpose and significance of the study are outlined. At the end of the chapter, research questions for the study are introduced and relevant definitions are provided.

Background

Digital technology underuse is an issue in higher education. Since its inception, implementation has been inconsistent (Henderson et al., 2017; Ledbetter & Finn, 2018; Loague et al., 2018). Despite the introduction of new and exciting technologies, college and university educators continue to teach how they were taught (Englund et al., 2017; Loague et al., 2018; Roney et al., 2017). Digital technologies such as mobile applications, audience response software, serious games, social media, three-dimensional printing, simulation technology, and virtual reality are becoming more accessible and beginning to be incorporated into undergraduate curricula (Moro et al., 2021). However, Microsoft PowerPoint, released in 1987, remains the common software for lecture delivery (Roberts, 2018). While PowerPoint has its merits, educators may not be aware of, or take the time to employ, the best practices for multimedia presentation design (Mayer, 2017). This is especially true for health professions educators who may not have had formal education in teaching or opportunities for professional development training.

Many radiologic science educators, for example, are clinicians first. They practice in the fields of radiography, magnetic resonance imaging, radiation therapy, etc. and because of their excellent practice, obtain teaching roles at colleges, universities, and hospitals. In these roles, they may teach how they were taught and perpetuate the use of PowerPoint. Some may take advantage of the aforementioned digital technologies. However, in 2014, the most touted technologies in radiologic science classrooms were mobile electronic devices, podcasting, online education, and social media (Wertz et al.). Therefore, there is a gap between the tools used in the classroom and those used in the workplace. Overall, radiologic science students' experiences with digital technologies may not be authentic, and the students may not be being properly prepared for the workplace.

Authors of recent literature have investigated how digital technology is used in higher education and have found enthusiasm for its potential to transform student learning (Englund et al., 2017). Institutions of higher education have embraced the latest trends and raced for the title of most innovative (Pechenkina & Aeschliman, 2017). However, there is little evidence for the claim in practice. Research indicates that technology is more commonly used in classroom management and class preparation than in teaching (Mercader & Gairin, 2020). In addition to PowerPoint, the types of digital technology most used by instructors in higher education are course management systems and desktop applications (Loague et al., 2018). These types of technology are teacher-centered, used to support lectures, and not student-centered, where students play an active role (Mercader & Gairin, 2020).

Students have even been reluctant to celebrate digital technology's benefits in education, as the reality of its use may be overstated (Henderson et al., 2017; Loague et al., 2018). Authors Henderson et al. (2017), for example, revealed a gap between educators' reported usefulness and students' actual uses of technology in the classroom. According to the authors, university students most used learning management systems, word processing software, and internet search engines to organize their studies, communicate, and research information. Authors Pechenkina and Aeschliman (2017) also reported that these students generally use technology narrowly unless it is familiar or presented as essential for their learning success. Overall, digital technology use has not yet met educator esteem or student expectations.

Other authors, therefore, have investigated the reasons for its underutilization (Kotcherlakota et al., 2017; Mercader & Gairin, 2020; Roney et al., 2017). Technophobia, or the fear of new technology, lack of time, lack of knowledge of technological teaching approaches, lack of training, lack of incentives, lack of assessment, lack of institutional planning, a generational gap, and excessive workload were implicated by health professions educators in a recent study (Mercader & Gairin, 2020). Another study implicated age as a factor for technology underuse and explained the relationship between age and technology use in nursing education. In this particular study, there was no significant relationship, although years of experience approached significance for lower levels of technology use (Roney et al., 2017). Age may correlate with years of teaching experience; however, an analysis of the two was not significant in that study. An additional study investigated years of experience as a predictor for nursing educators' technology use (Kotcherlakota et al., 2017). The authors found a negative relationship between years of experience and attitude toward technology use and adoption. As years of experience increased, nursing educators' attitudes toward technology use and adoption decreased.

Historical Overview

At the turn of the century, the integration of digital technology into instruction was deemed the most important issue surrounding information technology efforts in higher education. However, educator competencies did not guarantee digital technology use in the classroom or its effective use to enhance student learning. Rogers (2000) called for a paradigm shift for educators from teaching to learning, as well as adequate training and technical support. The author stated that if colleges and universities were to remain competitive, administrators would have to assist faculty in integrating the technology into their instruction (Rogers, 2000).

Remarkably, findings from investigations of barriers remain the same (Polly et al., 2021). Educators are enthusiastic about the potential and promise of digital technology but fail to implement it on a regular basis or to its fullest extent. Personal, professional, and institutional factors continue to be presented as hinderances for educators in higher education (Polly et al., 2021) and negative attitudes and beliefs continue to predict for such educators' decisions around technology use (Watson & Rockinson-Szapkiw, 2021). Perceived ability to use technology significantly impacts the variance in educators' intentions and as instructors gain knowledge and experience, their intention to use technology decreases. Authors Watson and Rockinson-Szapkiw (2021) encouraged experienced educators to model technology use in the classroom to inspire less experienced instructors to adopt the practice.

Society-at-Large

The rationale for implementing digital technology in education is that it enhances student learning and fosters a student-centered learning environment. In addition, it increases student engagement and satisfaction, provides opportunities for faculty and student interactions, increases student collaboration, and decreases attrition (Cherry & Flora, 2017). Today's students are more likely to be of “Generation Z,” those born between the years 1981 and 1996 who have been surrounded by technology and use it in their personal lives (Henderson et al., 2017). They are familiar with computers, smartphones, and video games and prefer learning environments that use digital technology intentionally (Ledbetter & Finn, 2018; Roney et al., 2017). Ultimately, they expect educators to use such technology and view them as most credible when they use the technology in and out of the classroom (Ledbetter & Finn, 2018). Educators are also expected to have a high level of technological knowledge (Glowatz & O’Brien, 2017). Further, computer skills and digital literacy are expected in society (Loague et al., 2018). Not using, inconsistently using, or underutilizing digital technology in higher education, therefore, hinders student learning.

It also hinders student success. Digital technology helps students develop the knowledge and skills they will need in their future professional work. Simulation technology, in particular, gives health professions students a safe environment in which to apply clinical knowledge and practice clinical skills before working with patients in the clinical setting (Kane, 2018). It is imperative that such students have this knowledge and these skills for patient safety. Further, these technologies give them advantages in competitive educational and professional settings, where small advantages can make large differences in system and professional outcomes (Moro et al., 2021). This shows benefits for not only students, but the educational system and larger community as well.

Theoretical Background

A prominent theory that informs the implementation of technology in higher education is Bandura’s (1977) self-efficacy theory. Bandura’s (1977) self-efficacy theory has been linked to educators’ intentions toward technology use (Saienko et al., 2020). Self-efficacy is defined as one's belief in his ability to carry out a task and produce a desired result, often in intimidating or stressful situations (Bandura, 1977). Individuals with high teacher self-efficacy are more likely to use more advanced instructional methods (Joo et al., 2018). They are also more likely to develop an interest in the task, as they view problems as challenges to be mastered (Roney et al., 2017). Of note, individuals with high general self-efficacy and high computer self-efficacy are more likely to have high self-efficacy with healthcare technology (Rahman et al., 2016). This is important for educators who are expected to teach with, and know how to use, such technology.

Grounded in Bandura's (1977) theory is technological self-efficacy, or one's belief in his ability to perform a new, technologically advanced task (McDonald & Siegall, 1992). Technological self-efficacy has been positively associated with job attitudes, behaviors, and performance (McDonald & Siegall, 1992) and, thus, may be associated with attitudes toward and behaviors and performance with technology in teaching. Authors Roney et al. (2017) investigated technological self-efficacy among nursing educators and found an, albeit weak, relationship with lower levels of technology use. Authors Kotcherlakota et al. (2017) also found a relationship between years of experience and attitude toward technology use and adoption. Interestingly, the relationship was negative, indicating a decrease in attitude with increasing years of teaching experience.

As digital technology evolves and demands for its use increase, it is important to examine other educators' experiences with technology and self-efficacy to use it in the classroom. Authors Joo et al. (2018) examined preservice teachers' self-efficacy and found that it influenced their intention to use technology. Likewise, authors Maican et al. (2019) investigated self-efficacy and technology use among teaching staff and researchers and found that self-efficacy had a direct effect on the use of online communication and collaboration technologies. Regarding radiologic science educators, authors Cherry and Flora (2017) investigated the relationship between technological self-efficacy and the use of technology-enhanced learning methods and reported a strong positive relationship among radiography faculty. Faculty members with high technological self-efficacy were more likely to use technology online (Cherry & Flora, 2017). This is the only study found in the recent literature that addresses radiologic science educators and two of the variables of interest, technological self-efficacy and digital technology use.

Problem Statement

Recent literature addresses the issue of digital technology underuse in higher education and acknowledges the challenges impeding technology integration in the classroom. College or university professors struggle to find the time to learn about new digital technologies and implement them while balancing their teaching and research workloads (Polly et al., 2021). They are also affected by self-efficacy and previous experiences (Reid, 2017). As stated, the health professions educators of a single study were affected by technophobia, lack of time, lack of knowledge of technological teaching approaches, lack of training, lack of incentives, lack of assessment, lack of institutional planning, a generational gap, and excessive workload (Mercader & Gairin, 2020). Age, years of experience, and technological self-efficacy also played roles for two different groups of nursing educators (Kotcherlakota et al., 2017; Roney et al., 2017).

Interestingly, articles concerning the implementation of technology in higher education were largely international publications and studies of preservice or student teachers. Few were conducted in the United States, and few assessed the intentions of health professions educators outside of the field of nursing. This is an interesting finding, as there are numerous technologies that could benefit health professions teaching and learning, and the majority of health professions are digital technology based. Radiologic science is particularly technology-driven, as it uses a variety of digital equipment to produce computer-based images of the body.

Regardless of the paucity of literature, the aforementioned authors called for additional research. Englund et al. (2017) expressed the need for research to address the disconnect between the enthusiasm for and the reality of technology use, as well as strategies to facilitate the implementation of technology in higher education in order to enhance student learning. Further, authors Kotcherlakota et al. (2017) called for research into the factor of years of teaching experience and the use of technology, and authors Roney et al. (2017) called for research into technological self-efficacy. The problem is that the literature has not examined if the factor of years of teaching experience relates to radiologic science educators' technological self-efficacy or digital technology use in the classroom.

Purpose Statement

The purpose of this quantitative, correlational study was to examine the relationships among radiologic science educators' years of teaching experience, technological self-efficacy, and digital technology use in the classroom. The independent variable in this study is years of teaching experience, and the dependent variables are technological self-efficacy and digital technology use. Years of teaching experience is defined as years of formal, part- or full-time didactic or clinical teaching in a collegiate or hospital setting. Technological self-efficacy is defined according to McDonald and Siegall's (1992) definition as the belief in one's ability to perform a new, technologically advanced task. Likewise, digital technology use is defined as educators' use of digital, informational, and/or educational technology (i.e., computers, laptops, smartphones, learning platforms, applications) in the classroom, with cutoffs for low, intermediate, and high use.

The population was composed of full-time radiologic science educators at colleges, universities, and hospitals in the United States. The participants in the study included educators at Joint Review Committee on Education in Radiologic Technology (JRCERT)-accredited radiography, magnetic resonance, and radiation therapy programs. The educators must have taught didactic or clinical content during the past academic year.

Significance of the Study

The findings of the present study will add to the body of knowledge on the implementation of digital technology in higher health professions education. Specifically, it will increase knowledge of a factor that may relate to technology use in the radiologic science classroom. Years of teaching experience has been investigated as a factor in at least two recent health professions education studies, which were in nursing education (Kotcherlakota et al., 2017; Roney et al., 2017). Further, the relationship between years of teaching experience and technological self-efficacy has only been examined in one of the same nursing education studies (Roney et al., 2017). While there are similarities among the health professions (Moro et al., 2021), education in the radiologic sciences is highly technological. Educators must be familiar with simulation technology, for example, as using active technology in teaching about x-rays is unethical. Radiologic science students must also be familiar with the technology used prior to entering the clinical setting.

It is important to examine the relationships of years of teaching experience, technological self-efficacy, and technology use among radiologic science educators since the majority are experienced practitioners, presumably with years of teaching experience. For example, the mean number of years of teaching experience in a national survey of 216 radiography faculty was 15 (Cherry & Flora, 2017). In addition, nursing educators indicated moderate to high levels of technology use and there was a positive relationship between years of teaching experience and lower levels of technology use in Roney et al.'s (2017) study. The findings of the present study will be interesting to compare in the future.

Further, the findings of this study will serve to enhance professional development opportunities within radiologic science education programs. There is a need for improved professional development (Mercader & Gairin, 2020) and investments in infrastructure and support are needed if digital technology use is to be increased (Cherry & Flora, 2017). Further, it is important to recognize the barriers that affect educators so that steps can be taken to address them (Mercader & Gairin, 2020). Program administrators may be interested in the results if digital technology use is a priority for their programs or institutions. Likewise, they may help in finding leaders for professional development efforts. As little is known regarding radiologic science educators' technological self-efficacy or digital technology use, any information on the topic, especially that informs supports for such technology integration, will be helpful.

Finally, the findings of the study will add to the body of knowledge around self-efficacy theory. Whether radiologic science educators have low-self efficacy and fear or avoid using digital technology in the classroom because they believe they are not capable of using it, or otherwise have high self-efficacy and confidently use it because they deem themselves capable, the findings will provide evidence for the theory within a new context. Moreover, the educators' self-efficacy could determine how much effort they put into learning and using a new technology and how long they continue to use it despite adverse experiences (Bandura, 1977).

Research Questions

RQ1: Is there a relationship between radiologic science educators' years of teaching experience and technological self-efficacy?

RQ2: Is there a relationship between radiologic science educators' years of teaching experience and digital technology use in the classroom?

Definitions

1. *Self-efficacy* – Self-efficacy is the belief in one's ability to carry out a task and produce a desired result (Bandura, 1977).
2. *Technological self-efficacy* – Technological self-efficacy is the belief in one's ability to perform a new, technologically advanced task (McDonald & Siegall, 1992).
3. *Technophobia* – Technophobia is the fear of new technology (Mercader & Gairin, 2020).

CHAPTER TWO: LITERATURE REVIEW

Overview

The author of the present study conducted a literature review to examine the issue of digital technology underuse in higher education. This chapter will include a review of the current literature on the topic. In the first section, the theoretical framework, Bandura's (1977) self-efficacy theory, will be covered, including the concept of technological self-efficacy. This will be followed by a synthesis of the recent literature regarding technology use, barriers to digital technology use including personal factors such as gender, age, and years of teaching experience, and self-efficacy. At the end, a summary will be provided and a gap in the literature will be revealed, identifying a need for the present study.

Theoretical Framework

The study of technology use in education is commonly linked to at least two theories and a model, namely the theory of planned behavior (Ajzen, 1985), the unified theory of acceptance and use of technology (UTAUT) (Venkatesh et al., 2003), and the technology acceptance model (Davis, 1989). The major components of the theory of planned behavior are attitude, subjective norms, and perceived behavior control (Ajzen, 1985), while those of the UTAUT are performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al., 2003). Likewise, the major components of the technology acceptance model are perceived ease of use and perceived usefulness (Davis, 1989). These theories and model have been applied to studies of technology use in education (Lai, 2017; Maruping et al., 2017); however, they have been used to explain educators' *intentions* to use technology. Intention to use technology is defined as educators' interest in using digital technology in the future (Joo et al., 2018).

Bandura's (1977) self-efficacy theory can be used to explain one's motivation toward behavioral change and educators' *actual* use of digital technology. Albert Bandura was a renowned psychologist who contributed several theories to the fields of psychology and education, including the social learning or social cognitive theory and the theoretical construct, self-efficacy. Self-efficacy refers to one's personal belief in his ability to successfully perform a task (Bandura, 1977). According to the self-efficacy theory, an individual's expectations of efficacy in performance determine whether he engages in coping behaviors, the level of effort he expends, and the length of time he extends the effort through adversity (Bandura & Adams, 1977). Continued effort through experiences the individual deems adverse, through to levels of success and mastery, increases self-efficacy and decreases coping behaviors. Overall, expectations for success are derived from performance accomplishments, vicarious experiences, verbal persuasion, and physiological states, including emotional arousal (Bandura, 1977; Bandura & Adams, 1977).

From this framework, self-efficacy affects both the initiation and continued performance of a behavior. One's initial belief in his ability to be successful affects whether he will even try to perform a task (Bandura, 1977). In Bandura et al.'s (1980) research, perceived efficacy predicted for level of behavioral change, no matter how self-efficacy was developed. Typically, individuals will fear and avoid experiences that threaten their coping skills and welcome and accept those that fall within their perceived capabilities (Bandura, 1982). The higher the individual's belief in his ability, the more effort he will expend and the longer he will persist (Bandura, 1977). Those who persist in the face of adversity will experience difficulties that thereby strengthen their self-efficacy and diminish their coping behaviors. The degree to which individuals increase their perceived efficacy is dependent on the task, its difficulty, the effort they put forth, the help they receive, the circumstances of the experience, and the timing of their successes and/or failures (Bandura et al., 1980). Those individuals who do not start, or end their efforts early, will retain their low expectations of success and their coping behaviors for a longer time (Bandura, 1977; Bandura & Adams, 1977).

The theoretical construct of self-efficacy has been applied in many fields of study, including education. Bandura's (1977) original experiments were in the field of psychology and involved individuals with a fear of snakes, while authors of recent literature have explored self-efficacy in education among students and teachers. This includes high school and college or university students, as well as preservice or in-service teachers and instructors or faculty members. Among the applications that have been explored are high school students' self-efficacy to be successful in college (van Rooij et al., 2017), preservice teachers' self-efficacy to teach (Clark & Newberry, 2019) and instructors' self-efficacy to use content-related humor in their teaching (Daumiller et al., 2020). Depending on the context and/or application, self-efficacy is also referred to as academic self-efficacy, educational self-efficacy, and teacher self-efficacy in the literature. Authors Saienko et al. (2020) and Corry and Stella (2018), for example, examined teacher self-efficacy in technology integration and online education, respectively.

The authors of two recent articles examined self-efficacy within the context of radiologic science education; however, they focused on student self-efficacy rather than instructor self-efficacy. The first author described the use of the social cognitive theory in teaching radiographic positioning (Callaway, 2020). In this article, Callaway (2020) defined self-efficacy and explained how students' levels of self-efficacy change as they progress through radiologic science education programs. The author concluded that an instructor's goal should be to increase students' self-efficacy so that they believe they are capable of obtaining optimal patient positioning and, therefore, quality radiographic images (Callaway, 2020). The second authors described the implementation and evaluation of an online anatomy, radiology, and contouring bootcamp for practicing radiation therapists (D'Angelo et al., 2022). In this article, the authors used a qualitative survey to measure participants' self-efficacy. Overall, the bootcamp increased the participants' self-efficacy to perform the given tasks (D'Angelo et al., 2022). The only example of an investigation of radiologic science educators' self-efficacy found in the recent literature was in the Philippines, where radiologic science education and training differ from that in the United States (Alipio, 2020).

A reference to self-efficacy and technology in the literature is the concept of technological self-efficacy. First defined by professors McDonald and Siegall in 1992, technological self-efficacy is an individual's belief in his ability to perform a technologically advanced task. In their study, McDonald and Siegall (1992) examined the self-efficacy of a group of telecommunications field service technicians, as their jobs had become more technological. Since this study, authors have examined self-efficacy in other technological settings. In medicine, authors have investigated technological self-efficacy among physicians (Tsai et al., 2019) and patients (Reychav et al., 2018). Likewise, in education, the concept has been explored among preservice teachers (Birisci & Kul, 2019) and experienced educators (Cherry & Flora, 2017; Roney et al., 2017). The latter two studies are important to the present study, as they focus on technological self-efficacy in higher health professions education, nursing and radiologic science education, respectively.

The present study will examine self-efficacy, specifically technological self-efficacy, among radiologic science educators and analyze Bandura's (1977) self-efficacy theory as part of a new context. In addition to the technological self-efficacy findings of authors Roney et al.

(2017) and the nursing educators they surveyed, the present study will address radiologic science educators. Likewise, in addition to the findings of authors Cherry and Flora (2017) and their survey of educators who practice in online education, the present study will shed light on digital technology use in the physical classroom. This study will also provide insight into such technology use in the classroom as a potential adverse experience for radiologic science educators and information on their attitudes and behaviors. Lastly, it will introduce the personal factor of years of teaching experience and explore the relationships among radiologic science educators' years of teaching experience and their beliefs in their abilities to use, and their actual use of, digital technology in the classroom.

Related Literature

Authors of the recent literature have discussed technology use in radiologic science and higher education, barriers to technology integration, including personal factors such as educators' gender, age, and years of teaching experience, and the role of self-efficacy in technology integration.

Technology Use in Radiologic Science Education

Technology has been found to enhance student learning (Cherry & Flora, 2017; Henderson et al., 2017), increase student satisfaction, increase student engagement, decrease attrition, improve collaboration among students, improve interaction between students and faculty, support delivery of online courses, and foster the development of student-centered learning environments (Cherry & Flora, 2017). When used effectively and in what students deem the right amount, it has been found to enhance students' perceptions of the course and instructor, as well as students' self-efficacy to learn (Ledbetter & Finn, 2018). In a study of university students' perceptions, instructors who used moderate amounts of technology were perceived in a more positive light than those who used no technology or technology alone (i.e., taught in an online classroom) (Ledbetter & Finn, 2018).

Integrating technology into the classroom is especially important for educators and students in the health professions, as these professions are inherently technology-driven. Health professionals use technology on a daily basis to provide patient care. Teaching and learning are also arguably more practical and hands-on in health professions education than in other academic disciplines (Moro et al., 2021). Health professions instructors are continuously modifying their teaching methods to adapt to the ever-changing health care environment. They are also adapting to individual student preferences and emerging educational trends (Wertz et al., 2014). Incorporating digital technology into teaching and learning can enhance health professions educators' ability to teach relevant, up-to-date content in such a volatile environment.

Among the technologies discussed by authors Moro et al. (2021) as important in health professions education were augmented and virtual reality, holograms and mixed reality, virtual dissection tables, social media, mobile applications and devices, 3-D printing, online hosted videos, simulation with technology-enhanced learning, serious games, and e-learning and audience response software. Among those discussed by authors in nursing education, communication technologies were the highest rated by faculty (Kotcherlakota et al., 2017). A white paper detailing technologies that were appropriate for radiologic science education was published in 2008 but has not yet been updated (Martino & Odle). At that time, portable electronic devices, podcasting, and virtual reality and simulation were among the technologies being explored for use in educational delivery.

When implementing new technologies, radiologic science educators must consider which technologies are most appropriate for the content and their students. Importantly, students of

Generation Z are now attending colleges and universities (Chicca & Shellenbarger, 2018). While not the only students participating in radiologic science education, especially at community colleges, students of this generation will comprise the majority of the younger student population. Part of a truly digital generation, these students have been instructed throughout their elementary, middle, and high school years with digital tools and materials. Students of this generation regularly use technology and desire these types of interactions. It is reported that members of Generation Z spend an average of nine hours per day on their cell phones (Chicca & Shellenbarger, 2018). Unfortunately, this can result in isolation and a lack of interpersonal skills. The unique characteristics of this generation may challenge radiologic science educators and require changes to their instructional design strategies. According to authors Chicca and Shellenbarger (2018), the use of available software, electronic learning materials, and internet-guided activities are strategies that may help engage these students. Interactions in practice exercises, role play, computer simulation, and games may also help them develop interpersonal skills (Chicca & Shellenbarger, 2018). Good interpersonal skills are essential for success in radiologic science education, and subsequently, the profession.

Radiologic science education emphasizes the production of quality images and the responsible delivery of ionizing radiation (O'Connor et al., 2021), and includes didactic as well as clinical education. Didactic education is comprised of teaching and learning that occurs in the physical or online classroom, while clinical education occurs in the laboratory or clinical setting. Both are important to developing well-rounded entry-level practitioners and both have changed over time. In the past, didactic education was provided by instructors who lectured while students passively listened (Spence, 2019b). Shorter attention spans among today's students challenge this type of instruction (McBee et al., 2022). In today's classrooms, technology can help students acquire the necessary knowledge and skills required to succeed in the clinical setting and, ultimately, in practice. A variety of digital technologies is available, from serious games to virtual dissection tables and 3-D printing, mobile electronic devices and applications to social media, and simulation to virtual reality.

Serious Games

Kahoot! is a free Web- or application ("app")-based game that allows instructors to question students' understanding of course content. Prior to class, the instructor inputs questions into the platform and sets a time limit for each question (Spence, 2019b). In class, students access the Kahoot! Web page or app using their computers or mobile electronic devices (e.g., smart phones, tablets, laptop computers). The faster the students answer the questions correctly, the more points they earn. When each question's time limit is up, the nicknames of the students with the top three scores are displayed on a leaderboard. Learning analytics provide the instructor with an idea of all of the students' learning and an opportunity to clarify concepts and provide feedback (Spence, 2019b). Instructors can also use Kahoot! as an audience response system for polls and surveys.

Author Spence (2019a) measured the effects of interactive quizzing with Kahoot! on radiologic science student learning and satisfaction. The results of the study revealed that students' average exam scores for units in which Kahoot! was used were significantly higher than units for which Kahoot! was not used. Ninety-three percent of the students (n = 40) responded favorably, found Kahoot! to be helpful in learning, and felt Kahoot! should be used in other radiologic science courses (Spence, 2019a). As this was a pilot study, additional research will need to be conducted with larger cohorts of students and future radiologic science courses in order to extrapolate the results.

Virtual Dissection Tables

Radiologic science programs that do not have access to cadaver labs may use the Anatomage Table to supplement anatomy teaching and learning. The Anatomage Table is a 3-D interactive system that consists of a digital cadaver and image library (Spence, 2019b). Students can manipulate the cadaver using touch-screen technology to reveal sectional images of anatomy of interest. The image library that accompanies the Anatomage table contains thousands of images of normal and pathologic anatomy for students to compare. Instructors can project the images for larger groups of students to participate, virtually dissect the images to remove overlying anatomy, label and annotate the images, and save the images for later use (Spence, 2019b). According to author Spence (2019b), students appreciate the opportunity to be hands-on and engage with the technology. Further, it is associated with improved classroom efficiency, exam grades, and high levels of student satisfaction and acceptance (Custer & Michael, 2015). A potential drawback for radiologic science education programs is its cost.

Instructors for a program recently used the Anatomage table to supplement students' learning (Ward et al., 2018). In switching from cadaver mode to radiology mode within the system, students were able to manipulate a virtual human skeleton to visualize correctly versus incorrectly positioned anatomy. Using the computed tomography and magnetic resonance imaging features, students were also able to visualize the body in different cross-sectional planes. Some students further used the table to create posters for presentations of pathologies. Overall, the Anatomage table was viewed as a welcomed addition to the program and students' reactions were positive. The instructors recommended more research into its effectiveness in order to justify its cost (Ward et al., 2018).

3-D Printing

Three-dimensional (3-D) printing allows users to create 3-D objects and models. Like the Anatomage table, 3-D printing can help in teaching human anatomy when a cadaver lab is not available (Lambert et al., 2022). Using a 3-D printer, students can print models of anatomical structures while learning about anatomy and/or pathology (Collinsworth & Clark, 2017). Printed 3-D models provide students with tangible anatomic parts that contain specific normal and/or pathologic features. Importing computed tomography or magnetic resonance imaging data sets to the printer can assist in reproducing nerves and vessels and in seeing how pathological processes affect surrounding anatomy (Lambert et al., 2022). Students can also design and print models of x-ray producing equipment while learning about the parts of the machines or bolus when learning about radiation therapy treatment planning. Despite the potential of 3-D printing in teaching and learning, and its increasing popularity, challenges to its implementation are time for printing and cost (Spence, 2019b).

Mobile Electronic Devices and Applications

Mobile electronic devices and apps provide radiologic science educators with familiar ways to engage students in course content. As mentioned, today's radiologic science students routinely use mobile devices in their daily lives (Wertz et al., 2014). They use them to access books, videos, presentations, and recordings, and download and save course-related files. Textbooks and patient positioning guides are often found on radiologic science students' mobile devices (Wertz et al., 2014). Such students also use mobile devices to play serious games, such as Kahoot!, as polling devices, and to access podcasts (Wertz et al., 2014). Digital resources directly available on these devices offer advantages over traditional materials (e.g., textbooks, models). Largely, they are more convenient, accessible, and portable (Greene & Spuur, 2018). In addition, they are affordable, accessible on multiple devices, and can be preloaded onto mobile devices purchased by academic institutions or radiologic science education programs (Gupta et al., 2020).

Numerous mobile apps have been developed to supplement teaching and learning in radiologic science education, including those containing interactive quizzes, patient positioning guides, and anatomy references/learning tools. Authors Greene and Spuur (2018) examined student use of radiologic science-based apps within an undergraduate program in Australia. Of the 97 students surveyed, 37% (n = 36) used radiologic science apps at least weekly, primarily anatomy atlases. The students who did not use apps reported they were not aware of the learning resource; however, 91% of those surveyed (n = 88) indicated they would use the apps if they were part of the curriculum (Greene & Spuur, 2018). Most agreed that apps offer a convenient way to engage with interactive content in the classroom. They also offer an alternate visual option to PowerPoint presentations and lectures. Still, the students surveyed preferred to use apps as supplemental study tools, deemed appropriate by the instructor (Greene & Spuur, 2018). It is important that radiologic science educators be apprised of free or low-cost, high-quality apps to inform their students. There is some research to suggest that if instructors are not skilled at using a mobile learning technology themselves, they are less likely to teach with the technology, and thus, share it with their students (Martin et al., 2020).

In the classroom, apps such as Google Docs allow for easy teacher-to-student, student-to-teacher, or student-to-student feedback and collaboration on assignments and projects. Changes to the Google-based documents are tracked and comments are noted in real-time (Gupta et al., 2020). Also within Google Docs is Google Forms, which can be used for audience response or question-based assessments. Other audience response apps include Poll Everywhere and TurningPoint and additional question-based assessment apps include Quizlet and Quizziz (Gupta et al., 2020). These apps encourage student engagement and mirror the game environment provided by Kahoot!.

Communication apps can also be helpful in sending text messages, photos, and videos, as well as sharing files. GroupMe, WhatsApp, iMessage, FaceTime, Facebook Messenger, and Google Hangouts are examples of free communication apps that can be downloaded on students' mobile devices (Gupta et al., 2020). Radiologic science educators and students should, however, be aware that communication within these apps is not secure, especially for transmitting patient information. Paid apps, such as Tiger Connect and Vocera, may be better suited for HIPAA compliance, especially when secure hospital-based networks are used. In addition to interpersonal communication apps, apps such as Webex and GoToMeeting can be used for audio and video, as well as screen sharing within lectures or professional meetings (Gupta et al., 2020).

The most useful images and case studies for radiologic science education are collected and maintained in online image repositories. Image- and case-based apps provide radiologic science students with more examples than can be offered by most institutions. Moreover, students of Generation Z learn by viewing images and not solely by reading text (Chicca & Shellenbarger, 2018). Radiopaedia, for example, is a large online library that promotes case-based learning (Gupta et al., 2020). Many of the apps have accompanying or similar websites that contain educational resources. IMAIOS, for example, provides a subscription-based service called eAnatomy with anatomy represented by computed tomography and magnetic resonance images. Students can visualize labeled anatomy and/or quiz themselves by labelling the anatomy on their own. AuntMinnie is a widely used website that includes radiology-based cases, conversations, and reports (Gupta et al., 2020).

YouTube is perhaps the most popular website/app for video-based instruction. It contains short educational videos on most course-related topics and allows instructors and students to access them for free for review. As previously stated, students of Generation Z learn by watching, so referring to digital media such as YouTube or other video clips may help to engage these students (Chicca & Shellenbarger, 2018). Similar to radiologic science-based apps, however, there are pitfalls to the use of YouTube, including inaccurate or outdated information. To combat misinformation, radiologic science educators can create and share lists of channels and/or videos that contain trustworthy content. Information overload can be an issue for students, and with the growing number of resources available, published lists can become quickly outdated. The value of a carefully created or frequently updated list cannot be understated (McBee et al., 2022). Instructors can also produce their own video content and upload their presentations to their own YouTube channel. In turn, they can share these resources with their students (Kauffman et al., 2022). Lastly, instructors can allow students to use their technology skills to create videos for the course (Chicca & Shellenbarger, 2018).

Social Media

Social media is widely used to connect with family and friends. In 2019, 88% of Americans aged 18 to 29 years, including radiologic science students who are members of Generation Z, used at least one social media platform and 73% used multiple platforms (Nickerson, 2019). In addition to connecting with others and reading the latest news, social media can be used to better understand concepts in the classroom. Facebook and Twitter have the largest potential applications in radiologic science education. Facebook allows users to create long messages, whereas Twitter allows them to post messages of less than 280 characters (Gupta et al., 2020). Both allow users to share links, photos, and videos. Professional organizations often use Facebook and Twitter to connect with potential and existing members and to promote local and/or upcoming activities and events. Likewise, academic medical centers and education/ training programs regularly post messages or links to journal abstracts or articles and videos (Gupta et al., 2020). These resources may spark teaching ideas for radiologic science educators or be interesting for students to explore.

Authors Clark and Wagner (2017) suggested the use of social media in pathophysiology and/or radiographic positioning or imaging courses. In pathophysiology courses, instructors can share a case study while students try to guess the pathology. Students can post their questions and findings and, primarily through Twitter, search for hashtags (#) that identify more information about the disease or a social media user with the pathology. Likewise, in radiographic positioning or imaging courses, instructors can add images to the social media platform for evaluation. Students can post their critiques and comment on others' posts (Clark & Wagner, 2017). Whether publicly or privately shared among classmates, this may replicate or replace current Wiki assignments or discussion forums. After all, Twitter "journal clubs," or Twitter-based chats, in radiologic science have been found to create learning environments comparable to classroom and face-to-face journal clubs. They have also been found to inform educational and clinical practice (Currie et al., 2017). Educators may also consider social media for content review, exam preparation, extra credit activities, and professional development (Clark & Wagner, 2017).

While there are benefits to the use of social media, such as access to professionals from around the world, networking (Watts, 2018), sharing information, dispelling myths/clarifying inaccuracies, engaging students, and modeling professionalism (Clark & Wagner, 2017), radiologic science educators should also be aware of the barriers. Privacy, ethical and professional concerns, lack of training and support, and health concerns are among those discussed by author Watts (2018). Radiologic science educators must be mindful of the risks and use proper planning to avoid the pitfalls.

Simulation

Simulation has a long history in medical education and training (Kane, 2018). There are many benefits to using simulation in radiologic science education. Simulation provides students with the opportunity to implement clinical skills in a controlled practice environment before interacting with real patients in the clinic under direct supervision. It also allows students to learn in a self-paced environment without the fear of failure (O'Connor et al., 2021; Spence, 2019b). Traditionally, necessary knowledge and skills are developed in the classroom and applied in the laboratory or clinical setting. Laboratory access is, however, limited by class size, scheduling commitments, and staffing requirements, and competition for clinical placements is high. The costs associated with the installation of lab equipment are also high. Simulation can supplement or replace energized laboratories and help overcome some of these limitations (O'Connor et al., 2021).

There are a number of ways to integrate simulation into the curriculum. Standardized patient learning experiences are common in radiologic science education. During the experiences, "patients" (e.g., instructors, members of the public) act out scenarios and students perform mock radiographic examinations or therapeutic procedures (Spence, 2019b). Throughout the exercises, the standardized patients present challenges for the students that mimic real-life clinical situations. Learning is aligned with instructional design principles as students apply their theoretical knowledge to the real-world scenarios within the virtual environment (O'Connor et al., 2021). In some cases, errors are embedded into the scenarios.

Interactions with the "patients" can be recorded, and students can evaluate their own performance or instructors can provide feedback (Spence, 2019b). Students from other academic disciplines (e.g., nursing, allied health) may join the simulated experiences to create opportunities for interprofessional education (King et al., 2020).

Virtual Reality

Virtual software can also be used to simulate radiographic examinations or therapeutic procedures. Virtual Radiography (Shaderware Ltd), for example, is a simulation program that allows students to perform radiographic examinations in a virtual room (Spence, 2019b). Likewise, the Virtual Environment for Radiotherapy (VERT) (Vertual Ltd) allows students to set up therapeutic procedures in a virtual room projected onto a screen, or visualized through 3-D glasses, in the classroom. The virtual rooms contain realistic x-ray-producing equipment, examination tables or treatment couches, and a number of virtual patients (Kane, 2018). Research demonstrates that the virtual software is valuable in helping students develop technical skills (Shanahan, 2016). Combined with classroom teaching, virtual simulation can reduce common errors, improve students' confidence and performance, and increase deep learning (Little, 2021). Overall, it can help ensure a successful transition into professional clinical practice. Again, the primary limitation of its implementation is cost. In addition, continual updates can make it challenging for education programs and instructors to keep up with the latest versions of the software (Spence, 2019b).

Integrating Digital Technologies

Integrating digital technologies into radiologic science education in ways that align with instructional design principles is necessary for effective learning. New technologies can encourage learning, but learning is ultimately dependent on strong pedagogy and strategic implementation, in order to maximize the benefits of the technologies (O'Connor et al., 2021; Wertz et al., 2014). Due to recent advancements in educational technologies, instructors are shifting away from traditional educational delivery methods (Wertz et al., 2014). Research has shown that an important aspect of integrating technology into the classroom is the instructor's ability to adapt the technology to meet their students' needs (Akers, 2019). Most instructors use slide-based presentations to provide information to students; however, most students do not respond to these types of presentations alone (Akers, 2019). Author Akers (2019) recommended that instructors incorporate multiple forms of delivery to keep students engaged with the content and increase the likelihood that they will retain the information presented. However, instructors who are adopting technologies in the classroom should be comfortable with key foundational skills, as these lead to the development of new technological skills (Reid, 2017). Radiologic science educators have the opportunity to reimagine the relationship between instructional design and today's digital technologies. They must adapt their traditional educational delivery methods to incorporate current technologies (Wertz et al., 2014).

As technology becomes more accessible for colleges, universities, and hospitals, there is increased emphasis that instructors not only use available technologies, but that they use them in ways that enhance teaching and learning (Martin et al., 2020). Radiologic science practitioners continually learn and use new technologies, so it is reasonable to think that integrating effective technologies into radiologic science education would be beneficial (Wertz et al., 2014). Most authors agreed that integrating specific types of technology was not only possible but also valuable in assisting instructors in the delivery of education (Wertz et al., 2014). Training educators on the effective use of such technologies allows individual instructors to match pedagogy with their teaching style and clinical expertise (McBee et al., 2022). By way of practice, reflection, and sharing, instructors can integrate technology into their classrooms effectively. It is up to the educators to take the initiative and adapt their teaching to today's standards (Akers, 2019).

The response to the COVID-19 pandemic demonstrated flexibility in teaching and learning and rapid adoption of digital technologies among radiologic science educators and students. Shutdowns and distancing requirements increased the use of digital technologies, in some cases replacing in-person education entirely (McBee et al., 2022). Reflection on recent events highlights the importance of careful thought and intention when integrating new technologies into health professions education (McBee et al., 2022). This integration of digital technologies could enable students to incorporate such tools into their daily practices. The innovating culture could also help foster the idea of continuing education throughout students' careers (Wertz et al., 2014). The specific technologies and strategies used should match modern instructional design, enabling both educators and students to advance as lifelong learners (McBee et al., 2022).

Technology Use in Higher Education

Many institutions have invested in technology-based classrooms to market themselves to the community as modern and innovative and to appeal to the current generation of technology-driven students (Nicol et al., 2018; Pechenkina & Aeschliman, 2017). Institution and education program accreditors have also added pressure by including expectations for technology integration in their standards (Roney et al., 2017). Some consider this essential given students' reliance on technology in their everyday lives. After all, these classrooms are said to foster better knowledge acquisition, improved critical thinking, and increased engagement with the content (Nicol et al., 2018). Instructors, however, may be frustrated by the amount of self-instruction and strategy changes required for these classrooms, and administrators may be disappointed by the amount of time for a return on investment. While there is a trend to build these high-technology active learning classrooms, the focus needs to be on technology infrastructure and student-centered education rather than on the technology-centered classrooms themselves.

Some institutions and instructors have led the way in integrating technology, while others have been slow to implement technology in the classroom (Loague et al., 2018). A number of studies have examined the reasons for the slow rate of technological change. These reasons include attitudes toward technology, lack of technology education, lack of technology training and support, lack of technology infrastructure, and lack of opportunities to observe technology-enhanced classrooms (Loague et al., 2018). Authors Loague et al. (2018) described the flow of technology adoption as the technology acceptance/use continuum. Along the continuum are low, intermediate, and high acceptance/use. Educators with low acceptance/use do not incorporate technology into their instruction or address it aside from internet resources, while those with intermediate acceptance/use are beginning to think of ways to incorporate technology into their teaching. At this point along the continuum, the instructors use technology in the classroom more than the students. Finally, those with high acceptance/use incorporate technology into their teaching whenever is it appropriate. In this case, the students use technology more than the instructors (Loague et al., 2018).

The Educause Center for Analysis and Research conducted a comprehensive survey of faculty in higher education in 2017, examining how they use technology and think about it in relation to teaching and learning. Overall, the faculty surveyed believed that the use of technology was beneficial to learning and supported new trends in education (Pomerantz & Brooks, 2017). In fact, they believed that the integration of technology tools, especially multimedia production, free web-based content, learning management systems, online collaborative tools, and simulation or educational games, would enable them to be more effective teachers (Skiba, 2018). They also felt that faculty are proficient in using prominent technologies; however, there were discrepancies between faculty and student perceptions (Pomerantz & Brooks, 2017). These findings conflict with authors Pomerantz and Brooks' (2017) general view that teachers encounter technological issues in the classroom and author Cuhadar's (2018) inference that the competency level of teachers overall is intermediate or low. The eight digital technologies most used in the surveyed faculty's classrooms were the course management system (i.e., Blackboard, Canvas), desktop applications, presentation applications, websites, collaboration tools, videos, online tutorials, and recorded lectures (Loague et al., 2018).

Underutilization, including lack of use and inefficient use, is still a major problem in higher education (Maruping et al., 2017; Mercader & Gairin, 2020). According to the same Educause report (Pomerantz & Brooks, 2017), only 65% of students agreed that most faculty used technology for instruction (Skiba, 2018). Only 55% agreed that faculty used technology to provide additional materials and 50% for collaboration. Generally, the students felt that the faculty did not encourage the use of technology in the classroom to deepen their understanding or engage them in learning. They wanted faculty to use more technology in the classroom (Skiba, 2018). The Horizon Report, another publication of Educause, an organization that champions the use of technology in higher education, shows the lack of digital technology use in the classroom, especially emerging technologies (i.e., bring your own devices (BYODs), learning analytics, adaptive learning, augmented and virtual reality, and robotics) (Alexander et al., 2019). As blended, or hybrid, learning designs, which integrate technology and traditional instructor-led activities, were a short-term trend highlighted in the report (Alexander et al., 2019), addressing the underutilization must be a priority if not a matter of urgency.

Authors Mercader and Gairin (2020) attribute the underutilization to the absence of institutional models for integrating technology into the classroom. Ultimately, this lack of infrastructure leads teachers to choose their own technological practices based on their interest in integrating technology in the classroom. Thus, practices are often sporadic. In fact, some faculty ban or discourage the use of technology, particularly smart phones, in the classroom (Skiba, 2018). Some faculty who allow laptops do not allow tablets and/or smart phones. While students acknowledged that they sometimes use their smart phones for non-class activities, they also use them to take notes, conduct research, and participate in instructor-led activities. Fortunately, faculty who believed they would be better instructors if they integrated technology tended to encourage the use of devices in the classroom (Skiba, 2018). As faculty become more skilled in classroom management and their own technology skills, they are more likely to encourage the use of mobile devices in the classroom (Pomerantz & Brooks, 2017).

In practice, the types of digital technology most used in the higher education classroom are course management systems, desktop applications, and presentation software (Loague et al., 2018). College and university educators prefer to use applications such as word processing, spreadsheets, and databases and presentation software such as PowerPoint, Prezi, and Keynote. Collaboration tools such as Google Docs and websites are also used. E-mail is still the main communication and collaboration application (Glowatz & O’Brien, 2017; Maican et al., 2019). Innovative tools such as social media, educational games, and polling software/clickers are often underused (Glowatz & O’Brien, 2017; Loague et al., 2018).

Consistent with some of the aforementioned findings, authors Martin et al. (2020) revealed higher education faculty's current use of digital technologies based on their perceptions of importance, competence, and motivation. Two hundred forty-seven faculty in the United States responded to the authors' survey. The surveyed faculty ranked the use of a learning management system as the highest in terms of importance and competence. Of note, there were significant differences between faculty with six to 10 years of experience and 11 to 15 years of experience and faculty who had more than 15 years of experience on the importance of learning management systems. Faculty who taught six to 10 or 11 to 15 years had higher beliefs about the systems than those who taught more than 15 years (Martin et al., 2020). This makes sense considering the widespread use of learning management systems and the popularity of the technology over time. The faculty ranked social media as the lowest in terms of importance and adaptive learning the lowest in terms of competence. The finding related to social media could be associated with the instructional issues, institutional limitations, or faculty concerns (e.g., privacy and integrity) related to the use of social media in higher education. Regarding motivation to integrate digital technology into their teaching, the faculty ranked benefit to learning as the most influential factor and reappointment, promotion, and tenure as the least influential factor (Martin et al., 2020).

Barriers

There is a push to identify the reasons why technology is not used more extensively in the higher education classroom, especially among less-experienced educators. Authors Polly et al. (2021) cited barriers such as the investment of time. Time, in this case, includes time to learn about a technology and time to plan, design, and create teaching and learning activities with the technology (Polly et al., 2021). Administrators surveyed as part of Polly et al.'s (2021) study even stated that faculty have little incentive/extrinsic motivation and receive little reward for investing hours into creating resources when there are other demands for their time.

The same authors cited workload balance as another significant barrier (Polly et al., 2021). The administrators they surveyed mentioned the expectation, especially of newer faculty, to conduct and publish research as a priority over creating technology-based activities (Polly et al., 2021). Authors Roney et al. (2017) emphasized the impact of integrating technology on workload and described it as a constraint against research productivity. The faculty they surveyed agreed that their motivation to use technology did not come from pedagogy but from the heavy influence of administration (Roney et al., 2017). Authors Polly et al. (2021) also cited the proliferation and complexity of technology, and the challenge to keep up, as well as the return on investment for using technology in the classroom as barriers.

Other authors presented findings that suggested that lack of resources, lack of suitable infrastructure, and lack of suitable training and support are the reasons technology is not consistently implemented (Glowatz & O’Brien, 2017). Faculty are not often provided with adequate training at convenient times when new technology is introduced (Polly et al., 2021). However, a study at a large university found that with varied means of support (e.g., printed resources, recorded screen casts, webinars, face-to-face workshops) over time, faculty use of a specific digital technology, a learning management system, increased (Rhode et al., 2017). If administrators value teaching with digital technology, they may consider providing faculty with opportunities to learn the technological skills for integrating technology and time to design and support others’ integration of technology in their teaching (Zheng et al., 2018).

Some authors insist that barriers are more prevalent depending on the academic discipline, as technology is used to a greater extent in certain subjects (Mercader & Gairin, 2020). In a study of faculty in the health sciences, there were a total of nine barriers – one personal barrier, three professional barriers, three institutional barriers, and two contextual barriers – that prevented educators from using technology in their classrooms. Technophobia was considered a personal barrier; lack of time, lack of knowledge of technological teaching approaches, and lack of training were considered professional barriers; lack of incentives, lack of assessment, and lack of planning were considered institutional barriers; and a generational gap and excessive workload were considered contextual barriers (Mercader & Gairin, 2020). The authors, Mercader and Gairin (2020), encouraged further study of the influence of instructor gender and age. As stated, age may correlate with years of teaching experience.

Authors of a study of nursing faculty introduced similar barriers: faculty viewing technology as a distraction, lack of knowledge, insufficient resources, unreliability of hardware and software platforms, using outdated tools and platforms, and pressure from administrators and students (Kotcherlakota et al., 2017). Unfortunately, respondents in Glowatz and O'Brien's (2017) study were not concerned with student expectations. Similarly, the authors of another nursing study reported lack of time, competing work demands, and lack of resources as deterrents that limit technology use in the classroom (Roney et al., 2017). Barriers noted for nursing faculty that may also apply to radiologic science educators include time, risks of policy or privacy violation, cost, and lack of familiarity with technology (Kotcherlakota et al., 2017). The authors added that many educators may be reluctant toward change overall and view it as a burden. They also attributed the slow adoption of technology to the aging factor (Kotcherlakota et al., 2017).

Personal Factors

Personal factors that affect technology use in the classroom include educators' gender, age, and years of teaching experience.

Gender

In a recent study by Martin et al. (2020), there were no significant differences in the scores between male and female instructors on the importance or competence of digital technologies. Authors Maican et al. (2019), however, found that male instructors present as being more interested in technology, more confident in their technological skills, and more enthusiastic about the use of technology than female instructors. Authors Cai et al. (2017) agreed, stating that male instructors had more favorable attitudes toward technology use than female instructors, especially in terms of self-efficacy. Female instructors exhibit positive attitudes (Cai et al., 2017), but seem to expect to encounter more difficulties and/or challenges (Maican et al., 2019). Instructors are unlikely to continue to use technology if they encounter difficulty (Shelton, 2017). Therefore, authors Cai et al. (2017) recommended future research into the factor of age, as related to the gender gap in attitude toward technology use.

Age

According to a meta-analysis performed by Hauk et al. (2018), some authors reported a negative correlation between age and technology acceptance, some reported no significant correlation, and others reported a positive correlation. With regard to intention to use technology, Hauk et al. (2018) reported an overall negative relationship. The authors stated that older adults find it more difficult to operate technology and perceive technology as difficult to use (Hauk et al., 2018). Authors of other studies found that older adults are more anxious and less self-confident when using technology than younger adults. Anxiety seems to be positively correlated with age, while self-efficacy is negatively correlated with it (Maican et al., 2019). Anxiety and self-efficacy are important in predicting educators' attitudes toward and actual use of technology. Anxiety could make educators less likely to try a new technology, more so if they are not accustomed to digital technology. They may be afraid of making mistakes or admitting their lack of technological knowledge or skills. They may also fear losing self-confidence and control over the educational process (Saienko et al., 2020). Likewise, lower self-efficacy could lead to lesser perceived benefits and lower likelihood of technology usage overall (Maican et al., 2019). Authors Saienko et al. (2020) experienced computer anxiety with senior teachers in their study. Interestingly, age had no effect on the use of technology in Maican et al.'s (2019) study. Technological self-efficacy did, however, have a significant direct effect on effort expectancy and technology use behaviors (Maican et al., 2019).

Years of Experience

Age and years of experience are not the same, as educators begin teaching at different ages, but age and experience can be closely related. Authors Englund et al. (2017) studied teachers' conceptions of and approaches to teaching with technology over a 10-year time period and revealed a distinct difference between novice and experienced teachers. Novice teachers had initially more teacher-focused conceptions, or beliefs about teaching and learning, but showed greater and more rapid change toward student-focused conceptions than their more experienced counterparts. Experienced teachers showed little to no change in conceptions. With regards to technology use over time, teachers often change their practices to reflect more student-centered beliefs. Likewise, teachers who hold constructivist beliefs (the idea that students create knowledge rather than passively take in information) tend to use technology at higher levels

(Tondeur et al., 2016). Authors Englund et al. (2017) stressed that both conceptions and approaches are essential for successful technology integration.

Kotcherlakota et al. (2017) examined nurse educators' preferences for technology use in the classroom and the relationship between their preferences and years of teaching experience. The authors found that there was a negative relationship between attitudes toward technology integration and years of experience. Newer faculty members were more likely to have positive attitudes toward technology than experienced faculty members. Likewise, experienced faculty were less likely to find value in obtaining new skills for technology adoption (Kotcherlakota et al., 2017). Authors Maican et al. (2019) had similar findings. Teachers with more seniority had poorer attitudes toward the use of online technology, were more anxious, and had lower technological self-efficacy than those with less teaching experience. The same was true for relationships with time since earning a Ph.D. degree (Maican et al., 2019). Authors Kotcherlakota et al. (2017) recommended future research to explore links among faculty age, years of experience, attitudes toward technology, and technology adoption and use.

Self-Efficacy

Self-efficacy is also worth examining as a barrier to technology integration. Authors Saienko et al. (2020) reported a difference in self-efficacy between novice and experienced teachers. Initial levels of self-efficacy were higher among experienced teachers, which may be explained by their self-confidence built through experience. Author Reid (2017) identified self-efficacy and educator background as barriers for instructors. Self-efficacy was defined as instructors' beliefs or confidence in their abilities to succeed, while background referred to instructors' previous experiences with technology. This includes teaching and learning experiences that also inform their pedagogical beliefs, as well as professional development experiences. Essentially, background experiences influence instructors' self-efficacy and self-efficacy determines how instructors will behave (Reid, 2017).

Teacher self-efficacy refers to teachers' personal beliefs in their abilities to plan instruction and accomplish lesson objectives. Overall, teacher self-efficacy is an expression of their personal beliefs about their abilities and skills as educators (Joo et al., 2018). Teachers who have high teacher self-efficacy are more open to new ideas, more willing to adopt new teaching methods (Joo et al., 2018), more likely to foster student-centered learning (Birisci & Kul, 2019), and more likely to use innovative tools in their instruction (Joo et al., 2018). Therefore, teacher self-efficacy can significantly affect teachers' motivation to adopt and use technology (Joo et al., 2018). In a study of preservice teachers, teacher self-efficacy affected teachers' intention to use technology in the classroom (Joo et al., 2018).

In terms of technology use, self-efficacy refers to individuals' beliefs in their own abilities to successfully undertake technology-related tasks (Cai et al., 2017). The results of another study of preservice teachers showed that they had high levels of self-efficacy to integrate technology in their teaching. This finding positively and highly correlated with their technopedogogical education competency, or knowledge of how to integrate technology into teaching (Birisci & Kul, 2019). Knowledge of technology increases self-efficacy for technology integration (Saienko et al., 2020). The technological pedagogical content knowledge framework was a problem for novice teachers in Saienko et al.'s (2020) study. Those with less than five years of experience implemented technological tools without any pedagogical backing (Saienko et al., 2020).

It is known that self-efficacy increases as experience with a task increases (McDonald & Siegall, 1992). Further, mastery experiences are essential for the development of self-efficacy beliefs (Birisci & Kul, 2019). Unfortunately, as preservice teachers gain knowledge and experience in teaching, their intention to use technology decreases (Watson & Rockinson-Szapkiw, 2021). Author Shelton (2017) found that unsuccessful experiences was one of three reasons instructors stopped using technology in teaching. This is unfortunate because technological self-efficacy can be viewed as an empowering factor that gives instructors self-confidence and bridges the gap between them and their younger students, likely to be familiar with technology as part of Generation Z (Saienko et al., 2020).

Little is known regarding technology use or self-efficacy for integrating technology into health professions education. One study explored the relationship between technology use and technological self-efficacy among nursing educators (Roney et al., 2017). Technological self-efficacy was defined as the belief in one's ability to perform a new, technologically advanced task. Nursing educators who taught didactic content reported moderate technology use in the classroom, while those who taught didactic and laboratory/clinical content reported high technology use (Roney et al., 2017). Importantly, opportunities to integrate technology may be more limited in the didactic setting than in the laboratory or clinical setting where technology is more related to the teaching. Likewise, younger or new faculty members may have teaching responsibilities in both the didactic and clinical settings. As they gain experience, they may shift to more didactic responsibilities, which would provide them with fewer opportunities to integrate technology (Roney et al., 2017). Regardless, most educators in Roney et al.'s (2017) study rated themselves as having high technological self-efficacy. As stated previously, a weak relationship between technological self-efficacy and educator years of teaching experience was also found in this study (Roney et al., 2017).

Even less is known about technology use and self-efficacy in radiologic science education. In a study of experienced radiologic science educators, faculty were confident in their ability to use technology in online education. The mean score for perceived competence for the sample was high at 3.97 out of five (Cherry & Flora, 2017). This does not speak to educators' technological competence in the classroom. Technological self-efficacy was also measured in the study. Faculty members with high technological self-efficacy were significantly more likely to use technology in the online environment (Cherry & Flora, 2017). Again, this was in the online setting and the data were self-reported. These were significant limitations of the study. No studies have measured technological self-efficacy among radiologic science educators for technology use in physical classrooms.

Summary

Bandura's (1977) self-efficacy theory provides a framework for the study of digital technology use in higher education. Overall, such technology is underused. Authors of the recent literature have provided reasons for its underuse, including personal, professional, institutional, and contextual barriers. Other authors have commented on personal factors, such as educators' gender, age, and years of teaching experience. In addition, the authors have explained the role of self-efficacy in technology integration, particularly technological self-efficacy. Technological self-efficacy reflects educators' beliefs in their abilities to perform new, technologically advanced tasks. There is a lack of literature, in general, on technology use in health professions education, and a specific gap in the discussion of personal factors and self-efficacy among health professions educators. The present study will fill the gap for educators in the field of radiologic science.

CHAPTER THREE: METHODS

Overview

The purpose of this quantitative, non-experimental correlational study was to examine two relationships – the relationship between radiologic science educators' years of teaching experience and technological self-efficacy, and the relationship between radiologic science educators' years of teaching experience and digital technology use in the classroom. The chapter begins with an introduction to the study design, followed by the research questions and hypotheses. Descriptions of the study participants and setting, as well as the instrumentation, procedures, and plans for data analysis are also provided.

Design

A quantitative, non-experimental correlational study design was used. According to authors Gall et al. (2007), one purpose of correlational studies is to discover variables that predict for other variables. Another purpose, as demonstrated in the present study, is to discover potential causal relationships among variables within a group. Data are collected from only one group and the group shares a common characteristic. As a form of non-experimental research, there is no random assignment of participants to groups. In the present study, years of teaching experience, technological self-efficacy, and digital technology use were the variables used. Years of teaching experience refers to years of formal, part- or full-time didactic or clinical teaching in a collegiate or hospital setting. Technological self-efficacy refers to the belief in one's own ability to perform a new, technologically advanced task, as measured by the General Self-Efficacy Scale (GSE) (Schwarzer & Jerusalem, 1995). Likewise, digital technology use refers to the level (low, medium, or high) that educators use digital technology in teaching, as measured by the Roney Technology Use Scale (Roney et al., 2017).

Overall, the purpose of correlational studies is to examine relationships between variables within a group through the use of correlational statistics (Gall et al., 2007). It is important that the sample is homogeneous, as the differences among the participants may influence the relationships. In correlational research, the usual assumption is that the relationship is linear; however, statistics are available to estimate both the strength and direction (positive or negative) of the relationship. As part of a correlational study, the researcher collects quantifiable data for each variable and on each participant and analyzes the data by correlating the participants' scores for the predictor variable (cause) with the criterion variable (effect). Data on each variable can be collected at the same time (Gall et al., 2007).

As the purpose of the present study was to examine the relationships among radiologic science educators' years of teaching experience, technological self-efficacy, and digital technology use in the classroom, this is an appropriate design. Authors Kotcherlakota et al. (2017) and Roney et al. (2017) also used correlational designs in their studies. These studies were similar to the present study in that Kotcherlakota et al. (2017) analyzed the relationship between years of teaching experience and nursing faculty technology use and Roney et al. (2017) analyzed the relationships among nursing educators' technological self-efficacy and technology use. To emphasize, a significant relationship, or correlation, does not imply causation. To explore causality, an experimental research design is more appropriate (Gall et al., 2007).

Research Questions

RQ1: Is there a relationship between radiologic science educators' years of teaching experience and technological self-efficacy?

RQ2: Is there a relationship between radiologic science educators' years of teaching experience and digital technology use in the classroom?

Hypotheses

The null hypotheses for the present study are:

$H_0$1: There is no significant relationship between radiologic science educators' years of teaching experience and technological self-efficacy as measured by the General Self-Efficacy Scale (Schwarzer & Jerusalem, 1995).

$H_0$2: There is no significant relationship between radiologic science educators' years of teaching experience and digital technology use in the classroom as measured by the Roney Technology Use Scale (Roney et al., 2017).

Participants and Setting

A description of the study population, participants, sampling technique, sample size, and setting follow.

Population

The participants for the study were selected from a population of radiologic science educators in the United States. A convenience sampling technique was used for the study, as the e-mail addresses of the educators were gathered from the JRCERT website and included in the researcher's database. The JRCERT accredits education programs in radiography, magnetic resonance, radiation therapy, and medical dosimetry. To be included in the study, the educators must have taught for one of the 692 JRCERT-accredited programs within the last academic year. In total, 300 names and addresses were listed.

Participants

According to authors Gall et al. (2007), a minimum of 66 participants is required for a Pearson product-moment correlation when assuming a medium effect size for a correlation coefficient (*r*) with a statistical power of .7 at the .05 alpha (α) level. For the present study, all of the educators, who were conveniently sampled and included in the database, were selected for participation. This resulted in a participant number that exceeded the required minimum number when assuming a medium effect size. Three hundred participants, including 62 males and 238 females, were sampled. The mean age of the 79 participants was 50 years, and most (90%) held the role of program director or didactic instructor (6.3%) in their respective radiologic science programs. Table 1 represents these data.

Table 1

Demographics

Sample Characteristics	*n*	%	*M*	*SD*
Gender				
Male	14	17.72		
Female	64	81.01		
Prefer Not to Say	1	1.27		
Age			49.57	9.55
Years of Teaching Experience			17.97	10.79
Role in Program				
Program Director	71	89.87		
Assistant/Associate Program Director	2	2.53		
Didactic Instructor	5	6.33		
Clinical Instructor	1	1.27		
Primary Teaching Discipline				
Radiography	52	65.82		
Computed Tomography	1	1.27		

Magnetic Resonance Imaging	5	6.33
Radiation Therapy	20	25.32
Other	1	1.27

Note: *N=79*

Setting

To participate in the study, the faculty member had to have taught full- or part-time in a JRCERT-accredited education program within the last academic year. The faculty member could have taught didactic and/or clinical content within the required timeframe.

Instrumentation

A sociodemographic questionnaire, the General Self-Efficacy Scale, and the Roney Technology Use Scale were used in the study. See Appendices A, B, and C for the instruments. See Appendix D for permission to use the Roney Technology Use Scale.

Sociodemographic Questionnaire

The sociodemographic questionnaire was used to measure the participants' length of teaching experience in years. The purpose of this instrument was to gather information on the radiologic science educators' years of teaching experience. It also included questions about the participant's gender, age, role in the radiologic science program, and primary teaching discipline.

General Self-Efficacy Scale

The General Self-Efficacy Scale (Schwarzer & Jerusalem, 1995) was used to measure participants' technological self-efficacy. The purpose of this instrument was to quantify radiologic science educators' self-efficacy with digital technology. The scale was developed by German professors Ralf Schwarzer and Mathias Jerusalem in 1979 and later revised and adapted by other co-authors. It was created to assess perceived self-efficacy with the aim of predicting coping skills with daily hassles and stressful life events. Since that time, the instrument has been translated into multiple languages and used in numerous peer-reviewed studies (e.g., Schwarzer & Hallum, 2008; Schwarzer et al., 1999). In such studies, measures of reliability, including Cronbach's alpha, ranged from .76 to .90, with the majority in the high .80s. This is good considering acceptable values range from .70 to .95 (Tavakol & Dennick, 2011). Furthermore, authors Yudhistira et al. (2021) tested the validity of the items on the scale using confirmatory factor analysis and showed that it was valid to measure the self-efficacy variable. Authors Scherbaum et al. (2006) also showed good discriminant validity, meaning the scale can differentiate between participants with similar but different levels of self-efficacy, especially at lower self-efficacy values, and good concurrent validity with Sherer's and Chen's general self-efficacy measures. As using digital technology in the classroom can be viewed as a daily hassle, and the present study aims to explore technological self-efficacy among radiologic science educators in the classroom, it is an appropriate instrument to use.

See Appendix B for the instrument, which is available for use by the public and published on Schwarzer's webpage (Schwarzer & Jerusalem, 1995). The scale is comprised of 10 items and scored on a four-point Likert scale. Answer options range from 1 (not at all true) to 4 (exactly true), with the sum of the responses yielding a final score of 10 to 40. There is no cut-off score. Lower scores indicate lesser self-efficacy and higher scores greater self-efficacy. The scale took approximately five minutes to complete.

Roney Technology Use Scale

The Roney Technology Use Scale was used to measure participants' digital technology use. The purpose of this instrument was to ascertain the participants' level of digital technology use in the classroom. The scale was developed by Dr. Linda Roney, an assistant professor of nursing in 2017, and colleagues to measure technology use among nursing educators. While the use of the scale has only been published in one study, its development was supported by DeVellis's (2012) guidelines and its validation was reported in the study (Roney et al., 2017). The scale was reviewed by a panel of experts and content validity indices were calculated and equaled to 1.0. Content validity of .90 with at least three experts is considered excellent (Polit & Beck, 2006). Reliability analyses were also conducted, with a Cronbach's alpha equal to .460; however, this is the only survey in the recent literature that addresses the types of technology used in health professions education. It is important to note that low reliability can lead to inaccurate estimates of the magnitude of relationships (Gall et al., 2007).

See Appendix C for the instrument. While all of the questions pertain to digital technology use, question six is the only question that addresses such technology use in the didactic classroom. Question eight is a similar question but addresses technology use in the clinical classroom and is specific to nursing technology. Question six reads, "When considering your teaching over the past six months, please rate your use of the following technology tools with the following scale…," with 19 answer items (i.e., 3 -D printing, real-time polling and assessment/student response tool, blogging/online journaling, etc.) that can be ranked on a six-point scale. A rank of one indicates no use or that the educator has never heard of the technology, a rank of two indicates no use but that the tool is available at the college or university for use by faculty or students, a rank of three indicates that the educator uses the tool very rarely (one time per semester), a rank of four indicates that the educator uses the tool rarely (less than one time per month), a rank of five indicates that the educator uses the tool moderately (several times per month), and a rank of six indicates that the educator uses the technology often (daily or several times a week). The lowest possible score for question six is 19, meaning the participant ranked each answer item as one. Similarly, the highest possible score is 114, meaning the participant ranked each item as six. A total score of 19 to 38 indicates a low level of technology use, 39 to 94 a medium level, and 95 to 114 a high level. The researcher was granted permission to change the wording of the question from "six months" to "academic year" and the answer item "NLCEX-RN," which is nursing specific, to "ARRT," which is radiologic science specific. The scale took approximately 10 minutes for the study participants to complete. Scoring for both instruments was completed by the researcher.

Procedures

After gaining IRB approval (see Appendix E), a pilot study was conducted. A convenience sample of three radiologic science educators completed the combined instruments and provided feedback on accessibility and clarity of instructions. All of the educators in the researcher's database, derived from the JRCERT's website, were then sent an e-mail with information about the study, a link for participation via an electronic survey platform, and the researcher's contact information. See Appendix F for the e-mail to the participants. A statement of informed consent was also included. See Appendix G for the participant consent form. A reminder e-mail was sent two weeks after the initial e-mail to participants who had not yet responded.

To maintain data security, data collected by the electronic survey platform was accessible only to the researcher. At all times, information that could identify participants was protected. All data were stored securely on a password-protected laptop computer with password-protected cloud storage. When not being used, the computer was stored in a locked drawer. The data will be retained for a period of three years after the completion of the study.

Data Analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) and the Pearson product-moment correlation coefficient (*r*), or Pearson *r*, was calculated for both hypotheses. The Pearson *r* is used to determine the relationship between two quantitative variables and the degree to which the two variables are linearly related (Warner, 2021). According to authors Gall et al. (2007), *r* is calculated when there is a linear relationship between variables and both variables are expressed as continuous scores. Continuous scores are scores of a variable located on a continuum, along which there are an indefinite number of points. As the scores for all three variables in the present study – years of teaching experience, technological self-efficacy, and digital technology use – are continuous, *r* is an appropriate statistic. The value of *r* can range from -1.0, indicating a perfect negative linear relationship to +1.0, a perfect positive linear relationship. A value of 0 indicates no relationship at all (Gall et al., 2007). An advantage of Pearson's *r* is its small standard error (Gall et al., 2007).

All collected data were visually inspected for missing data points and inaccuracies and further inspected for outliers using scatter plots for the group. Assumption testing was performed, including tests for bivariate outliers, linearity, and bivariate normal distribution. The variables were measured on an interval scale and the observations within each variable were independent.

A scatter plot was also created between the variables of years of teaching experience and technological self-efficacy and another between the variables of years of teaching experience and digital technology use for assumption testing. Years of teaching experience was placed on the x-axes and technological self-efficacy and digital technology use, respectively, on the y-axes. Any extreme bivariate outliers were identified for the assumptions of bivariate outliers and linearity.

Lastly, the classic “cigar shape” was identified for the assumption of bivariate normal distribution (Gall et al., 2007).

The *r* value was also used to represent and report the effect size at the .05 α level. Effect size is an estimate of the magnitude and practical significance of the relationship under study and, in the case of the present study, calculated by squaring the value of *r*. A small to medium effect size ranges from 0.10 to 0.30, a medium to large effect size from 0.30 to 0.50, and a large to very large effect size more than 0.50. Effect sizes can also be used to determine the consistency of findings across studies of the same variables (Gall et al., 2007).

Finally, a Bonferroni correction was also calculated since two Pearson product-moment correlations were conducted. This is needed to guard against type I error, or the rejection of the null hypothesis when it is true and unwarranted (Gall et al., 2007). This alpha level is calculated to be .03.

CHAPTER FOUR: FINDINGS

Overview

The purpose of this study was to determine if there were significant relationships among radiologic science educators' years of teaching experience, technological self-efficacy, and digital technology use in the classroom. The independent variable was years of teaching experience, and the dependent variables were technological self-efficacy and digital technology use. Pearson product-moment correlations were used to test the hypotheses. The Findings section includes the research questions, null hypotheses, data screening, descriptive statistics, assumption testing, and results.

Research Questions

RQ1: Is there a relationship between radiologic science educators' years of teaching experience and technological self-efficacy?

RQ2: Is there a relationship between radiologic science educators' years of teaching experience and digital technology use in the classroom?

Null Hypotheses

$H_0$1: There is no significant relationship between radiologic science educators' years of teaching experience and technological self-efficacy as measured by the General Self-Efficacy Scale (Schwarzer & Jerusalem, 1995).

$H_0$2: There is no significant relationship between radiologic science educators' years of teaching experience and digital technology use in the classroom as measured by the Roney Technology Use Scale (Roney et al., 2017).

Descriptive Statistics

Descriptive statistics were obtained on each of the variables. The sample consisted of 79 participants. Technological self-efficacy was measured using the General Self-Efficacy Scale (Schwarzer & Jerusalem, 1995). Scores range between 10 and 40, with a higher score indicating more self-efficacy. Digital technology use in the classroom was measured by the Roney Technology Use Scale (Roney et al., 2017). The lowest possible score is 19 and the highest possible score is 114. A total score of 19 to 38 indicates a low level of technology use, 39 to 94 a moderate level, and 95 to 114 a high level of technology use. Descriptive statistics for the variables years of teaching experience and technological self-efficacy can be found in Table 2 and for years of teaching experience and digital technology use in Table 3.

Table 2

Descriptive Statistics

	N	Minimum	Maximum	*M*	*SD*
YoTE	79	1.00	44.00	17.9684	10.86347
TSE	79	24.00	39.00	33.5190	3.32381
Valid N (listwise)	79				

Table 3

Descriptive Statistics

	N	Minimum	Maximum	*M*	*SD*
YoTE	79	1.00	44.00	17.9684	10.86347
DTU	79	29.00	91.00	63.2658	12.59803
Valid N (listwise)	79				

Results

Data Screening

The researcher sorted the data and scanned for inconsistencies on each variable. No data errors or inconsistencies were identified. Scatter plots were used to detect bivariate outliers between the independent variable and dependent variables. No bivariate outliers were identified. See Figure 1 for the scatter plot between years of teaching experience and technological self-efficacy and Figure 2 for the scatter plot between years of teaching experience and digital technology use.

Figure 1

Scatter Plot – Years of Teaching Experience vs. Technological Self-Efficacy

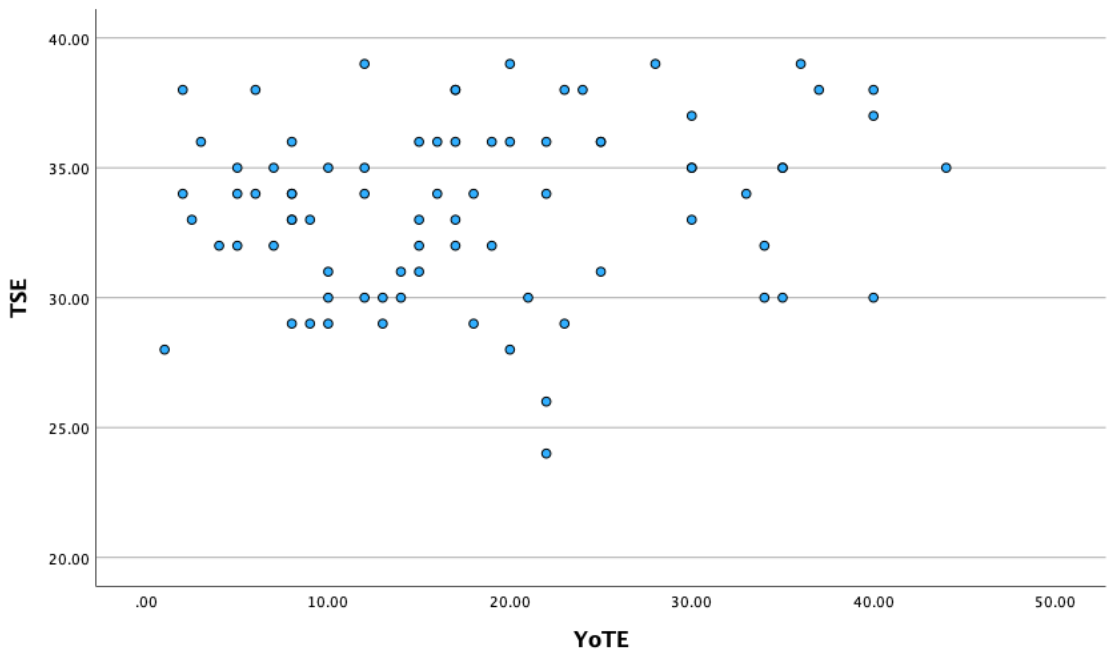
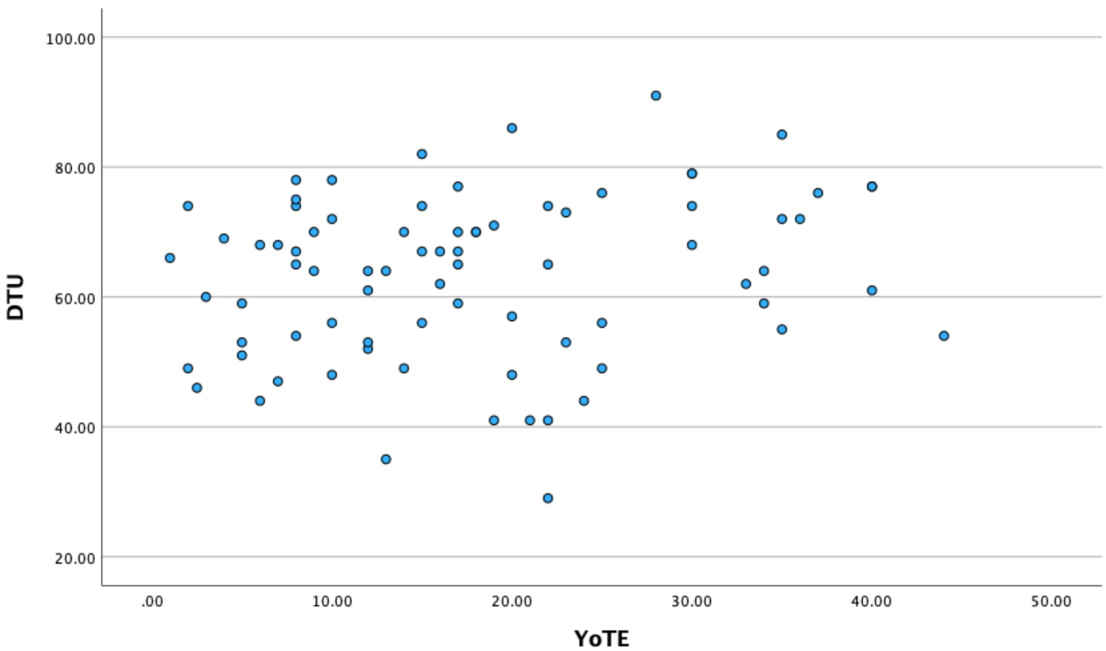


Figure 2

Scatter Plot – Years of Teaching Experience vs. Digital Technology Use



Assumption Testing

In addition to the assumption of outliers, which was met, the Pearson product-moment correlation requires that the assumption of linearity also be met. Linearity was examined using scatter plots. There was a linear relationship between the two variables. The assumption of linearity was met. See Figures 1 and 2 for the scatter plots.

The Pearson product-moment correlation requires that the assumption of bivariate normal distribution be met. The assumption of bivariate normal distribution was examined using scatter plots. The classic cigar shape was demonstrated. The assumption of bivariate normal distribution was met. See Figures 1 and 2 for the scatter plots.

Null Hypothesis One

Null Hypothesis One states, "There is no significant relationship between radiologic science educators' years of teaching experience and technological self-efficacy as measured by the General Self-Efficacy Scale (Schwarzer & Jerusalem, 1995)."

A Pearson product-moment correlation was conducted to see if there was a significant relationship between radiologic science educators' years of teaching experience and technological self-efficacy. The independent variable was years of teaching experience, and the dependent variable was technological self-efficacy. The researcher failed to reject the null hypothesis at the 95% confidence level where $r(77) = .16$, $p = .15$. The alpha level was calculated to be .03 with the Bonferroni correction. There was no statistically significant relationship between the independent variable (years of teaching experience) and dependent variable (technological self-efficacy), although the relationship was slightly positive. See Table 4 for the Pearson product-moment correlation test results.

Table 4

Pearson Product-Moment Correlation Test

Correlations

		YoTE	TSE
YoTE	Pearson Correlation	1	.163
	Sig. (2-tailed)		.152
	N	79	79
TSE	Pearson Correlation	.163	1
	Sig. (2-tailed)	.152	
	N	79	79

Null Hypothesis Two

Null Hypothesis Two states, "There is no significant relationship between radiologic science educators' years of teaching experience and digital technology use in the classroom as measured by the Roney Technology Use Scale (Roney et al., 2017)."

An additional Pearson product-moment correlation was conducted to see if there was a significant relationship between radiologic science educators' years of teaching experience and digital technology use in the classroom. The independent variable was years of teaching experience, and the dependent variable was digital technology use. The researcher failed to reject the null hypothesis at the 95% confidence level where $r(77) = .20$, $p = .08$. The alpha level was calculated to be .03 with the Bonferroni correction. There was no statistically significant relationship between the independent variable (years of teaching experience) and dependent variable (digital technology use), although the relationship was slightly positive. See Table 5 for the Pearson product-moment correlation test results.

Table 5

Pearson Product-Moment Correlation Test

Correlations

		YoTE	DTU
YoTE	Pearson Correlation	1	.198
	Sig. (2-tailed)		.081
	N	79	79
DTU	Pearson Correlation	.198	1
	Sig. (2-tailed)	.081	
	N	79	79

CHAPTER FIVE: CONCLUSIONS

Overview

A Pearson product-moment correlation was used to test the relationships between radiologic science educators' years of teaching experience and technological self-efficacy and radiologic science educators' years of teaching experience and digital technology use in the classroom. Overall, there were no statistically significant relationships between the variables, though the relationships were slightly positive. In this concluding chapter, the researcher provides a discussion of the findings, their implications, limitations of the study, and recommendations for future research.

Discussion

The purpose of this quantitative, correlational study was to examine the relationships among radiologic science educators' years of teaching experience, technological self-efficacy, and digital technology use in the classroom. A convenience sample of 300 radiologic science educators from colleges, universities, and hospitals in the United States was surveyed. A total of 79 educators, primarily female radiography program directors, with a mean age of 50 years, and an average of 18 years of teaching experience, responded to the survey. Years of teaching experience ranged from one to 44 years.

Research Question One

The first research question was, "Is there a relationship between radiologic science educators' years of teaching experience and technological self-efficacy?" Based on the calculation of the Pearson product-moment correlation, the author failed to reject the null hypothesis. There was no statistically significant relationship between the variables years of teaching experience and technological self-efficacy. The relationship was, however, slightly positive.

This can be explained by the finding that, overall, participants in the present study had a high level of self-efficacy with technology initially. Most – 69 out of 79, or 87% – achieved a score of greater than 30 out of 40 on the General Self-Efficacy Scale (Schwarzer & Jerusalem, 1995), indicating a higher level of self-efficacy. The lowest self-reported score was 24; however, this participant did not provide a response for two of the statements. "Exactly true" was chosen by the majority of participants for the statements, "I am confident that I could deal efficiently with unexpected events" and "I can solve most problems if I invest the necessary effort." "Moderately true" was selected by the majority for the remaining eight statements. These statements ranged from solving difficult problems, to overcoming opposition, to sticking to aims and accomplishing goals. "Hardly true" and "not at all true" were rarely chosen by the participants.

This finding was also true for the radiologic science educators in Cherry and Flora's (2017) study. In this study, faculty were confident in their ability to use technology in online education. Educators in Roney et al.'s (2017) study of nursing educators also rated themselves as having high-technological self-efficacy, while there was a difference in initial self-efficacy between novice and experienced teachers in Saienko et al.'s (2020) study. Initial levels of self-efficacy were higher among experienced teachers, which may be explained by the teachers' self-confidence built through experience. Having worked with technology in the clinic, many radiologic science educators may have established their self-confidence with technology as a practitioner prior to teaching.

Likewise, authors Roney et al. (2017) found a weak relationship – as did the present study – between nursing educators' years of teaching experience and technological self-efficacy.

In contrast to the present study, there was a positive relationship between educators' years of teaching experience and lower levels of technology use (Roney et al., 2017). Maican et al. (2019) had a similar finding. Teachers with more seniority had lower technological self-efficacy than those with less teaching experience. This was in the context of online technology where these teachers also had poorer attitudes toward its use and were more anxious than those with less teaching experience (Maican et al., 2019).

Research Question Two

The second research question was "Is there a relationship between radiologic science educators' years of teaching experience and digital technology use in the classroom?" Again, there was no statistically significant relationship between years of teaching experience and digital technology use. The relationship was, however, slightly positive. This can be explained by the finding that, overall, unlike the nursing educators in Roney et al.'s (2017) study who indicated moderate to high levels of technology use, participants in the present study achieved moderate levels. Seventy-seven achieved a moderate level with scores between 39 to 94 on the Roney Technology Use Scale (Roney et al., 2017), and only two – one with 13 and one with 22 years of teaching experience – achieved a low level. This is perceived as advantageous, as the findings of Ledbetter and Finn's (2018) study revealed that instructors who used moderate amounts of technology were more positively perceived by university students than those who used no technology or technology alone.

The types of digital technology used most often (several times/week) by participants of the study were computerized ARRT registration exam preparation, course management platforms, publisher-generated resources, presentation software, and video conferencing/webchat. Those used moderately (several times/month) were real-time polling and assessment/student response tools, screen capture, and web-based surveys. “Use very rarely (≤1/semester)” was also a common response for real-time polling and assessment/student response tool. This is in contrast to the technologies being explored for use and reported by Martino and Odle in 2008, which were portable electronic devices, podcasting, and virtual reality and simulation, and those touted in radiologic science classrooms by Wertz et al. in 2014, which were mobile electronic devices, podcasting, online education, and social media. Interestingly, tablets or personal digital assistants, podcasts, and virtual reality simulation were among the technologies that participants in the present study most reported “no use/never heard of this.”

Still, course management platforms and presentation software remain among the most used. This is consistent with the findings of authors Loague et al. in 2018, who said that these types of digital technologies, in addition to desktop applications, websites, collaboration tools, videos, online tutorials, and recorded lectures were the most used by instructors in higher education. There was no difference, however, in the use of course management platforms between faculty with six to 10 and 11 to 15 years of experience as there was in Martin et al.’s (2020) study. In the present study, 66 (84.6%) of the total number of respondents responded that they use course management platforms often (several times/week) and six (7.7%) responded that they use them moderately (several times/month).

It is unknown why participants commonly responded “no use but available at my college/university/hospital for use by faculty/students” to three-dimensional printing, blogging/online journaling, ePortfolio, and podcasts. Perhaps these technologies are underused by all faculty/students at the institution or there are significant barriers to their use that have not been overcome. While there may be benefits to the technologies, perhaps the faculty/students have not determined how to integrate them effectively into the classroom.

Implications

Despite the lack of a significant relationship, the results of the study provide evidence for the self-efficacy theory within the context of radiologic science education. With the use of digital technology as a potential adverse experience for radiologic science educators, the study provides information on their attitudes and behaviors, and beliefs in their abilities to use, and their actual use, of digital technology in the classroom. The results imply that among the radiologic science educators surveyed, digital technology use in the classroom is not a particularly adverse experience. Those surveyed have high technological self-efficacy and belief in their ability to perform new technologically advanced tasks. Of note, this does not speak to the educators' technological competence in the classroom.

The results of the study also demonstrate that technology underuse may not be as significant in radiologic science education than in other areas of higher education. While those surveyed may not have ever used or heard of the majority of the technologies listed in the Roney Technology Use Scale (Roney et al., 2017), they may use other digital technologies in the classroom. These educators may have more experience with the technologies discussed in the literature, including serious games or apps, which can be used as real-time polling and assessment/student response tools. They may also have more experience with online technologies and/or technologies that prepare students for the workplace.

Limitations

The present study is not without limitations, as there were threats to both its internal and external validity. Threats to the internal validity included the list of technologies in, and wording of, the Roney Technology Use Scale (Roney et al., 2017), and to the external validity, the population surveyed and the response rate. Steps were taken to limit the threats where possible.

Among the digital technologies discussed from the literature – serious games, virtual dissection tables, 3-D printing, mobile electronic devices, applications, social media, simulation, and virtual reality – only 3-D printing and virtual reality simulation were included in the Roney Technology Use Scale (Roney et al., 2017). As this scale was published for nursing educators in the year 2017, the digital technologies listed may not be representative of those used in radiologic science education or be up to date. As stated, the Roney Technology Use Scale (Roney et al., 2017) is the only survey in the recent literature that addresses the types of technology used in health professions education. In addition, the wording of the answer option, "no use/never heard of this" may have limited the participants' answers. The participant may not use the digital technology, but he/she may have heard of it.

The present study surveyed radiologic science educators who have taught didactic or clinical content full- or part-time in a college-, university, or hospital-based program in the last academic year. This included program directors, associate/assistant program directors, didactic instructors, and clinical instructors in JRCERT-accredited programs, as the contact information of program directors of these programs was readily available to the researcher. As such, the large majority of responses (89.87%) were from program directors. While many of the program directors may also have been didactic or clinical instructors, only one respondent indicated that he/she was a clinical instructor. As noted by Roney et al. (2017), nursing educators who taught didactic content reported moderate technology use in the classroom, while those who taught didactic and laboratory/clinical content reported high technology use. As educators gain experience and move into administrative roles, they may also shift to more didactic responsibilities, which could provide them with fewer opportunities to integrate technology into the classroom. Those who teach laboratory/clinical content need to incorporate the technologies used in the clinic into their teaching in order to train students for clinical practice.

It may be assumed that most of the program directors taught didactic content; however, it is unknown whether they also taught laboratory/clinical content. Nonetheless, the findings of the present study support some technology underuse in the classroom. Of the 19 digital technologies listed on the Roney Technology Use Scale (Roney et al., 2017), the majority of participants responded “no use/never heard of this” for nine (47%) of them. The perceptions of radiologic science students on faculty technology use are also unknown. There is no information in the present study to corroborate Skiba’s (2018) findings that 65% of the students in her study agreed that most faculty used technology for instruction or Ledbetter and Finn’s (2018) findings that instructors who use moderate amounts of technology are positively perceived.

In addition, only 300 radiologic science educators were surveyed. The JRCERT accredits around 700 radiography, radiation therapy, magnetic resonance, and medical dosimetry programs, so presumably, there were many more educators to query. The survey response rate was also 26%. Only 79 of the 300 surveyed responded within three weeks and the majority (67%) were from radiography programs. Because invitations to participate in the study were sent via e-mail, it is possible that those who participated in the study could have higher technological self-efficacy or high levels of technology use than those who did not participate. They may have been more motivated to respond. It is difficult to generalize the results to all radiologic science educators in all colleges, universities, and hospitals in the United States.

Recommendations for Future Research

The results of the present study are limited to a small population of radiologic science educators from colleges, universities, and hospitals in the United States. Recommendations for future research include a(n):

1. study of a larger population of radiologic science educators, targeting didactic versus clinical instructors.
2. investigation into the barriers that specifically affect radiologic science educators' use of digital technology in the classroom.
3. the development of a scale using digital technologies popular among radiologic science educators.
4. examination of the role of age as it relates to years of teaching experience.

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APPENDIX A

Sociodemographic Questionnaire

1. What is your gender?
   a. male
   b. female
   c. other
   d. prefer not to say

2. What is your age in years? _____

3. How many years of radiologic science teaching experience do you have? This should include formal, part- or full-time didactic or clinical teaching in a collegiate or hospital setting. _____

4. What is your role in your radiologic science program?
   a. Program Director
   b. Assistant/Associate Program Director
   c. Didactic instructor
   d. Clinical instructor

5. What is your primary teaching discipline?
   a. radiography
   b. computed tomography
   c. magnetic resonance imaging
   d. radiation therapy
   e. other

APPENDIX B

General Self-Efficacy Scale

1. I can always manage to solve difficult problems if I try hard enough.
2. If someone opposes me, I can find the means and ways to get what I want.
3. It is easy for me to stick to my aims and accomplish by goals.
4. I am confident that I could deal efficiently with unexpected events.
5. Thanks to my resourcefulness, I know how to handle unforeseen situations.
6. I can solve most problems if I invest the necessary effort.
7. I remain calm when facing difficulties because I can rely on my coping abilities.
8. When I am confronted with a problem, I can usually find several solutions.
9. If I am in trouble, I can usually think of a solution.
10. I can usually handle whatever comes my way.

1 = not at all true
2 = hardly true
3 = moderately true
4 = exactly true

APPENDIX C

Roney Technology Use Scale

When considering your teaching over the past six months, please rate your use of the following technology tools with the following scale: *no use/never heard of this; no use but available at my college/university for use by faculty/students, use very rarely (≤1/semester), use rarely (≤1/month), use moderately (several times per month), use often (several times a week)*

3D printing; real-time polling and assessment/student response tool; blogging/online journaling; computerized NCLEX-RN preparation; course management platforms; ePortfolio; Google Glass; high-fidelity patient simulators; lecture capture; tablet or personal digital assistant either in classroom or clinical setting; publisher-generated resources; podcasts; presentation software; simulated electronic health records; student response systems; screen capture; video conferencing/webchat; virtual reality simulation; web-based surveys; other

APPENDIX D

Permission to Use Roney Technology Use Scale

Yes, you have my permission to use the RTUS- and these edits are acceptable.
Please let me know what you find!
All of my best

[redacted]

APPENDIX E

IRB Approval

February 7, 2023

Jessica Church

Rebecca Lunde

Re: IRB Exemption - IRB-FY22-23-810 RELATIONSHIPS AMONG RADIOLOGIC SCIENCE EDUCATORS' YEARS OF TEACHING EXPERIENCE, TECHNOLOGICAL SELF-EFFICACY, AND DIGITAL TECHNOLOGY USE IN THE CLASSROOM

Dear Jessica Church, Rebecca Lunde,

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study to be exempt from further IRB review. This means you may begin your research with the data safeguarding methods mentioned in your approved application, and no further IRB oversight is required.

Your study falls under the following exemption category, which identifies specific situations in which human participants research is exempt from the policy set forth in 45 CFR

46:104(d):

Category 2.(i). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording).
The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects.

Your stamped consent form(s) and final versions of your study documents can be found under the Attachments tab within the Submission Details section of your study on Cayuse IRB. Your stamped consent form(s) should be copied and used to gain the consent of your research participants. If you plan to provide your consent information electronically, the contents of the attached consent document(s) should be made available without alteration.

Please note that this exemption only applies to your current research application, and any modifications to your protocol must be reported to the Liberty University IRB for verification of continued exemption status. You may report these changes by completing a modification submission through your Cayuse IRB account.

If you have any questions about this exemption or need assistance in determining whether possible modifications to your protocol would change your exemption status, please email us at [redacted]

Sincerely,

[redacted]

APPENDIX F

E-mail to Participants

Dear Radiologic Science Educator:

As a graduate student in the School of Education at Liberty University, I am conducting research as part of the requirements for a doctoral degree. The purpose of my research is to determine if there are relationships among radiologic science educators' years of teaching experience, technological self-efficacy, and digital technology use in the classroom, and I am writing to invite eligible participants to join my study.

Participants must be full-time radiologic science educators at colleges, universities, and/or hospitals in the United States. The educators must have taught didactic or clinical content during the past academic year. Participants, if willing, will be asked to complete an online survey. It should take approximately 15 minutes to complete the survey. Participation will be completely anonymous, and no personal, identifying information will be collected.

To participate, please click here: https://forms.gle/M7WFKtqWq8H5Jpuf8

A consent document is attached to this e-mail. The consent document contains additional information about my research. After you have read the consent form, please click the link to proceed to the survey. Doing so will indicate that you have read the consent information and would like to take part in the survey.

Sincerely,
Jessica Church, MPH, RT(R)(T), CMD
Doctoral Candidate
[redacted]

APPENDIX G

Participant Consent Form

Title of the Project: Relationships among Radiologic Science Educators' Years of Teaching Experience, Technological Self-Efficacy, and Digital Technology Use in the Classroom
Principal Investigator: Jessica Church, MPH, RT(R)(T), CMD. Doctoral Candidate, School of Education, Liberty University

Invitation to be Part of a Research Study

You are invited to participate in a research study. To participate, you must be a full-time radiologic science educator at a college, university, and/or hospital in the United States. You must also have taught didactic or clinical content during the past academic year. Taking part in this research project is voluntary.

Please take time to read this entire form and ask questions before deciding whether to take part in this research.

What is the study about and why is it being done?

The purpose of the study is to determine if there are relationships among radiologic science educators' years of teaching experience, technological self-efficacy, and digital technology use in the classroom. Technological self-efficacy refers to the belief in one's ability to successfully perform a technologically advanced new task.

What will happen if you take part in this study?

If you agree to be in this study, I will ask you to do the following:

1. Complete an online survey that will take no more than 15 minutes.

How could you or others benefit from this study?

Participants should not expect to receive a direct benefit from taking part in this study.

Benefits to society include the addition of knowledge of self-efficacy theory and the implementation of digital technology in radiologic science education, as well as the potential enhancement of professional development opportunities for radiologic science educators.

What risks might you experience from being in this study?

The expected risks from participating in this study are minimal, which means they are equal to the risks you would encounter in everyday life.

How will personal information be protected?

The records of this study will be kept private. Research records will be stored securely, and only the researcher will have access to the records.

Participant responses will be anonymous.

Data will be stored on a password-locked computer. After three years, all electronic records will be deleted.

How will you be compensated for being part of the study?

Participants will not be compensated for participating in this study.

Is study participation voluntary?

Participation in this study is voluntary. Your decision whether to participate will not affect your current or future relations with Liberty University. If you decide to participate, you are free to not answer any question or withdraw at any time prior to submitting the survey without affecting those relationships.

What should you do if you decide to withdraw from the study?

If you choose to withdraw from the study, please exit the survey and close your internet browser. Your responses will not be recorded or included in the study.

Whom do you contact if you have questions or concerns about the study?

The researcher conducting this study is Jessica Church, MPH, RT(R)(T), CMD. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at [redacted] You may also contact the researcher's faculty sponsor, Dr. Rebecca Lunde, at [redacted]

Whom do you contact if you have questions about your rights as a research participant?

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the IRB. Our physical address is [redacted]

Disclaimer: The Institutional Review Board (IRB) is tasked with ensuring that human subjects research will be conducted in an ethical manner as defined and required by federal regulations. The topics covered and viewpoints expressed or alluded to by student and faculty researchers are those of the researchers and do not necessarily reflect the official policies or positions of Liberty University.

Your Consent

Before agreeing to be part of the research, please be sure that you understand what the study is about. You can print a copy of the document for your records. If you have any questions about the study later, you can contact the researcher using the information provided above.