VALIDATING AN INSTRUMENT FOR GATHERING FACULTY PERCEPTIONS OF ONLINE EDUCATION IN RADIOLOGIC SCIENCE PROGRAMS

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The purpose of this quantitative study was to provide a valid and reliable instrument that can be used to collect radiologic science faculty members' perceptions of online education. Using a survey modified from an existing study, data were collected concerning faculty perceptions of online education in radiologic sciences. R was used to analyze the survey data through exploratory factor analysis, confirmatory factor analysis, short form optimization, and weighted multiple regression analysis to produce an instrument that exhibits both content and construct validity, is reliable, and is a shortened, optimized version of the original instrument. The findings are discussed and recommendations for future research are provided to begin work broadening this under-researched area in the field of radiologic sciences.

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TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Background

Millions of people around the world have access to online learning, which is why higher education institutions utilize this method of education (Harrison et al., 2017; Moreira, Henriques, Goulão, & Barros, 2017). Many radiologic science programs offer complete degrees entirely online, and the number of online health science degrees is steadily increasing (Lee et al., 2010; Reeves & Reeves, 2008). Jaschik and Lederman (2017) surveyed approximately 23,500 faculty members and digital leaders in 2017 and found, "42% of professors say they have taught an online course, and 36% have taught a blended or hybrid course. The proportion of faculty members who have taught an online course has increased from 30% to 42% since 2013" (p. 6). However, radiography is a relatively young academic profession (Knapp, Wright, Clarke, McAnulla, & Nightingale, 2017); therefore, instructors for radiologic science programs in higher education generally come from a clinical background rather than a background in education. Most instructors with a clinical background are products of face-to-face programs, so most have limited experience in online education, conducting research, and engaging in scholarship (Britt, 2006; Knapp et al., 2017). In fact, some instructors teaching online courses have limited experience as not only an online teacher, but also as an online student (McQuiggan, 2012).

Health science fields, including radiologic sciences, are hands-on and lend themselves best to learning from experience, which is why they include a clinical component (Lisko & Odell, 2010). Instructors in these fields with primarily clinical backgrounds are employing teaching methods largely based on previous experience as a student or as an instructor in a clinical setting, rather than formal training in pedagogy or instructional methods (Knapp et al., 2017). The instructors often learn as they go and are self-taught. According to the American Society of Radiologic Technologists' (ASRT) 2019 Radiologic Technologist Wage and Salary Survey, 13.9% of participants hold a certificate, 51.7% hold an associate's degree, 28.5% hold a bachelor's degree, 5.1% hold a master's degree, 0.5% hold a doctoral degree (including medical), and 0.2% stated 'other' as the highest level of education completed (ASRT, 2019).

According to the aforementioned ASRT survey, it is evident that many radiologic science faculty members do not have formal training in education; therefore, the tasks and responsibilities they face teaching online create an urgent need for training and development (Knapp et al., 2017). Tough (1971) stated, "It is common for an adult to face some task or responsibility. He may have to make a decision, develop a set of recommendations, build something, or produce something" (p. 50). According to Tough (1971), this is the primary reason for an adult to take the time to gain knowledge and skills, and one will often do so in order to perform the desired action at a higher level of performance.

Acquiring knowledge and developing critical thinking skills are the goals of higher education (Esani, 2010), and when properly executed, online learning can be just as effective as face-to-face instruction for developing skills and knowledge in health science courses (Carbonaro et al., 2008). However, according to Braun (2008), learning in online environments is vastly different than in traditional classrooms. In a face-to-face classroom, discussions, lab exercises, and oral and written examinations are utilized, and instructors can use visual cues from students to enhance the delivery of the material (Esani, 2010). When teaching online, faculty have few, if any, visual cues to aid instructional delivery, and what is available gets filtered through technology. The depth of learning and the critical thinking skills of learners in the online setting are not always displayed to the instructor (Esani, 2010). “Online students need a structured system of acquiring cognitive knowledge to produce positive learning outcomes” (Esani, 2010, p. 188). To achieve this, instructors should provide a logical flow for lessons and activities that assess and reinforce student learning so adjustments to instruction can be made in a timely manner (Esani, 2010).

The responsibilities for faculty also change in online courses. Simply transferring classroom course materials to an online course platform is not effective (Haugen & Metcalf, 2018). The instructor must prepare course material long before the course opens; every piece of instruction and communication must be typed and provided in an organized manner so students can understand (Esani, 2010). Feedback must also be provided in writing, which causes some lag time in communication. Generally, online students are doing course work at night or on the weekends, which means their questions come outside of the instructor’s normal office hours (Esani, 2010). The constant messages from learners can be time-consuming and labor intensive. The entire online experience for the instructor from creation to feedback can feel much more overwhelming than a face-to-face course (Esani, 2010). Because of the fundamental differences between online and face-to-face teaching, some faculty members are apprehensive about online teaching and learning (Bennett & Lockyer, 2004; Herman, 2012; Hunt et al., 2014; Johnson et al., 2012). Childs, Blenkinsopp, Hall, and Walton

(2005) explored the frustration experienced by faculty toward online learning in the health field and discovered inadequate technology, lack of skills, computer anxiety, and the time-intensive nature of online learning.

Problem Statement

The problem addressed in this research is the limited amount of information regarding faculty perceptions of online education in radiologic science programs. When exploring the literature related to this study, there were few fully-vetted, validated surveys related to the perceptions of radiologic science faculty members toward online education. An extensive search for an instrument was conducted using the following academic databases: Academic Search Complete, CINAHL Complete, EbscoHost, ERIC, Health Source: Nursing/Academic Edition, JSTOR, MEDLINE Complete, MedOne Radiology, ProQuest, PsycARTICLES, PsycINFO, PUBMed, and ScienceDirect College Edition. Search terms used for the search included: *radiologic sciences education; radiology education; radiology faculty; radiology faculty perceptions; online education; perceptions of online education; radiology faculty AND online education; radiography education; allied health education; allied health faculty perceptions; nursing education; nursing faculty perceptions; and allied health AND online education*. After performing this search, several surveys were found pertaining to faculty perceptions of online education; however, few were specific to radiology or even allied health and nursing. The only instrument found that met the criteria of the study was published by Cherry (2015). However, there was no validity information available, which can be a hindrance to developing further research on this topic.

Purpose of Study

The purpose of this study was to provide a valid and reliable instrument that can be used to collect radiologic science faculty members' perceptions of online education. According to Allen and Seaman (2012), faculty have an overall pessimistic view of online teaching and learning. Nearly two-thirds feel that online learning outcomes are inferior to face-to-face outcomes, and the remaining one-third feel the outcomes are comparable. Faculty members currently teaching online worry about learning outcomes (Allen & Seaman, 2012). However, faculty with experience teaching online tend to have positive opinions of online teaching and learning (Allen & Seaman, 2012; Jaschick & Lederman, 2017). Bunk, Li, Smidt, Bidetti and Malize (2015) discovered feelings of excitement versus fear combined with experience teaching online acted as emotional motivational factors explaining some faculty members' feelings about online teaching and learning, both positive and negative. For example, "when faculty had more fear than excitement and had no experience teaching online, they reported the highest levels of agreement that their institution is pushing for too much online education" (Bunk, Li, Smidt, Bidetti, & Malize, 2015, p. 8-9). Limited training in education and online instruction is noted in many studies as contributing to negative faculty perceptions toward teaching online (Allen & Seamen, 2012; Badia, Garcia, & Meneses, 2017; Bunk et al., 2015; Chen & Chen, 2006; Childs, Blenkinsopp, Hall, & Walton, 2005; Horvitz, Beach, Anderson, & Xia, 2015; Jaschik & Lederman, 2017; Smidt, McDyre, Bunk, Li, & Gatenby, 2014).

The uneasiness felt by faculty members about teaching online can be quelled when they are well-trained on the technology they will be using (Bennett & Lockyer, 2004; Herman, 2012; Hunt et al., 2014; Johnson et al., 2012). De Smet, Bourgonjon, De Wever, Schellens, and Valcke (2012) found instructors are more likely to use technology provided in an LMS when proper support is offered at the institutional level. However, for radiologic science faculty members, that training and support is often not available or not well advertised by the institution (Haugen & Metcalf, 2018). Professional development is critical for the ongoing growth of instructors (Altany, 2012). Learning management systems are evolving and offering even more features and tools, so instructors will need well-designed professional development to learn how to improve their teaching practice (Milman, 2016; Rhode & Krishnamurthi, 2016). Sheffield et al. (2015) found

> given the opportunity to learn, with support and experience gained through online training, a peer-team learning environment, hands-on LMS design, and first-hand online teaching and learning experience, graduate students and future faculty can gain awareness, competence, and confidence regarding both learning and teaching in the online environment (p. 10).

Significance

While much research exists about perceptions of online instructors, a minimal amount is currently available specific to radiologic science faculty members with a primarily clinical background. This is significant because, as mentioned earlier, the number of online health science degrees is steadily increasing (Lee et al., 2010; Reeves & Reeves, 2008). Students in online radiologic sciences classes are generally non-traditional students already employed in the clinical environment. These students are going back to school either for personal gain or to advance their career (Britt, 2006). It is necessary to explore the perceptions of radiologic science faculty members teaching online, which could affect the quality of the education being provided. In order to accomplish this, a validated, reliable instrument must be made available.

Theoretical Framework

Community of Inquiry (CoI) Framework

A worthwhile education requires a community of inquiry that includes teachers and students and follows a model consisting of cognitive presence, social presence, and teaching presence (Garrison, Anderson, & Archer, 2000). While these elements are not necessarily difficult to achieve in a face-to-face environment, when the teaching medium changes to that of asynchronous online learning, the quality of education can suffer. Garrison, Anderson, and Archer (2000) proposed a template to ensure all elements of a community of inquiry are being met in a text-based online teaching and learning environment. For cognitive presence, a model of practical inquiry based on the works of Dewey was constructed and consists of four elements: perception, deliberation, conception, and action (Garrison et al., 2000). The three categories of social presence were shaped by the community of inquiry model and emerged as emotional expression, open communication, and group cohesion (Garrison et al., 2000). Finally, three categories of teaching presence were identified: instructional management, building understanding, and direct instruction (Garrison et al., 2000). All elements of the CoI framework will be further discussed in Chapter 2.

Diffusion of Innovation Theory

Diffusion of innovation (DoI) occurs when communication among members in a social system takes place over time in response to learning about an innovation or new idea (Rogers, 2003). According to Scott and McGuire (2017), DoI theory has been applied by educators examining adult education practices, medical researchers interested in adopting and using a new drug, and scholars of public health policy. In terms of adopting an innovation, there are usually five progressive stages: initial knowledge and awareness, persuasion of the value, a decision to adopt, implementation, and confirmation of the decision (Rogers, 2003; Scott & McGuire, 2017). Some individuals possess innovativeness, a trait Rogers (2003) described as adopting an innovation earlier than others. There are generally five categories of innovativeness, decreasing in willingness to adopt: innovators, early adopters, early majority, late majority, and laggards (Rogers, 2003; Scott & McGuire, 2017). These phases of adoption can be applied to the field of online education, including in radiologic science programs. Cherry (2015) and Kowalczyk (2014) both found a varying level of adoption of online learning by radiologic science faculty members due to various perceived barriers.

Adult Learning Theory

The adult learning theory has two “pillars”: andragogy and self-directed learning (Merriam, 2001), the one more closely related to this study is andragogy because the participants are adult learners, teaching in an adult learning environment. Andragogy is the art and science of adult learning (Baumgartner, 2003; Merriam, 2001; Pappas, 2013). In higher education, learners are considered adult learners, and according to Knowles’ (1984) research on andragogy, adults learn based on five assumptions: self-concept, adult learner experience, readiness to learn, orientation to learning, and motivation to learn. Adult learners are self-directed, have a greater volume of experience, learn based on developmental tasks in a problem-centered environment, and are internally motivated to learn (Knowles, 1980, 1990). While a single theory will never capture all the complexities of adult learning (Merriam, 2001), conclusions can be drawn that adult learners prefer to be self-directed and involved in the planning of their learning. Their learning needs to be experiential, task-oriented, and based more on problem-solving rather than content, where instructors provide guidance rather than lecturing (Culatta, 2015). These theories are discussed further in Chapter 2.

Research Questions

The research questions for this study were:

1. What is the current instrument on radiography faculty perceptions of online education measuring?
2. How consistent is the current instrument on radiography faculty perceptions of online education?
3. What are the covariates of online education perceptions of radiologic science faculty members using the assembled optimal inventory to measure those perceptions?

Research Method

After reviewing the study by Cherry (2015) on radiography faculty perceptions of online education, it was discovered that the instrument has reliability information; however, it was never validated. Therefore, the instrument needed to be validated and re-tested. A quantitative analysis was performed using post-validation analysis involving a multiple regression model with factors as predictors to determine the principal questions of interest, aid in providing validity and reliability of the survey, and provide a shortened form of the instrument. Following the post-validation analysis of the entire survey, the shortened form of optimal questions underwent the same analysis to determine final validity and reliability of the shortened instrument. This research design has provided a shortened, validated, reliable instrument for use in the field of radiology. The research method is outlined in more detail in Chapter 3.

Limitations

Participants in this study are already teaching in radiologic science programs nationwide that utilize online courses and have a variety of clinical and teaching experience at various academic levels. This was a sample of convenience. Since this survey was only distributed to radiologic science faculty members teaching in JRCERT accredited programs, the generalizability is limited to this population. However, the demographic questions of this survey could be altered to make the survey applicable to other populations.

Delimitations

The participants for this study were limited to radiologic science programs in the United States that are accredited by the Joint Review Committee on Education in Radiologic Technology (JRCERT). Accreditation is "the primary means of assuring and improving the quality of higher education institutions and programs in the United States" (Joint Review Committee on Education in Radiologic Technology [JRCERT], n.d., para. 1). JRCERT accreditation offers programs a degree of legitimacy in the field, enables programs to receive federal, state, and private funding, aids programs in maintaining a high quality of service, and is required for states with professional licensure (JRCERT, n.d.).

Definition of Terms

- *American Registry of Radiologic Technologists (ARRT)* – "is the world's largest organization offering credentials in medical imaging, interventional procedures, and radiation therapy. [The ARRT] certifies and registers technologists in a range of disciplines by overseeing and administering education, ethics, and examination requirements. [The ARRT] also advocates for safety and advancement in radiological sciences professions by supporting initiatives and contributing to industry research studies" (ARRT, n.d.a, para. 1,2).

- *American Society of Radiologic Technologists (ASRT)* – An organization that "advances and elevates the medical imaging and radiation therapy professions and enhances the quality and safety of patient care through education, advocacy, research and innovation" (ASRT, n.d., para. 1,2).
- *Andragogy* – "the art and science of helping adults learn" (Knowles, 1984, p.43). Andragogy makes the following assumptions: (1) adults need to know why they need to learn something, (2) adults need to learn experientially, (3) adults approach learning as problem solving, and (4) adults learn best when the topic is of immediate value (Knowles, 1973).
- *Antcolony* – "can produce short forms of scales that are optimized with respect to characteristics selected by the developer, such as model fit and predictive relationships with other variables" (Raborn, 2020, para. 1).
- *Comparative fit index (CFI)* – "compares the fit of a target model to the fit of an independent, or null, model." Cutoff for good fit: CFI ≥ 0.90. (Parry, n.d., para. 5).
- *Community of inquiry (CoI)* – A social constructivist model of learning processes in online and blended environments. The framework is built upon three dimensions: teaching presence, social presence, and cognitive presence (Huang, Hurt,

Richardson, Swan, & Caskurlu, 2018).

- *Confirmatory factor analysis (CFA)* – "specifies how a set of observed variables are related to some underlying latent factor or factors" (Hartman, 2018, para. 1).

- *Convergence* – The ability of an estimation algorithm to arrive at values that meet prescribed criteria within a set number of iterations (Anderson & Gerbing, 1984).

- *Covariance* – A measure of how much two random variables vary together, and indicates the direction of the linear relationship between variables (Saha, 2018).

- *Diffusion of innovation theory (DoI)* – Originated in communication to explain how, over time, an idea or product gains momentum and diffuses (or spreads) through a specific population or social system. The end result of this diffusion is that people, as part of a social system, adopt a new idea, behavior, or product (LaMorte, 2018).

- *European Qualifications Framework (EQF)* - A translation tool that helps understand and compare qualifications awarded in different countries and by different education and training systems. Its eight levels are described in terms of learning outcomes: knowledge, skills and competences (Europass, n.d.).

- *Exploratory factor analysis (EFA)* – "an expedient way of ascertaining the minimum number of hypothetical factors that can account for the observed covariation, and as a means of exploring the data for possible data reduction" (Kim & Mueller, 1978, p. 9).

- *Goodness-of-fit indices* – Continuous measures of model-data correspondence; for goodness-of-fit indices, higher values indicate a better fit. Common indices include CFI, TLI, SRMR, and RMSEA (Kline, 2016).

- *Joint Review Committee on Education in Radiologic Technology (JRCERT)* – "promotes excellence in education and elevates the quality and safety of patient care through the accreditation of educational programs in radiography, radiation therapy, magnetic resonance, and medical dosimetry" (JRCERT, n.d., para. 1).
- *Lavaan* – Latent variable analysis; fits a variety of latent variable models, including confirmatory factor analysis, structural equation modeling, and latent growth curve models (Rosseel, 2019).
- *Omega* – An estimate of the general factor saturation of a test (Revelle, 2019b).
- *Online education* – Also referred to as distance education, is an educational process characterized by the separation, in time or place, between instructor and students. Distance education courses are taught primarily (more than 50%) through the use of the TV, audio, or computer transmissions; audio or computer conferencing; video cassettes or disks; correspondence; and/or a combination of face-to-face instruction with a distance learning component (hybrid) (JRCERT, 2011).
- *Optimal test assembly* - Allows assembly of "a test or set of tests…from a large variety of item pools, with a result that is optimal with respect to an objective chosen from a large set of alternatives by the test assembler" (van der Linden, 2005, p. 25).
- *Proportion of variance* - Based on the relationship strength between variables, and is often represented as an index representing the outcome variable that is associated with predictor(s) or independent variable(s) (Fan & Konold, 2010).
- *Psych* – "a general purpose toolbox for personality, psychometric theory and

experimental psychology. Functions are primarily for multivariate analysis and scale construction using factor analysis, principal component analysis, cluster analysis and reliability analysis" (Revelle, 2020, para. 1).

- *R* - A language and environment for statistical computing and graphics that is available as free software (The R Foundation, n.d.).

- *Radiologic science education* – Also referred to as radiography education, includes two primary components: didactic instruction and clinical instruction. Didactic instruction involves teaching and learning in the classroom or laboratory, or online. Clinical instruction occurs at health care facilities and typically is facilitated by staff or supervising radiologic technologists (Spence, 2019).

- *Root mean square error of approximation (RMSEA)* - An absolute fit index that assesses how far a hypothesized model is from a perfect model and is scaled as a badness-of-fit statistic where a value of zero indicates the best result; cutoff for "good" fit: $\text{RMSEA} < 0.8$, cutoff for "adequate" fit: $\text{RMSEA} < 0.10$ (Kline, 2016; Parry, n.d.).

- *Shortform* – "performs automatic creation of short forms of scales with an ant colony optimization algorithm and a Tabu search" (Raborn, 2019, para 1.).

- *Standardized root mean square residual (SRMR)* – "an absolute measure of fit and is defined as the standardized difference between the observed correlation and the predicted correlation"; cutoff for "good" fit: $\text{SRMR} < 0.8$, cutoff for "adequate" fit: $\text{SRMR} < 0.12$ (Kenny, 2015, para. 36; Kline, 2016; Parry, n.d.).

- *Tucker Lewis Index (TLI)* – an incremental fit index that was adapted from the normed fit index (NFI) so it is not affected by sample size; also called the non-normed fit index (NNFI); cutoff for "good" fit: $\text{TLI} \geq 0.95$ (Cangur & Ercan, 2015; Parry, n.d.).

- *Very simple structure (VSS)* - Compares the fit of the simplified model to the original correlations and tends to peak at the optimal number of factors (Revelle, 2019c).

Summary

It is important to examine the research that has been completed in relation to online education and the perceptions of radiologic science faculty members. Since there were few instruments found during the review of literature, as well as limited validity and reliability information on the instrument that was found, this study will contribute to the current body of knowledge by providing a validated, reliable instrument that can be used to further explore this area of research. Chapter 2 is a review of the literature containing current and historical research of concepts associated with online education, radiologic science education, and faculty perceptions of teaching online. This literature review will help to provide a framework for understanding the elements discussed in the introduction.

CHAPTER 2

LITERATURE REVIEW

Online Education

Learning in higher education can be accomplished face-to-face, online, or in a combination of the two, often referred to as blended learning (de Jong, Savin-Baden, Cunningham, & Verstegen, 2014). For some, online or distance education encompasses “all aspects of programming that allows a learner to continue learning beyond the walls of a classroom” (Vanek, Simpson, Johnston, & Petty, 2018, p. 13), and has become an attractive alternative to traditional face-to-face courses because of the flexibility and lack of geographic barriers (Bonnici, Maatta, Klose, Julien, & Bajjaly, 2016; Molnar & Kearney, 2017; Wang, Quek, & Hu, 2017). For radiologic science education courses, the Joint Review Committee on Education in Radiologic Technology (JRCERT, 2011) defines distance education/delivery as:

> an educational process characterized by the separation, in time or place, between instructor and students. Distance education/delivery courses are taught primarily (more than 50%) through the use of TV, audio, or computer transmissions (broadcast, closed-circuit, cable, microwave, satellite transmissions); audio or computer conferencing; video cassettes or disks; correspondence; and/or a combination of face-to-face instruction with a distance learning component (hybrid) (policy 10.803).

Online education environments are a great option for non-traditional, adult learners who have responsibilities outside of school, and they boost enrollment and revenue for colleges and universities (Haugen & Metcalf, 2018; Wertz, Hobbs, & Mickelson, 2014). Online courses are accessed through the Internet via a learning management system (LMS) such as WebCT, Blackboard, Desire2Learn, Moodle, and Canvas which allows communication between faculty and students through e-mail and discussion boards (Kowalczyk, 2014; Wertz et al., 2014).

In online education, faculty members encourage students to think critically and learn autonomously, take responsibility for their education, and explore resources available online (Kowalczyk & Copley, 2013; Wertz et al., 2014). To achieve this, faculty members have to be managers, technical advisors, facilitators, social directors, coaches, collaborators, educators, and mentors (Cherry, 2015; Kowalczyk, 2014). However, many faculty members are reluctant to take on these roles, due to lack of experience, lack of support, lack of student contact, and lack of release time for course development (Britt, 2006; Kowalczyk, 2014). This is primarily true for faculty members in radiologic science programs (Britt, 2006; Cherry, 2015; Kowalczyk, 2014).

Radiologic Science Education

Radiologic science education, or radiography education, consists of didactic (classroom) as well as clinical learning. In the past, didactic instruction consisted of faculty simply lecturing to students in a classroom, with or without the use of basic technology (Spence, 2019). Learning is evolving by incorporating innovative technologies and alternative teaching practices to enhance student achievement and shift the focus of instruction from the teacher to the student (Holmström & Ahonen, 2016; Spence, 2019). The American Registry of Radiologic Technologists (ARRT) (n.d.b), as well as the European Qualifications Framework (EQF) (Holmström & Ahonen, 2016) require radiography graduates to "demonstrate a critical understanding of the theory and principles of the profession, demonstrate mastery of equipment and technique and innovation by solving complex and unpredictable problems presented in a clinical setting, make responsible decisions in unpredictable work contexts, and manage the professional development of individuals and [a] group" (Holmström & Ahonen, 2016, p. 371). As a way to aid the development of critical-thinking skills, radiography educators can implement teaching strategies such as active learning, peer learning, instructional technology, and simulation of clinical components in the didactic classroom (Spence, 2019).

Online education is becoming increasingly more prevalent in radiography education. Some entry-level radiography programs require students to take online courses during the clinical portion of learning (Papillion & Aaron, 2017), and there are also completion degree programs that are entirely online in radiologic sciences offering working professionals with an associate degree an opportunity to pursue a bachelor's degree. However, despite the steady increase in online course availability, radiologic science educators appear to make a slow transition to incorporating online learning strategies, generally only uploading PowerPoint presentations used in face-to-face lectures rather than incorporating interactive online tools (Haugen & Metcalf, 2018; Kowalczyk & Copley, 2013). In accordance with Rogers' Diffusion of Innovation Theory, according to the study performed by Kowalczyk and Copley (2013), radiologic science educators are neither early nor late adopters, but perhaps fall somewhere in the middle of the continuum. Based on the results of Kowalczyk and Copley (2013), there is a rapid and steady growth in the use of online teaching technologies in radiologic sciences; however, only a minority of programs indicated they offered fully online courses. The status of adoption appears to be to offer hybrid or blended courses, as more than 75% of the educators reported using online activities in this manner (Kowalczyk & Copley, 2013).

Cherry (2015) conducted a quantitative study on radiography faculty perceptions of the effectiveness of asynchronous online courses and found that age, years of teaching experience, type of institution, and faculty position had no significant effect; however, as the years of teaching online courses, number of online courses taught in the last five years, and perceived competence with technology use increase, faculty perceptions increased. The study also showed radiography faculty were satisfied overall with teaching online courses and institutional support, but had neutral responses regarding interactions in online courses (Cherry, 2015). Finally, Cherry (2015) found that overall, faculty perceived online courses to be effective to a significant extent.

JRCERT standards one, two, three, five, and six can be applied to ensure the quality of online radiologic science education programs (Aaron, 2015). Standard Four is withheld because it encompasses student safety, which applies to face-to-face courses and clinical sites (JRCERT, 2014). Standard One addresses the integrity of a program, primarily student privacy (JRCERT, 2014). Informing students about the use and associated costs of online education in the program and providing secure logins aids in compliance of Standard One (Aaron, 2015). Standard Two focuses on resources available to the program; therefore, adequate student learning resources, technical support, and student services consistent with face-to-face courses must be available to support students enrolled in online courses (Aaron, 2015; JRCERT, 2014).

Standard Three evaluates the curriculum and academic practices of the program (JRCERT, 2014). “Instruction and learning experiences should be effective and enhance learning whenever distance education is used” (Aaron, 2015, p. 221). Faculty teaching online courses should be evaluated on their use of distance education methods and technology, as well as their proficiency in online education (Aaron, 2015). Standard Five concentrates on the assessment practices of the program (JRCERT, 2014). All programs must evaluate student learning outcomes regardless of the delivery method and report the findings to the JRCERT (Aaron, 2015). Standard Six relates to institutional and programmatic data, and requires faculty to be qualified for their assignments (JRCERT, 2014). To be successful in online education, faculty must be provided with "adequate training and professional development related to the technology employed and to the teaching methodology" (Aaron, 2015, p. 221).

Faculty Perceptions of Teaching Online

There are some distinct advantages for faculty teaching in an online environment, such as the ability to incorporate additional research information for the learners from outside sources, the option to bring in experts as online guests, and the ability to grade assignments, update course work, etc. from any location any time (Britt, 2006). Cherry (2015) also found faculty reported satisfaction with the convenience and flexibility of teaching online, as well as the opportunity to try innovative teaching methods. As with anything else, with advantages come disadvantages. In terms of online education, faculty disadvantages can include lack of experience with online delivery, limited knowledge and training on designing and implementing an online course, increased amount of time to prepare and maintain the online course with no additional release time provided by the institution, difficulty assessing students' understanding, and additional time required to answer email, schedule online meetings, or respond to discussion posts (Britt, 2006).

Instructor presence is a large contributor to student success in an online environment (Askov, Johnston, Petty, & Young, 2003; Vanek et al., 2018; Zhao, Lei, Yan, Lai, & Tan, 2005). In a study by Richter and Schuessler (2019), participants indicated "an effective faculty to student relationship is 'the most important of all' and when this relationship is strong 'the other falls into place'" (p. 27). Any questions students have regarding an online course must be directed to the instructor via email, which can cause a delay in response that is frustrating to students (Britt, 2006). Britt (2006) also noted peer-to-peer communication and socialization among students is limited to threaded discussion boards and email, which can be discouraging.

When assessing faculty perceptions of interactions in an online course, Cherry (2015) found faculty were satisfied that students were active in communicating regarding course-related matters, and they felt student-to-student interactions were meaningful. However, faculty also felt students were somewhat passive when contacting their instructors and faculty also missed the lack of face-to-face contact with students. Papillion and Aaron (2017) conducted a study regarding student perceptions of online radiologic science courses using a Likert scale of 1-5 (with 5 being the highest). One survey item stated "Timely instructor feedback is necessary and supplements my understanding of course content," had a mean rating of 4.6, making it the second most important component to the participants who completed the survey, just behind "A well-organized course is important for effective learning in online radiologic science courses" (Papillion & Aaron, 2017, p. 370).

Previous studies have demonstrated faculty members' major concerns about teaching online were lack of time for course development, course maintenance, and learning the technology (Cherry, 2015; Kowalczyk, 2014; Richter & Schuessler, 2019), the increased time it takes to grade assignments (Cherry, 2015), the negative impact online teaching has on student evaluations of instruction (Cherry, 2015), lack of technological and institutional support (De Smet et al., 2012; Kowalczyk, 2014; Richter & Schuessler, 2019), and lack of training (Allen & Seamen, 2012; Badia et al., 2017; Bunk et al., 2015; Chen & Chen, 2006; Childs et al., 2005; Horvitz et al., 2015; Jaschik & Lederman, 2017; Kowalczyk, 2014; Richter & Schuessler, 2019; Smidt et al., 2014). Also, beliefs about the effectiveness of online learning in comparison with face-to-face learning play a role in creating feelings of hesitation about teaching online (Cherry, 2015; Sheffield, McSweeny, & Panych, 2015; Zhen, Garthwait, & Pratt, 2008).

A study by Hodges, Way, and Shepherd (2013) also cited frustrations such as technical issues, particularly with the LMS, lack of face-to-face contact with the students, student expectations, and workload. When discussing lack of face-to-face contact with students, while Hodges et al. (2013) found many of the same difficulties previously cited in this discussion, participants also mentioned instructional concerns, as well as inability to get to know students well enough to provide letters of recommendation for future endeavors. One specific frustration of participants in the study by Hodges et al. (2013) was the sense that students feel entitled to an immediate response from instructors, regardless of time of day or proximity to the time an assignment is due. Many students procrastinate and then are left trying to ask questions of the instructor via email outside normal office hours, usually without receiving a response. This perceived delay in response from the instructor often results in a poor instructor evaluation by the student (Hodges et al., 2013).

Buchanan, Sainter, and Saunders (2013) assessed factors affecting faculty use of learning technologies and found that Internet self-efficacy was positively associated with the use of technology by academic faculty. Conversely, low perceived usefulness and inhibiting conditions, such as limited university resources and support, were associated with lower reported use (Buchanan et al., 2013). Gibson, Harris, and Colaric (2008) also evaluated technology acceptance in an academic context in terms of faculty acceptance of online education using the technology acceptance model (TAM). In this study, perceived usefulness was found to be the better predictors of technology acceptance over perceived ease of use.

Wasilik and Bolliger (2009) also studied faculty satisfaction in an online environment and discovered that 93.1% of instructors surveyed indicated that they “looked forward to teaching another online course;” however, the data indicated that instructors were only moderately satisfied with online teaching at the institution studied (p. 177). When assessing positive and negative aspects of teaching online, the findings were similar to previous studies. Major frustrations included technology-related problems, lack of face-to-face contact with students, and lack of student involvement (Wasilik & Bolliger, 2009). Positive aspects included greater flexibility of schedules, improved access to materials, and increased educational opportunities for students who otherwise would not have access to courses (Wasilik & Bolliger, 2009).

Theoretical Framework

Community of Inquiry (CoI) Framework

Garrison, Anderson, and Archer (2000) introduced three elements they believed were crucial to the success of an online learning environment: social presence, cognitive presence, and teaching presence. These elements combine to create a framework known as the Community of Inquiry (CoI) framework. While this framework is often seen as a model for success in any higher education setting, it is particularly important in online environments (Garrison et al., 2000). Social presence refers to "the ability of participants in a community of inquiry to project themselves socially and emotionally, as "real" people (i.e., their full personality), through the medium of communication being used" (Garrison et al., 2000, p. 94). Cognitive presence is defined as "the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse" (Huang et al, 2018, p. 1). Teaching presence involves the instructional design and organization of the course and activities, facilitation of the course and activities, and direct instruction (Huang et al., 2018).

Social Presence

The creation and sustainability of cognitive presence in an online environment is partly dependent on how communication is restricted or encouraged (Garrison et al., 2000). Social presence is arguably one of the more difficult areas of the CoI framework to obtain in an online environment, since the majority of communication is text-based. With text-based communication you lose visual cues present in a face-to-face environment such as facial expression and body language (Garrison et al., 2000). To aid in the success of a social presence in an online environment, the tone of messages should be questioning but engaging, expressive but responsive, skeptical but respectful, and challenging but supportive (Garrison et al., 2000).

To improve social presence in an online environment, Huang et al. (2018) suggested the following ideas: use announcements, emails, videos, etc. to project an online teaching persona; offer optional virtual office hours through an online hosting program such as WebEx, Skype, or Zoom to answer questions and address concerns periodically throughout the semester; and create weekly check-in videos or announcements. Also mentioned was to develop icebreaker course activities to develop early communication and trust; model and encourage the use of verbal immediacy values and encourage students to share anecdotes and personal experiences relevant to the content; and finally, design collaborative activities (Huang et al., 2018). Teachers must also facilitate dialogue by interacting in discussion boards, posing questions and making observations, limiting dominating students when they become a hindrance, and drawing out those students that are less interactive (Garrison & Arbaugh, 2007).

Cognitive Presence

Huang et al. (2018) offered suggestions for promoting cognitive presence in an online environment. For example, identify the main ideas in the content and develop major course activities around the assessment of those ideas. Other suggestions include the following: provide frequent opportunities for testing and feedback; use self-testing, practice assignments, simulations and other interactive activities to support skill development and convergent thinking; provide multiple representations of the knowledge students should acquire and multiple activities for practicing desired skills; and encourage experimentation, divergent thinking, and multiple perspectives in online discussions through provocative, open-ended questions to encourage diverse points of view (Huang et al., 2018). It is important to remember that cognitive presence alone will not sustain a successful learning environment. Individuals must feel comfortable interacting with one another; therefore, another critical element to examine is the social presence in an online environment (Garrison et al., 2000). Also, students will never reach the levels of cognitive presence necessary for learning without properly designed and executed activities through teaching presence (Garrison, Anderson, & Archer, 2010).

Teaching Presence

Teaching presence is viewed “as a significant determinant of student satisfaction, perceived learning, and sense of community” (Garrison & Arbaugh, 2007, p. 163) and acts as the binding element in a community of inquiry (Garrison et al., 2000). Teaching presence causally influences social and cognitive presence (Garrison et al., 2000, 2010). While often considered the most critical element in the CoI, teacher presence is also one of the most difficult to maintain in an online teaching environment (Garrison et al., 2000). Students can also feel separated from teachers and teachers can inadvertently become a bystander in their own course (Garrison & Arbaugh, 2007). Teachers must be engaging, explicit, and transparent in the design and organization of the course to improve the success rate of students in an online environment.

Instructional design and organization can include things like including Power Point presentations and lecture notes onto the course site, developing audio/video mini-lectures, providing personal insights into the course material, creating a desirable mix of individual and group activities, and providing guidelines on how to use the medium effectively (Garrison & Arbaugh, 2007). Finally, direct instruction, while widely debated, is seen in a CoI as necessary because appropriate amounts of interjections through direct instruction can maximize the development of cognitive presence without reducing opportunities for knowledge construction by students (Anderson, 2017). Examples of direct instruction in an online course include “pre-developed presentations, assessing student work and providing instructive feedback, diagnosing misconceptions, clarifying concepts, and referring students to additional resources or practice opportunities” (Indiana University, n.d., para. 3). Often, direct instruction in online courses is achieved through screencasts or synchronous sessions (Bronkey, 2015).

With the integration of new technologies such as blogs, immersive reality systems, synchronous technologies, wikis, and MOOCs, Anderson (2017) speculated on ways the CoI has and is continuing to evolve over the almost 20 years since its inception. The use of CoI to develop online courses has brought about threaded discussions, improved student postings through required activity or additional participation points, better utilization of new and old technology, more appropriate learning activities that promote higher levels of critical thinking, and the integration of social media (Anderson, 2017). Based on these advancements, it is evident that the CoI framework is very essential to the success of online learning environments and provides a framework for lifelong learning as well as formal education.

Diffusion of Innovation (DoI) Theory

Diffusion is “a social process that occurs among people in response to learning about an innovation” (Dearing & Cox, 2018, p. 183). Typically, the innovation is communicated though certain channels over time among the members of a specific social system (Rogers, 2003). The usual dependent variable in a diffusion of innovation is time of adoption; however, in some instances, subsequent implementation is a more accurate measure of change (Dearing & Cox, 2018). Commonly, rates of adoption follow an S-shaped curve with an initial slow rate of adoption giving way to a rapidly accelerating rate, which slows as fewer non-adopters remain (Dearing & Cox, 2018; Rogers, 2003). When the adoption of the innovation is voluntary, acceleration in the rate of diffusion occurs generally because influential members of the social system make the decision to adopt and communicate the decision to the remaining members, who often follow the leaders. Along those same lines, when leaders adopt an innovation, social systems change, but when the leaders do not support adoption of an innovation, systems do not change (Dearing & Cox, 2018).

An innovation is something that is perceived to be new, but not necessarily better, by potential adopters; therefore, diffusion is an atypical outcome – unworthy innovations sometimes diffuse while effective innovations do not (Dearing & Cox, 2018). Factors that affect diffusion include each innovation's set of pros and cons; characteristics of the adopters; and the larger social context (Dearing & Cox, 2018). Adopters fall into one of five categories of innovativeness: (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards (Rogers, 2003).

Innovators are typically venturesome and have a "desire for the rash, the daring, and the risky" (Rogers, 2003, p. 283). Innovators may not be respected by the other members of the social system, but they play an important role in the diffusion process and act as gatekeepers for the flow of new ideas into a system (Rogers, 2003). Early adopters are more integrated into the social system and generally have the highest degree of opinion leadership in most systems. Early adopters serve as a role model for many other members in the social system and help trigger the critical mass when they adopt an innovation (Rogers, 2003). The early majority adopt innovations just before the average members of the system. These adopters also play an important role in the diffusion process because they provide a connection between the very early and relatively late adopters and generally make up one-third of all members of a system (Rogers, 2003).

The late majority adopt new ideas just after the average members of the system and also make up one-third of the social system. For these adopters, accepting the innovation may be an economic necessity and or the result of peer pressure. They are skeptical and cautious and require most of the uncertainty to be resolved before they adopt (Rogers, 2003). Finally, laggards are the last to adopt an innovation in a social system. Laggards generally make decisions based on what was done in the past and they socialize with others who have similar traditional values. They tend to be suspicious of and resistant to innovations and change and must be certain the innovation will not fail before they adopt (Rogers, 2003).

DoI has been used in many disciplines over the past several decades. For example, the health care innovation of Project ECHO was introduced to partner academic medical centers with rural primary care clinicians to extend specialty care in areas (Dearing & Cox, 2018). Project ECHO began at one site in New Mexico in 2003 for hepatitis C care, and by November 2017, there were 158 sites across the US, with 60 more sites in 24 other countries reported incorporating HIV/AIDS, geriatrics, and psychiatric medication management (Dearing & Cox, 2018). DoI has also been used for areas such as adult education practices, drug research by physicians, public policies, social issues, understanding terrorist networks, and understanding public adoption of technology (Scott & McGuire, 2017). DoI has also acted as a bridge for the research-practice gap in areas such as counseling (Murray, 2009) and autism intervention

(Dingfelder & Mandell, 2011), and a framework for research in library and informational sciences (Minishi-Majanja & Kiplang'at, 2005), teachers' adoption of interactive whiteboards (Jwaifell & Gasaymeh, 2013), and the use of technology in hospitality education (Hsu, 2016).

Adult Learning Theory

Adult education was founded as a professional field of practice in the 1920s, at which time study of the way adults learn began (Merriam, 2001). While many scholars dabbled in the field of adult learning, the term andragogy is most closely associated with Malcolm Knowles (Graham, 2017). Knowles (1980) defined andragogy as "the art and science of helping adults learn" (p.43). Knowles proposed a program-planning model for designing, implementing, and evaluating educational experiences with adults based on five assumptions (Merriam, 2001). These five assumptions are as follows: (1) the adult learner has an independent self-concept and can direct his own learning; (2) the adult learner has a bank of life experiences to use as a resource for learning; (3) the adult learner has learning needs closely related to changing social roles; (4) the adult learner is problem-centered and interested in the immediate application of knowledge; and (5) the adult learner is motivated to learn by internal rather than external factors (Merriam, 2001).

Since the proposal by Knowles, many researchers have delved into the topic of adult learning. As a result, "a mosaic of theories, models, principles, and explanations that, when combined, compose the knowledge base of adult learning" (Merriam, 2001, p. 3). Initially, adult learning was regarded as a cognitive process; however, it is currently interpreted as a much broader activity involving the body, emotions, spirit, and the mind (Merriam, 2008). Accepting the idea that adult learning is a multifaceted phenomenon not only changes the way researchers examine how adults learn, but it also plays a role in constructing instructional strategies to foster adult learning. For example, critical reflection is imperative to all areas of adult learning, as well as connecting new learning with learners' previous experiences (Merriam, 2008). According to Merriam (2008), "when storing new sensory input, the brain 'looks for' connections to earlier information" (p. 97). When the information learned has no meaningful links to prior experience, little, if anything, is retained (Merriam, 2008).

Knowles (1978) mentioned applications of the andragogical framework to social work education, religious education, undergraduate and graduate education, and management training. There is growing evidence that the use of the andragogical theory is changing the way programs of adult education are being organized and operated, the way teachers of adults are being trained, and the way adults are being helped to learn (Knowles, 1978). Burge (1988) explored andragogy's application to distance education and believed that the learner-centered approach would contribute to the academic rigor of online courses. Burge (1988) stated that distance educators should tap into learners' experiences, should promote knowledge application through projects and case studies, and should help learners see connections between theory and practice. Gibbons and Wentworth (2001) agreed, stating that online teachers should generate meaningful online dialogue through discussion questions that promote analysis and synthesis. Finally, Darden (2014) stated that within the distance learning context, Knowles' andragogy model optimizes the learning process to ensure the adult learner acquires the information he or she will need.

Summary

Online learning in higher education has become an attractive alternative for non-traditional, adult degree seekers. More and more institutions are implementing online courses, even offering full degrees entirely online. One area that is no exception to this is radiologic sciences. Many entry-level programs offer online courses during the didactic portion of learning, or even have entirely online degrees for students who are already registered as technologists. However, many faculty members in radiologic sciences have been slower to adopt online learning; therefore, it is necessary to create a valid instrument to explore the perceptions of radiologic science faculty members. Chapter 3 outlines the methods associated with investigating radiologic science faculty members' perceptions of the online learning environment. It includes an examination of the data collection methods that were used and a description of the analyses implemented.

CHAPTER 3

METHODOLOGY

The purpose of this study was to provide a valid, reliable instrument that can be used to collect radiologic science faculty members' perceptions of online education. This study extended the existing instrument created by Cherry (2015), and then modified and shortened it using optimal test design. This chapter explains the methodology that was used for the study. The methodology was driven primarily by the research questions and a review of current literature. A quantitative analysis was performed using post-validation analysis involving a multiple regression model with factors as predictors to determine the principal questions of interest, aid in providing validity and reliability of the survey, and provide a shortened form of the instrument. Following the post-validation analysis of the entire survey, the shortened form of optimal questions underwent the same analysis to determine final validity and reliability of the shortened instrument. This research design has provided a shortened, validated, reliable instrument for use in the field of radiology.

Research Questions

The research questions for this study were:

1. What is the current instrument on radiography faculty perceptions of online learning measuring?
2. How consistent is the current instrument on radiography faculty perceptions of online learning?
3. What are the covariates of online education perceptions of radiologic science faculty members using the assembled optimal inventory to measure those perceptions?

Research Design

As previously mentioned, for this study, quantitative methods were used to perform a post-validation analysis involving a multiple regression model with factors as predictors to determine the principal questions of interest and aid in establishing validity and reliability of the survey and to provide a shortened form of the instrument. Following the post-validation analysis of the entire survey, the shortened form of optimal questions underwent the same analysis to determine validity and reliability of the shortened instrument. This research design provided a shortened, validated, reliable instrument for use in the field of radiology. IRB approval was obtained through the University of North Texas on February 11, 2020 for IRB #: IRB-19-540 and can be found in Appendix A.

Participants

The population for the study included 1,715 current faculty members teaching in Joint Review Committee on Education in Radiologic Technology (JRCERT) accredited radiologic science programs nationwide. A list of institutions and faculty members was obtained from the JRCERT. A survey was sent to radiologic science faculty members at hospital-based programs, two-year junior colleges, and four-year universities across the United States. These faculty members are registered technologists in either magnetic resonance imaging, medical dosimetry, nuclear medicine, radiation therapy, radiography, or sonography, hold at minimum a bachelor’s degree, and are currently employed as either program faculty, clinical faculty, program directors, or administration. The only other requirement to participate in this study was that the faculty member must have some experience with online teaching. The aim was to have participants with varying backgrounds, teaching experience, and experience with online education, so the demographic questions included at the beginning of the survey not only provided that information, but also screened out participants with no online experience, and provided information regarding where they might fall in the diffusion of innovation adoption spectrum.

Instrumentation

After permission was granted from the author (see Appendix B), a modified form of the survey entitled *Radiography Faculty Perceptions of Online Education Survey* was developed and used for this study (Cherry, 2015). The original instrument was compiled from three surveys: *Online Faculty Satisfaction Survey* (Wasilik & Bolliger, 2009), *Technology Acceptance* Survey (Gibson et al., 2008), and *Factors Affecting Faculty Use of Technology Survey* (Buchanan et al., 2013), and validation information was not available for the original survey by Cherry (2015). However, for this study, validity and reliability information was obtained post-data collection using optimal test assembly with a 0-1 linear programming approach, which is described further in the Data Analysis section of this chapter.

Establishing Content Validity

A panel of three faculty members with expertise in radiologic sciences and instrumentation analyzed the survey for understandability, clarity, and brevity, as well as to establish a baseline of time needed to complete the instrument. It was the consensus of the experts that there appeared to be three factors being explored in the original survey: perceptions, self-efficacy, and perceived ease of use. The experts stated the survey took approximately 15 minutes to complete. The experts also discussed the possibility that the survey could actually be measuring three different things and agreed that a factor analysis should be performed. Finally, the experts suggested adding an additional answer choice to the first demographic question to encompass all possible faculty roles and to add two additional demographic questions regarding the instructional program the faculty. Since all tests of reliability, validity, and factor analysis were conducted post-data collection, no pilot test was performed. The original survey by Cherry (2015) can be found in Appendix C, and the modified survey used for the study can be found in Appendix D.

Data Collection

The survey that was adapted from Cherry (2015) based on changes suggested by the panel of experts was disseminated to the full participant list via email through SurveyMonkey. The initial dissemination began as soon as IRB approval was obtained. A reminder email was sent one week later, with a final reminder email sent out one week after that. The entire survey period lasted three weeks. The ideal rate of return for this study was based on factor structure. There are potentially three factors in this instrument, so utilizing a 10:1 ratio for responses produces an ideal return rate of approximately 30%. This return rate was not quite achieved with the 402 surveys returned; however, since the exact number of factors was not yet known and the statistical methods being used could still be applied, the 24.9% return rate was deemed acceptable. It is also important to note that of the 402 returned surveys, only 216 qualified to complete the entire survey, and of those 216, 18 had missing data in the Likert-type questions. Further discussion about the method of analysis and treatment of the data can be found in the next section.

Data Analysis

Since previous validity data were not available for the survey and the survey was adapted, new testing had to be conducted to provide accurate reliability and validity information. Once data collection was complete, the results were coded so they could be analyzed by the statistical software, R. Once the information was coded and uploaded in to R, the 198 complete results were split to hold out a portion of the responses. An exploratory factor analysis and an optimal item selection procedure were conducted on the first set of responses to determine the optimal inventory design. Using the identified factor structure with the optimally selected items, the second set of responses was used to validate the optimized factor structure. Optimal test assembly allows assembly of "a test or set of tests…from a large variety of item pools, with a result that is optimal with respect to an objective chosen from a large set of alternatives by the test assembler" (van der Linden, 2005, p. 25).

Procedure

The Likert-type question data uploaded into R were first separated into split-half hold out data called "train" and "test". All initial analyses were conducted on the "train" data only. To determine the number of factors, very simple structure (VSS) analysis in R for both five and three factors was conducted first, which implied a need for only three factors. From there an exploratory factor analysis was run for two, three, four, and five factors where it was verified that three factors were ideal. This was further confirmed through an omega estimate which showed only eight cross-loading items across the three factors. Once the three factors were decided, those eight cross-loading items were thrown out, and a confirmatory factor analysis was conducted using "lavaan" to analyze a full model fit using all of the remaining 59 items. This analysis revealed that the original instrument did not have content or construct validity and the items within the factors were not a good fit.

Based on that information, the next step was to formulate a short form of the instrument. In an effort to minimize the items as much as possible, but still capture a full picture of the domains being explored, a six, seven, and eight item scale analysis was conducted. This analysis revealed that all three instruments were valid; however, the eight item scale provided the most thorough representation of the domains. The six and seven item scales could be used as alternative instruments for longitudinal studies to prevent habituation of responses. Further analysis of the eight item scale presented a convergence issue because Q44 was highly correlated with Q45. To overcome this issue, Q44 was removed from F2, thus making the scale an 8/7/8 item three factor scale.

A multi-group constrained model confirmatory factor analysis was then conducted on the new 8/7/8 scale with thresholds and loadings constrained to accommodate the small sample size. Once this analysis provided information that the "train" data exhibited construct and content validity, a final lavaan full model analysis was conducted on the combined data sets of "train" and "test". This analysis confirmed that the new short form scale exhibited both construct and content validity. The final step was to determine if the scale was reliable. To do this, the omega total coefficient was used to accommodate different loadings. The omega total coefficient was calculated for each factor and the instrument as a whole and all results were deemed reliable with a score of at least 0.70. Through all of these tests, the weakest factor was always Factor 3; however, it did meet all validity and reliability criteria. Arguably, based on the correlation information, item 15 could be dropped, making it an 8/7/7 scale; however, this was not deemed necessary for purposes of this study.

The final steps in data analysis were providing multiple regression analyses. Because of the small sample size, the researcher felt it was important to calculate weighted multiple regression analyses to account for response bias. This was achieved by using the position of the participants as a weight since this information was known prior to distribution of the instrument. The weighted regression analyses were conducted on the “train” data set and revealed a statistically significant relationship between position and competence in all factors, as well as at least two other statistically significant relationships in factors one and two. Including this weighted multiple regression allows for a more accurate representation of the population.

Exploratory Factor Analysis

When determining exploratory factor analysis, while there may be an expected number of factors, “the researcher does not impose a specific latent structure on the observed indicators, but rather allows the optimal number of factors to be determined based on several statistical and interpretability criteria” (Finch & French, 2015, p. 9). For this study, factor analysis was conducted in R using the “VSS” function in the package “psych”. Very Simple Structure (VSS) allows “one to compare solutions of varying complexity and for different number of factors. Graphic output indicates the "optimal" number of factors for different levels of complexity” (Revelle, 2019c, para. 1).

Creating a Short Form Inventory

Using the software package “ShortForm” (Version 0.4.4, Raborn, 2019), the R program used a confirmatory factor analysis (CFA) latent variable analysis (lavaan) (Version 0.6-5, Rosseel, 2019) to validate the factor structure found with the VSS procedure mentioned above. The goal of this retrospective design was to obtain the best set of items for the domain of interest and the composite reliability, Omega, which also serves as a generalizability index for the domain (Zinbarg, Revelle, Yovel, & Li, 2005). To do this, the R packages, “psych”, “lavaan” and “ShortForm” mentioned previously were used. This R package “psych” has a function called “omega” that takes the chosen items and returns the reliability and generalizability coefficients (Revelle, 2019b).

Once this analysis was complete, the optimal items were analyzed using the second half of initial participants to demonstrate construct and content validity and reliability of the chosen items. First, descriptive statistics were calculated to find measures of central tendency and measures of variability. Once descriptive statistics were analyzed, a multiple regression model was used where the outcomes of interest were the scale measures, and the predictors were a set of factors to account for potential demographic confounders (van der Linden, 2005).

Summary

A survey was distributed via email to a population of 1,715 radiologic science faculty members teaching in JRCERT accredited programs across the United States. Upon completion of data collection, post-collection validation and reliability information was conducted to obtain an optimum short form instrument. The same post-collection validation and reliability information was analyzed for the new short form of the instrument providing ultimate validation and reliability of an optimal instrument. The findings of all analyses are discussed in Chapter 4.

CHAPTER 4

RESEARCH FINDINGS

Introduction

An instrument was modified from the original by Cherry (2015) to include two additional demographic questions and remove two Likert-type questions based on the recommendations of the panel of experts that reviewed the original survey. The option of neutral was also removed from the Likert-type questions at the recommendation of the panel to force a decision by the respondents. The modified instrument was disseminated to 1,715 participants via email with a link to the instrument housed in SurveyMonkey. Of those, 105 emails were undeliverable or returned, leaving a total of 1,610 possible respondents. There were 402 respondents in SurveyMonkey, which is a return rate of 24.9%. However, of the 402 respondents, only 216 qualified because the respondents had experience teaching online, and 18 of those had missing information in the Likert-type questions, making the final total number of respondents 198. Before any analysis was conducted, the Likert-type data were coded using a 1-4 scale with 1 representing strongly agree, 2 representing agree, 3 representing disagree, and 4 representing strongly disagree. The Likert-type questions were also numbered 1-67, separating them from the demographic questions. Finally, the responses were separated into training and testing data sets using the train-test split function in R, randomly dividing the participants into two data sets with a 50-50 split (see Figure 1), so the validation and reliability testing could be performed without having to pilot the instrument. While only pertinent data are displayed in this chapter, the researcher did maintain all R coding and results for every analysis conducted.

The coded data was saved in Microsoft Excel as a comma separated values (.csv) file to be uploaded into R. Once the data were uploaded into R, they were separated using the code found in Figure 1. The data labeled as “train” are the data that were used for exploratory factor analysis, initial Omega calculations, and to determine optimal short form analysis. The data labeled “test” are the data that were used to provide validity and reliability information for the optimal short form of the instrument.

```
data(Coded_Survey_Responses)
smp_size = floor(0.5 * nrow(Coded_Survey_Responses))
smp_size
set.seed(1)
train_ind = sample(seq_len(nrow(Coded_Survey_Responses)), size = smp_size)
train = Coded_Survey_Responses[train_ind, ]
test = Coded_Survey_Responses[-train_ind, ]
train
test
```

Figure 1. R Code for separating responses.

Demographic Data

Demographic data were collected from the qualified 216 participants regarding their role as an educator in the field of radiologic sciences. This information came from the modified version of Cherry’s instrument and was analyzed within SurveyMonkey. Of the 216 participants, 41.67% (*n* = 90) were program directors, 30.09% (*n* = 65) were program faculty, 25.93% (*n* = 56) were clinical coordinators, and 2.31% (*n* = 5) listed other and cited instructor, retired, assistant program director, dean, and university provost. The two primary types of institutions employing the participants were four-year colleges or universities with 41.67% (*n* = 90), and community colleges with 38.89% (*n* = 84). Other types of institutions included hospitals at 7.87% (*n* = 17), technical college-institutes at 6.02% (*n* = 13), and proprietary institutions at 1.85% (*n* = 4). The remaining 3.7% (*n* = 8) selected other; however, their responses indicated programs that were listed above such as hospital-based, private college, and career college. One response did indicate a two-year university.

When asked about their current entry-level radiologic science program, the participants shared the following: 47.22% (*n* = 102) indicated the availability of an associate degree program with simultaneous didactic/clinical curriculum, 30.56% (*n* = 66) indicated the availability of a bachelor's degree program with simultaneous didactic/clinical curriculum, 7.41% (*n* = 16) indicated the availability of an associate degree program with separate didactic/clinical curriculum, 6.48% (*n* = 14) indicated the availability of a certificate program with simultaneous didactic/clinical curriculum, and 6.02% (*n* = 13) indicated the availability of a bachelor's degree program with separate didactic/clinical curriculum. The remaining 2.31% (*n* = 5) indicated other, with responses including not currently teaching, teaching in two programs: both AAS at community college and BS at four-year university, and master's degree programs with simultaneous didactic/clinical curriculum.

In reference to those radiologic science programs, the participants were asked to select the primary discipline of their instructional program. For this question, there were only 215 responses: 84.19% (*n* = 181) teach in radiography, 6.98% (*n* = 15) teach in magnetic resonance imaging, 3.72% (*n* = 8) teach in radiation therapy, 1.4% (*n* = 3) teach in sonography, and 0.46% (*n* = 1) teach in nuclear medicine. The remaining 3.25% (n = 7) had one not currently teaching, two teaching in medical dosimetry, one teaching in computed tomography, radiography, and magnetic resonance imaging, one teaching in computed tomography and magnetic resonance imaging, one teaching in radiography and magnetic resonance imaging, and one teaching in radiography, computed tomography, magnetic resonance imaging, and sonography. Information about the participants' ages and teaching experience are shown in Table 1.

Table 1

Age and Teaching Experience

Factor		*n*	%
Age	18-30	5	2.31
	31-50	125	57.87
	51-60	60	27.78
	61 or older	26	12.04
Years Teaching in Radiologic Sciences	Less than 1	2	0.92
	1-5	43	19.91
	6-10	44	20.37
	11-15	47	21.76
	16 or more	80	37.04
Years Teaching Online in Radiologic Sciences *this question only had 215 responses	Less than 1	14	6.51
	1-5	96	44.65
	6-10	57	26.51
	11-15	35	16.28
	16 or more	13	6.05
Number of Online Courses Taught in the Past 5 Years *this question only had 215 responses	1-5	102	47.44
	6-10	37	17.21
	11-15	17	7.91
	16-20	21	9.77
	21 or more	38	17.67

The final demographic question asked of the participants was regarding their perceived level of competence with technology. Of the 216 respondents, 54.63% (*n* = 118) rated themselves as having above average competence, 23.61% (*n* = 51) rated themselves as having excellent competence, 21.3% (*n*=46) rated themselves as having average competence, and 0.46% (*n* = 1) rated themselves as having poor competence.

Likert-Type Question Data

The remaining items on the modified version of Cherry's instrument are Likert-type questions with a scale of strongly agree (1), agree (2), disagree (3), and strongly disagree (4). All 67 were analyzed using the "train" data set (*n* = 99) to determine the optimal number of factors to be included and were analyzed for five and three possible factors using very simple structure (VSS) in R. The reason for starting with five factors is because the original research conducted by Cherry (2015) implied five factors in the discussion of the data. However, after running the five factor VSS, it was evident that there were really only three main factors; however, until the short form analysis was conducted, these factors were not yet identified. The code for the three factor VSS configuration, as well as the plotted results are shown in Figure 2.

```
vss.fit<-vss(train.nona, n=3, rotate="varimax")
```

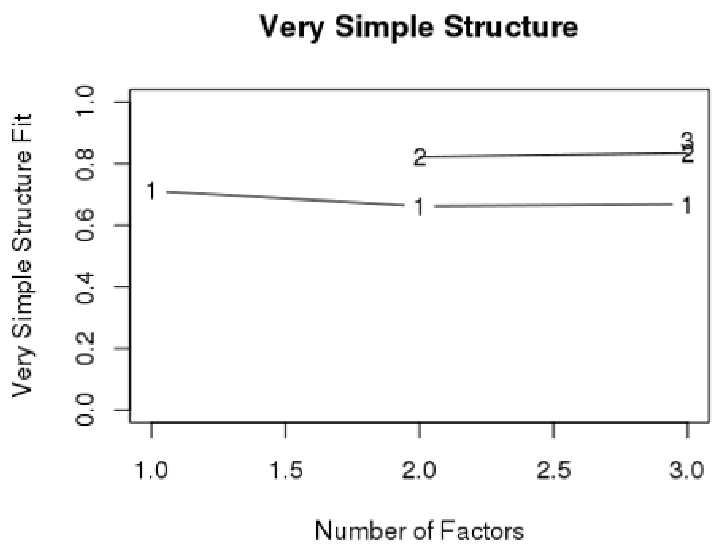


Figure 2. VSS code and plot for 3 factors

Exploratory Factor Analysis

Based on these results, the next analysis needed was an exploratory factor analysis. Using the library "psych", an analysis of "fa with minres", which is a factor analysis with the minimal residual algorithm, was conducted in R on Cherry's (2015) original 67 items with the "train" data set (*n* = 99). This approach is an "unweighted least squares solution" (Revelle, 2019a, para. 10) that uses the "optim" function and produces results most like maximum likelihood. This analysis was run for possible five, four, three, and two factors to be sure the implications drawn from the VSS analysis were correct. After analyzing the results of all factor analyses, it was determined that the same three factor solution was the best for this instrument. The code used to run the factor analysis as well as the fit information can be found in Figure 3.

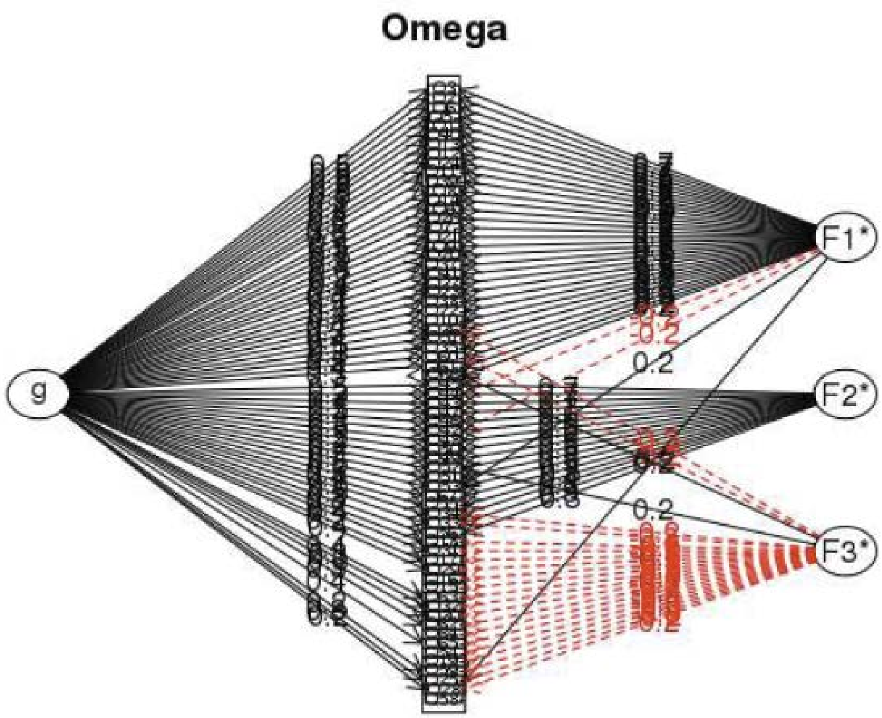
```
train.fa3 <- fa(r=train.nona.corr, nfactors=3, rotate="varimax")
train.fa3

The root mean square of the residuals (RMSR) is  0.08
## The df corrected root mean square of the residuals is  0.08
##
## Fit based upon off diagonal values = 0.92
## Measures of factor score adequacy
##                                                    MR1  MR2  MR3
## Correlation of (regression) scores with factors   0.98 0.98 0.94
## Multiple R square of scores with factors          0.96 0.96 0.88
## Minimum correlation of possible factor scores     0.93 0.91 0.76
```

Figure 3. FA code and fit information for 3 factors.

After analyzing the results shown in Figure 3, it was evident that three factors were acceptable; however, some of the questions had a negative factor loading. The questions that displayed a negative factor loading were reviewed and determined to have an opposite wording as the other questions within the grouping; however, they were still a fit for the factor demonstrated in the analysis.

As a final method of verifying the three factor analysis, an “omega” estimate was calculated in the “psych” package of R. This function takes the factor analysis data, rotates the factors obliquely, performs a Schmid Leiman transformation, and then finds omega (Revelle, 2019b). The results of this estimate are helpful to identify specific cross-loading questions. An “omega” estimate was calculated for five, four, three, and two factors on the modified version of Cherry’s instrument, just as the VSS and FA were. Again, the three factor omega demonstrated the best fit, but it is still not clear what the factors are representing since the short form analysis has not yet been conducted. Results of the omega analysis are demonstrated in Figure 4.

```
library(psych)
omega.fit.3<-omega(train.nona.corr, nfactors=3, rotate="promax")
```




```
omega.fit.3
```

Figure 4. Omega Fit 3 factor plot.

As demonstrated in the graphic in Figure 4, factor one (F1) appears to have only four cross-loading questions, factor two (F2) appears to have no cross-loading questions, and factor three (F3) appears to have four cross-loading questions. This can be determined by the broken lines and solid lines leading from F1 to F2 (3) and F3 (1), and the broken and solid lines leading from F3 to F1 (3) and F2 (1). When looking at measures of factor score adequacy, all three factors had a correlation of scores with factors greater than 0.85 and a multiple R square of scores with factors greater than 0.7. Also, the omega total for total scores and subscales was 0.82 or greater for all factors. These are in line with the general rule of thumb of a minimum of 0.7 for internal reliability (Tay & Jebb, 2016). After reviewing the questions contained in each factor and agreeing with the results, it was decided to maintain a three factor structure for this instrument.

Confirmatory Factor Analysis and ShortForm

Once the exploratory factor analysis was complete and the instrument was deemed to have three factors, a confirmatory factor analysis was conducted on the original 67 items with the data set “train” (*n* =99) using the package “lavaan” on the full model fit with all items defined by the three factor structure discussed previously. This model produced covariances of F1 – F2 at 0.324 with p value of 0.001, F1 – F3 at -0.205 with p value of 0.053, and F2 – F3 at -0.165 with p value of 0.128. The goodness-of-fit indices for the full model were as follows: Comparative Fit Index (CFI) = 0.605, Tucker Lewis Index (TLI) = 0.590, Standardized Root Mean Residual (SRMR) = 0.118, and Root Mean Square of Approximation (RMSEA) = 0.1.

The thresholds for “good” fit for each of these variables are: CFI ≥ 0.90, TLI ≥ 0.95, SRMR < 0.08, and RMSEA < 0.08 (Parry, n.d.). However, for this study, a threshold of “adequate” fit for SRMR and RMSEA of 0.12 and 0.10 respectively (Kline, 2016) was deemed appropriate because of the small sample size. Based on the cutoffs, these results provide statistical evidence that the full item instrument did not exhibit construct or content validity and the items did not have an acceptable goodness of fit, thus exhibiting the need for an optimized short form..

```
lavaan.model.specs = list(model.type = "cfa",
                          auto.var = TRUE, estimator = "default",
                          ordered = unlist(allItems) , int.ov.free = TRUE,
                          int.lv.free = FALSE, std.lv = TRUE, auto.fix.first = FALSE,
                          auto.fix.single =TRUE, auto.cov.lv.x = TRUE, auto.th = TRUE,
                          auto.delta = TRUE, auto.cov.y =TRUE)
```

Figure 5. Lavaan model specs code for antcolony optimization.

```
scalesShortForm = antcolony.lavaan(data = origData.2,
                           # Works best with ant=1
                           ants = 1,
                           evaporation = 0.70,
                           # Initial model to start  with
                           antModel = Model.Init,
                           # All items to select from
                           list.items = allItems,
                           full = 59,
                           lavaan.model.specs=lavaan.model.specs,
                           # Items to retain per factor
                           i.per.f =c(6, 6, 6),
                           factors = c('F1','F2','F3'),
                           steps = 1,
                           fit.indices = c('cfi', 'srmr', 'pgfi', 'tli', 'rmsea'),
                           fit.statistics.test = "(cfi > 0.90)&(rmsea<.05)&(tli>

                           0.90)&(pgfi>.60)&(srmr<.15)",
                           feedbackfile = "fb.out",
                           summaryfile = "sf.out",
                           max.run = 300,
                           verbose=TRUE)
```

Figure 6. Antcolony optimization code.

The next step was building the short form of the instrument using “antcolony”, “lavaan”, and “ShortForm” in R. A polychoric correlation matrix was used instead of a Pearson correlation because the scale used in the instrument is ordinal, not continuous.

The first step was to initialize the “lavaan” model specifications before optimization. The code for that is shown in Figure 5. It is important to note that using “ordered” as an option is critical for the calculations to converge. All eight cross-loading questions were thrown out making the total number of items 59, the “antcolony” optimization code was entered (Figure 6), and six, seven, and eight item short form scales were produced

After reviewing the results of the six, seven, and eight item short form scales, all exhibited construct and content validity and the results were similar; however, the eight item scale demonstrated the most thorough representation of the domains. It should not be discounted that there is a possibility for using the six and seven item scales as alternate scales for longitudinal studies to prevent habituation of items.

```
# Fit statistics;   Items that are in the scale have a 1 in the column.
scalesShortForm.8.bak

##            cfi      srmr      pgfi       tli      rmsea mean_gamma Q1 Q2 Q3 Q4
## [1,] 0.994441 0.1078515 0.7163586 0.9938382 0.05273433      0.301  0  0  1  0
##      Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q20 Q21 Q22 Q23 Q24 Q26 Q27 Q37 Q38 Q39
## [1,]  1  1  0  0  0   0   0   1   0   0   0   0   1   0   0   1   0   0   1   1
##      Q40 Q41 Q57 Q61 Q34 Q42 Q43 Q44 Q45 Q46 Q47 Q48 Q49 Q50 Q51 Q52 Q53 Q55
## [1,]   0   0   0   0   0   1   0   1   1   1   1   0   0   0   1   1   0   0
##      Q56 Q67 Q15 Q16 Q17 Q18 Q19 Q29 Q30 Q31 Q32 Q54 Q59 Q62 Q63 Q64 Q65
## [1,]   1   0   1   0   0   0   0   1   0   0   1   1   0   1   1   1   1

scalesShortForm.7.bak

##             cfi       srmr       tli      rmsea mean_gamma Q1 Q2 Q3 Q4 Q5 Q6 Q7
## [1,] 0.9917742 0.09888815 0.9907128 0.05926058      0.305  1  0  0  0  0  1  0
##      Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q20 Q21 Q22 Q23 Q24 Q26 Q27 Q37 Q38 Q39 Q40 Q41
## [1,]  0  0   0   1   0   0   1   0   0   0   1   0   1   0   1   0   0   0   0
##      Q57 Q61 Q34 Q42 Q43 Q44 Q45 Q46 Q47 Q48 Q49 Q50 Q51 Q52 Q53 Q55 Q56 Q67
## [1,]   0   0   0   0   1   1   1   1   0   1   0   0   1   0   0   0   0   1
##      Q15 Q16 Q17 Q18 Q19 Q29 Q30 Q31 Q32 Q54 Q59 Q62 Q63 Q64 Q65
## [1,]   0   0   0   1   0   1   1   0   1   1   1   0   1   0   0

scalesShortForm.6.bak

##             cfi       srmr      pgfi       tli      rmsea mean_gamma Q1 Q2 Q3 Q4
## [1,] 0.9979322 0.08976708 0.6384302 0.9976032 0.02655846      0.246  0  1  1  0
##      Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q20 Q21 Q22 Q23 Q24 Q26 Q27 Q37 Q38 Q39
## [1,]  0  0  0  0  0   0   0   0   1   0   1   0   1   0   0   0   0   0   0   1
##      Q40 Q41 Q57 Q61 Q34 Q42 Q43 Q44 Q45 Q46 Q47 Q48 Q49 Q50 Q51 Q52 Q53 Q55
## [1,]   0   0   0   0   0   1   0   0   0   0   0   0   1   1   1   0   1   0
##      Q56 Q67 Q15 Q16 Q17 Q18 Q19 Q29 Q30 Q31 Q32 Q54 Q59 Q62 Q63 Q64 Q65
## [1,]   0   1   0   1   0   0   0   0   1   1   1   0   1   0   1   0   0
```

Figure 7. ShortForm scales.

Figure 7 shows the fit statistics for scalesShortForm.8.bak, scalesShortForm.7.bak, and scalesShortForm.6.bak. The ShortForm7 scale was modified to remove pgfi to allow for convergence of the model. The data shown are the 0-1 linear programming data where 1 indicates inclusion in the scale and 0 indicates that they were not included.

Table 2 displays the model fit statistics for each of the item scales. Note that the fit measures use the scaled versions of CFI and TLI for a more accurate representation to compensate for the standardization of factors.

Table 2

Fit Measures for ShortForm Scales

	8 item scale	7 item scale	6 item scale
Covariance F1 – F2	0.274 / p 0.001	0.319 / p 0.000	0.441 / p 0.000
Covariance F1 – F3	-0.351 / p. 0.000	-0.368 / p 0.000	-0.311 / p 0.001
Covariance F2 – F3	-0.287 / p 0.001	-0.223 / p 0.010	-0.337 / p 0.000
CFI-scaled	0.991	0.990	0.997
TLI-scaled	0.992	0.991	0.997
SRMR	0.108	0.099	0.090
RMSEA	0.010	0.030	0.000

As shown in Table 2, across the scales, the covariances have small but meaningful relationships and the direction (positive or negative) makes sense for the data represented. The correlations are low indicating they are relatively independent of the other two domain factor scores. Also, all covariances were statistically significant. The content validity as demonstrated by the CFI-scaled and TLI-scaled results was greater than the cutoff and almost a perfect score of 1. The RMSEA is also better than the cutoff with measures of less than 0.08 with almost a perfect score of 0. The SRMR is not within the “good” cutoff range; however, it is within the “adequate” range deemed appropriate for this study, making it acceptable.

Table 3 demonstrates the comparison between the full model fit statistics of the original 67 items and the eight item scale to show the improvement made by creating a short form of the instrument. The covariances of the full model and eight item scale are similar; however, all three are statistically significant in the eight item scale. There is also a marked increase in the CFI and TLI numbers with the eight item scale, indicating a much more valid instrument. The SRMR and RMSEA decreased, bringing the RMSEA below the recommended cutoff of 0.08.

Table 3

Comparison of Fit Measures for Full Model versus 8 Item Scale

	Full Model	8 item scale
Covariance F1 – F2	0.324 / p 0.001	0.274 / p 0.001
Covariance F1 – F3	-0.205 / p 0.053	-0.351 / p. 0.000
Covariance F2 – F3	-0.165 / p 0.106	-0.287 / p 0.001
CFI / CFI-scaled	0.605	0.991
TLI / TLI-scaled	0.590	0.992
SRMR	0.118	0.108
RMSEA	0.100	0.010

After the eight item scale was determined to be the best choice for this instrument, the items included in each factor were reviewed. The items included in each factor are shown in Table 4. The items included in each factor did seem to reflect the same domain. F1 assesses faculty valuation of online education, F2 evaluates faculty self-efficacy in terms of online technology, and F3 examines faculty perceptions of institution valuation of online education. To reinforce the possibility mentioned previously of using the six and seven item scales as alternative forms for additional or longitudinal studies, Table 5 illustrates the items by factor for each of those scales.

Table 4

8 Item Scale by Factor

Factor	Items
F1	Q3 + Q5 + Q6 + Q12 + Q22 + Q26 + Q38 + Q39
F2	Q42+ Q44 + Q45 + Q46 + Q47 + Q51 + Q52 + Q56
F3	Q15 + Q29 + Q32 + Q54 + Q62 + Q63 + Q64 + Q65

Table 5

6 and 7 Item Scales by Factor

	6 Item Scale	7 Item Scale
F1	Q2 + Q3 + Q13 + Q20 + Q22 + Q39	Q1 + Q6 + Q11 + Q14 + Q23 + Q26 + Q37
F2	Q42 + Q49 + Q50 + Q51 + Q53 + Q67	Q43 + Q44 + Q45 + Q47 + Q48 + Q51 + Q67
F3	Q16 + Q30 + Q31 + Q32 + Q59 + Q63	Q18 + Q29 + Q30 + Q32 + Q54 + Q59 + Q63

When further analyses were attempted on the eight item scale, it was discovered that Q44 was highly correlated with Q45 which caused model convergence issues. The decision was made to remove Q44 and have an 8/7/8 item scale with the three factors. This improved the goodness of fit considerably. Table 6 shows the new item layout for the instrument.

Table 6

8/7/8 Item Scale by Factor

	8/7/8 Item Scale
F1	Q3 + Q5 + Q6 + Q12 + Q22 + Q26 + Q38 + Q39
F2	Q42 + Q45 + Q46 + Q47 + Q51 + Q52 + Q56
F3	Q15 + Q29 + Q32 + Q54 + Q62 + Q63 + Q64 + Q65

Validating Scales with Multigroup CFA and Hold-Out Data

Once the new scale was identified, both groups of data (“train” and “test”) were analyzed for the remaining tests, making the new n = 198. First, the syntax for measurement equivalence was evaluated. This analysis, “measEq.syntax”, “automatically generates lavaan model syntax to specify a CFA model with equality constraints imposed on user-specified measurement (or structural) parameters” (Jorgensen, n.d., para. 1). The syntax can also “return the fitted model (if data are provided) representing some chosen level of measurement equivalence/invariance across groups and/or repeated measures” (Jorgensen, n.d., para. 1). To identify the location and scale of each common factor, the factor means and variances were fixed to 0 and 1, respectively, unless equality constraints on measurement parameters allow them to be freed. The location and scale of each latent item-response underlying 21 ordinal indicators were identified using the "delta" parameterization, and the identification constraints recommended by Wu and Estabrook (2016). See Figure 8.

```
##     F1  F2  F3
## Q3  ord
## Q5  ord
## Q6  ord
## Q12 num
## Q22 ord
## Q26 ord
## Q38 ord
## Q39 ord
## Q42     ord
## Q45     ord
## Q46     ord
## Q47     ord
## Q51     ord
## Q52     ord
## Q56     num
## Q15         ord
## Q29         ord
## Q32         ord
## Q54         ord
## Q62         ord
## Q63         ord
## Q64         ord
## Q65         ord
```

Figure 8. Pattern matrix indicating num(eric), ord(ered), and lat(ent) indicators per factor.

The confirmatory factor analysis was then conducted on the new 8/7/8 scale on the "train" and "test" data sets (n = 198), with the appropriate measurement parameters now in place. Thresholds and loadings were also constrained to accommodate the small sample size. The code for the multigroup constrained confirmatory factor analysis is shown below in Figure 9.

```
## Fit multigroup constrained model to the data
fit.metric <- cfa(mod.metric, data =train.test.df, group = "grp",
                    estimator="DWLS",
                    auto.var=TRUE,
                    auto.fix.first=FALSE,
                    std.lv=TRUE,
                    auto.cov.lv.x=TRUE,
                    parameterization = "theta")
```

Figure 9. Multigroup constrained model CFA code.

The new covariances for the "train" group are as follows: F1-F2 = 0.467, F1-F3 = -0.184, and F2-F3 = -0.317, all with a p value equal to 0.000. Group two "test" covariances were: F1-F2 = 0.499, F1-F3 = -0.462, F2-F3 = -0.589. The fit measures for this multigroup CFA were: CFI: 0.977, TLI: 0.976, SRMR: 0.118, and RMSEA: 0.091. For the final CFA, the data sets were combined and analyzed as a full model with all data and no constraints across groups. The code for that analysis is shown in Figure 10, and the results are displayed in Table 7.

```
# Full model (not including Q44) with all data (no constraints across groups)
best.model.fit.8 <- lavaan(model = Model.best.8,
                           data = train.test.df,
                           estimator="DWLS",
                           ordered = unlist(names(train.test.df))[-1],
                           # Don't include "grp"
                           auto.var=TRUE,
                           auto.fix.first=FALSE,
                           std.lv=TRUE,
                           auto.cov.lv.x=TRUE)
```

Figure 10. Full model lavaan code.

Table 7

Fit Measures for Full Model Short Form of Instrument

	Full Model
Covariance F1 – F2	0.377 / p 0.000
Covariance F1 – F3	-0.304 / p 0.000
Covariance F2 – F3	-0.383 / p 0.000
CFI	0.987
TLI	0.989
SRMR	0.093
RMSEA	0.061

The results of this analysis demonstrated that the new three factor, 8/7/8 item scale short form instrument exhibited both construct and content validity. The next step was to determine reliability of the new instrument. To determine this, the omega total (omega t) coefficient was used for each factor. The reason for utilizing the omega coefficient instead of Cronbach's alpha was because omega allows loadings to be different, which best suits this study and provides a more accurate reliability readout (Dunn, Baguley, & Brunsden, 2013). F1 had an omega total value of 0.89, F2 had an omega total value of 0.86, and F3 had an omega total value of 0.70. The omega total for the full instrument was 0.87. Following the general rule of thumb for acceptable reliability scores of a minimum of 0.70 (Tay & Jebb, 2017), all factors, and the overall short form instrument are deemed reliable.

Regression Analyses

The final analyses conducted were weighted multiple regressions. Multiple regression provides information to "predict the value of a variable based on the value of two or more other variables" (Laerd Statistics, n.d., para. 1). Also, multiple regression analysis can help “determine the overall fit of the model and the relative contribution of each of the predictors to the total variance explained” (Laerd Statistics, n.d., para. 3). For this study, a weighted multiple regression analysis with relative importance values was conducted to also off-set response bias. The weighting for these analyses came from the position of the respondents (i.e. program directors, clinical coordinators, program faculty, or other). This information was available in the original email list provided by the JRCERT, so comparing the original numbers of respondents that hold that title with the statistics provided from respondents who completed the survey, weighting adjustments were made.

When analyzing the weighted multiple regressions, the new 8/7/8 item Likert-type questions were brought together with the nine demographic questions and analyzed by factor for the “train” data set (n = 99). The code for these analyses as well as the coefficients produced are shown in Figures 11 and 12. For F1, the proportion of variance explained by the model was 39.73%. Of this variance, the three items that produced statistically significant relationships with position were technology competence ($p = 0.00$), number of online courses taught in the past 5 years ($p = 0.01$), and age ($p = 0.01$). The relative importance of these three relationships were 26.64%, 21.19%, and 16.79% of the total 39.73% variance, respectively. For F2, the proportion of variance explained by the model was 48.33%. Of this variance, the four items that produced statistically significant relationships with position were technology competence ($p = 0.00$), position 1 (program director) ($p = 0.00$), years of teaching experience ($p = 0.03$), and position 4, which was “other” ($p = 0.03$). The relative importance of these relationships were 62.24% (technology competence), 12.10% (position), and 4.45%

(years of teaching experience) of the total 48.33% variance. Finally, F3 produced a proportion of variance of 30.29% with only one statistically significant relationship with position: technology competence (p = 0.03). However, technology competence only accounts for 11.76% of the total 30.29% variance. The results of this weighted multiple regression allow for a more accurate representation of the population.

```
# F1
lm.f1.fit.8<-lm(F1 ~ factor(Position) + factor(Institution) + factor(Program) +
                  factor(Discipline) + Age + Years.Teaching + Years.Online +
                  Online.Courses + Competence, data=best.model.fit.8.pred)

# F2
lm.f2.fit.8<-lm(F2 ~ factor(Position) + factor(Institution) + factor(Program) +
                  factor(Discipline) + Age + Years.Teaching + Years.Online +
                  Online.Courses + Competence, data=best.model.fit.8.pred)

# F3
lm.f3.fit.8<-lm(F3 ~ factor(Position) + factor(Institution) + factor(Program) +
                  factor(Discipline) + Age + Years.Teaching + Years.Online +
                  Online.Courses + Competence, data=best.model.fit.8.pred)
```

Figure 11. Regression model code for F1, F2, and F3.

```
# F1

## Coefficients:
##                        Estimate Std. Error t value Pr(>|t|)
## (Intercept)            -1.23977    0.82769  -1.498 0.138421
## factor(Position)2      -0.28329    0.23478  -1.207 0.231413
## factor(Position)3      -0.28893    0.23336  -1.238 0.219582
## factor(Position)4      -0.02234    0.64187  -0.035 0.972324
## factor(Institution)2 -0.01352    0.29001  -0.047 0.962937
## factor(Institution)3 -0.18582    0.40804  -0.455 0.650164
## factor(Institution)4  0.77028    0.72316   1.065 0.290264
## factor(Institution)5 -0.03927    0.62733  -0.063 0.950254
## factor(Institution)6 -0.34254    0.64281  -0.533 0.595714
## factor(Program)2       0.11945    0.67103   0.178 0.859203
## factor(Program)3      -0.12254    0.76413  -0.160 0.873027
## factor(Program)4       0.16940    0.73387   0.231 0.818087
## factor(Program)5      -0.44274    0.84699  -0.523 0.602729
## factor(Program)6      -0.41379    1.10351  -0.375 0.708748
## factor(Discipline)2  -0.82448    1.00318  -0.822 0.413793
## factor(Discipline)3  -0.74423    0.61360  -1.213 0.229028
## factor(Discipline)4  -0.47065    0.36745  -1.281 0.204242
## factor(Discipline)5  -0.65475    0.95822  -0.683 0.496553
## factor(Discipline)6  -0.08459    0.73802  -0.115 0.909060
## Age                    0.39907    0.16433   2.428 0.017595 *
## Years.Teaching         0.02177    0.12665   0.172 0.863969
## Years.Online           0.04937    0.13712   0.360 0.719811
## Online.Courses        -0.19662    0.07874  -2.497 0.014754 *
## Competence             0.52759    0.15175   3.477 0.000853 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8435 on 74 degrees of freedom
## Multiple R-squared:  0.3973, Adjusted R-squared:   0.21
## F-statistic: 2.121 on 23 and 74 DF,  p-value: 0.008089
```

```
# F2

## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)            -2.164397   0.735148  -2.944  0.00432 **
## factor(Position)2       0.353852   0.208528   1.697  0.09392 .
## factor(Position)3       0.194943   0.207269   0.941  0.35001
## factor(Position)4       1.232301   0.570108   2.162  0.03389 *
## factor(Institution)2 -0.174138   0.257582  -0.676  0.50112
## factor(Institution)3 -0.407929   0.362421  -1.126  0.26399
## factor(Institution)4  0.403369   0.642305   0.628  0.53194
## factor(Institution)5  0.088412   0.557190   0.159  0.87436
## factor(Institution)6  0.562996   0.570943   0.986  0.32731
## factor(Program)2        0.097741   0.596006   0.164  0.87018
## factor(Program)3       -0.643034   0.678696  -0.947  0.34649
## factor(Program)4       -0.273329   0.651820  -0.419  0.67619
## factor(Program)5       -0.644519   0.752291  -0.857  0.39435
## factor(Program)6        0.692927   0.980127   0.707  0.48180
## factor(Discipline)2  -0.833661   0.891019  -0.936  0.35251
## factor(Discipline)3   0.018431   0.544996   0.034  0.97311
## factor(Discipline)4  -0.303722   0.326366  -0.931  0.35508
## factor(Discipline)5   0.155281   0.851086   0.182  0.85573
## factor(Discipline)6   0.068941   0.655501   0.105  0.91652
## Age                     0.007609   0.145959   0.052  0.95856
## Years.Teaching          0.240103   0.112487   2.134  0.03611 *
## Years.Online           -0.100380   0.121787  -0.824  0.41246
## Online.Courses          0.060195   0.069940   0.861  0.39221
## Competence              0.860649   0.134785   6.385 1.34e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7492 on 74 degrees of freedom
## Multiple R-squared:  0.4833, Adjusted R-squared:  0.3228
## F-statistic:  3.01 on 23 and 74 DF,  p-value: 0.00018

calc.relimp(lm.f2.fit.8, rank=TRUE, rela=TRUE)
```

```
# F3

## Coefficients:
##                        Estimate Std. Error t value Pr(>|t|)
## (Intercept)             0.35617    0.83821   0.425   0.6721
## factor(Position)2       0.26829    0.23776   1.128   0.2628
## factor(Position)3       0.12750    0.23633   0.539   0.5912
## factor(Position)4      -0.16730    0.65003  -0.257   0.7976
## factor(Institution)2    0.11469    0.29369   0.390   0.6973
## factor(Institution)3   -0.06669    0.41323  -0.161   0.8722
## factor(Institution)4   -1.39396    0.73235  -1.903   0.0609 .
## factor(Institution)5   -0.44690    0.63530  -0.703   0.4840
## factor(Institution)6    0.20945    0.65098   0.322   0.7485
## factor(Program)2        0.02477    0.67956   0.036   0.9710
## factor(Program)3       -0.14367    0.77384  -0.186   0.8532
## factor(Program)4        0.22317    0.74320   0.300   0.7648
## factor(Program)5       -0.08510    0.85776  -0.099   0.9212
## factor(Program)6       -0.26332    1.11753  -0.236   0.8144
## factor(Discipline)2    -0.30723    1.01593  -0.302   0.7632
## factor(Discipline)3     0.61743    0.62140   0.994   0.3237
## factor(Discipline)4     0.34651    0.37212   0.931   0.3548
## factor(Discipline)5     0.73449    0.97040   0.757   0.4515
## factor(Discipline)6    -0.91740    0.74740  -1.227   0.2235
## Age                    -0.04869    0.16642  -0.293   0.7707
## Years.Teaching         -0.06156    0.12826  -0.480   0.6327
## Years.Online            0.10412    0.13886   0.750   0.4557
## Online.Courses         -0.04399    0.07975  -0.552   0.5828
## Competence             -0.32190    0.15368  -2.095   0.0396 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8542 on 74 degrees of freedom
## Multiple R-squared:  0.3029, Adjusted R-squared:  0.08619
## F-statistic: 1.398 on 23 and 74 DF,  p-value: 0.1416
```

Figure 12. Regression model coefficients for F1, F2, and F3.

Summary

Survey data were collected from 216 respondents via SurveyMonkey over a three-week period. Of those responses, 198 were deemed complete and acceptable for analysis. The demographic data were analyzed in SurveyMonkey and the Likert-type questions were numbered 1-67 and coded for use in R. The coded data were uploaded into R and separated into split-half hold out data sets, “train” and “test” (*n* = 99 for each).

Multiple analyses were conducted on the "train" data, including exploratory factor analysis, latent variable analyses (lavaan), confirmatory factor analyses, and short form optimization. Once the short form was created using a three factor, 8/7/8 item scale, further confirmatory factor analyses and lavaan analyses were conducted to validate the new instrument. Once validation was achieved, omega coefficients were analyzed on each factor, as well as the short form instrument as a whole and all were determined reliable. Finally, weighted regression analyses were conducted displaying the relationships between factors and demographics and accounting for response bias. Further discussion of these data as well as conclusions about the study as a whole and implications for further research are discussed in Chapter 5.

CHAPTER 5

DISCUSSION AND CONCLUSIONS

Introduction

The purpose of this chapter is to present the summary and conclusions. While research suggests that overall there is an increase in online education, radiologic sciences has been slower to adopt this practice. In previous studies outside radiologic sciences, faculty had an overall pessimistic view of online education (Allen & Seamen, 2012). Limited training in education and online instruction is noted in many studies as contributing to negative faculty perceptions toward teaching online (Allen & Seamen, 2012; Badia, Garcia, & Meneses, 2017; Bunk et al., 2015; Chen & Chen, 2006; Childs, Blenkinsopp, Hall, & Walton, 2005; Horvitz, Beach, Anderson, & Xia, 2015; Jaschik & Lederman, 2017; Smidt, McDyre, Bunk, Li, & Gatenby, 2014).

When attempting to explore the attitudes of radiologic science faculty members, an extensive search for an instrument was conducted using the following academic databases: Academic Search Complete, CINAHL Complete, EbscoHost, ERIC, Health Source: Nursing/Academic Edition, JSTOR, MEDLINE Complete, MedOne Radiology, ProQuest, PsycARTICLES, PsycINFO, PUBMed, and ScienceDirect College Edition. Search terms used for the search included: *radiologic sciences education; radiology education; radiology faculty; radiology faculty perceptions; online education; perceptions of online education; radiology faculty AND online education; radiography education; allied health education; allied health faculty perceptions; nursing education; nursing faculty perceptions; and allied health AND online education*. The only instrument found that met the criteria of the study was published by Cherry (2015). After reviewing the study, it was determined that the instrument used had not been validated, though reliability was provided. This study examined the current instrument by Cherry and extended it by creating a modified instrument that is shorter, validated, and reliable.

The purpose of this study was to provide a valid, reliable instrument that can be used to collect radiologic science faculty members' perceptions of online education. The research questions identified for this study were:

1. What is the current instrument on radiography faculty perceptions of online education measuring?
2. How consistent is the current instrument on radiography faculty perceptions of online education?
3. What are the covariates of online education perceptions of radiologic science faculty members using the assembled optimal inventory to measure those perceptions?

The process for this study was different than most studies in this field because instead of using a pilot study to modify the survey, all analyses were conducted after the data were collected. The original survey was first reviewed by a panel of experts who offered suggestions for minor modifications and provided an approximate length of time necessary to complete the survey. Once these modifications were made, the full survey was sent to 1,715 radiologic science faculty members in JRCERT accredited programs across the United States. However, 105 emails were returned as undeliverable, leaving the total number of possible respondents at 1,610. There were 402 respondents in SurveyMonkey; however, of those 402 respondents, only 216 qualified for the survey because they had experience teaching online, and 18 of those had missing information in the Likert-type questions, making the final total number of respondents 198.

Data analysis for this instrument was conducted in SurveyMonkey and R. The demographic information was analyzed in SurveyMonkey, and after being coded for R, the Likert-type question data were separated into training and testing data sets using the train-test split function in R, randomly dividing the participants into two data sets with a 50-50 split, and analyzed in R using very simple structure (VSS), exploratory factor analysis, omega, confirmatory factor analysis with lavaan, short form with antcolony, best model fit with lavaan, and weighted regression analysis.

Findings Based on Research Questions

The new instrument developed in this study transitioned into a reliable 8/7/8 item, three factor instrument exhibiting both content and construct validity with a total of 23 items, not counting demographics. This is down from the original 67 items not counting demographics (Cherry, 2015). Each of the research questions are addressed in turn.

Research Question 1

> *What is the current instrument on radiography faculty perceptions of online education measuring?*

Based on previous research utilizing the current instrument, it appeared to be measuring five factors: radiography faculty perceptions of online courses, information about selected aspects of faculty satisfaction with teaching online courses, perceived ease of use and perceived usefulness associated with online technology, technological self-efficacy of faculty, and information about use or potential use of technology-enhanced learning methodologies (Cherry, 2015). The research by Cherry (2015) provided Cronbach's alpha reliability information for each of the three surveys used to develop the instrument for that study, as well as reliability scores for each of the five factors being assessed in the developed instrument. No validity information was reported. Upon analysis of the data produced by this study, the current instrument did not demonstrate clear factors, and did not exhibit content or construct validity. These results demonstrated the current instrument by Cherry (2015) was not accurately measuring what the author intended.

Research Question 2

How consistent is the current instrument on radiography faculty perceptions of online education?

This research question can be answered by examining the analysis of the full model instrument. The original instrument was analyzed with a “lavaan” model confirmatory factor analysis of the 59 items remaining after the eight cross-loading items were removed. This analysis provided statistical evidence that the original instrument did not exhibit construct or content validity and the items did not have an acceptable goodness of fit. While no statistical analysis was conducted to provide an exact measure of consistency, the lack of validity or goodness of fit implies the consistency of the instrument is likely low.

Research Question 3

What are the covariates of online education perceptions of radiologic science faculty members using the assembled optimal inventory to measure those perceptions?

The covariates of this study consisted of the information provided in the nine demographic questions at the beginning of the study. These include the following: position of the participant, type of institution at which the participant works, type of entry-level program in which the participant teaches, primary radiologic science discipline in which the participant teaches, age, number of years the participant has been teaching in radiologic sciences, number of years the participant has been teaching online courses in radiologic sciences, number of online courses the participant has taught in the past 5 years, and the participant's perceived personal level of competence with technology. Through the weighted multiple regression analysis, these covariates were evaluated and demonstrated three statistically significant relationships in factor one (F1), four statistically significant relationships in factor two (F2), and one statistically significant relationship in factor three (F3). The one relationship exhibited in F3, technology competence, was also present in the other two factors.

Relationship of Findings to Theoretical Framework

Community of Inquiry (CoI) Framework

The community utilized in this study was JRCERT faculty members in radiologic science programs. The three areas of CoI: social presence, cognitive presence, and teaching presence, are all addressed in the three factors of the new instrument. The items in factor one, which assesses faculty valuation of online education, reflect the definition of social presence, "the ability of participants in a community of inquiry to project themselves socially and emotionally, as "real" people (i.e., their full personality), through the medium of communication being used" (Garrison et al., 2000, p. 94). Items 3, 5, 6, 12, 38, and 39 assess how the faculty member perceives themselves, and items 22 and 26 assess faculty contact with students in online education.

The items in factor two, which evaluates faculty self-efficacy in terms of online technology, reflect the definition of cognitive presence, "the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse" (Huang et al, 2018, p. 1). All items in this factor assess the faculty member's confidence utilizing online hardware and software. Finally, the items in factor three, which examines faculty perceptions of institution valuation of online education, reflect the definition of teaching presence, which involves the instructional design and organization of the course and activities, facilitation of the course and activities, and direct instruction (Huang et al., 2018). These items all assess the faculty member's perceptions of time, resources, training, and support provided when utilizing online education.

Diffusion of Innovation (DoI) Theory

The demographic data gathered during this study aid in the connection to the diffusion of innovation theory. Utilizing this data can provide information on radiologic science faculty members' adoption of online learning. According to Rogers (2003), adopters fall into one of five categories of innovativeness: (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards. To determine which category radiologic science faculty members fall into in terms of online education, the first statistic gleaned from this study showed that of the 396 respondents that answered the question "Have you ever taught an online course in a radiologic sciences program?", 39.39% (n = 156) indicated "no". This answer automatically disqualified those participants from going any further in this study. Of the 60.61% (n = 240), only 216 continued with the questions. Based on this information alone, it appears radiologic science faculty could be laggards; however, there are many variables that could be causing this lack of adoption, such as the opportunity not being available.

Further assessment of the demographic data provides information about the number of years the respondents have been teaching in radiologic sciences and how many years the respondents have been teaching online courses in radiologic sciences.

The majority of the respondents (62.04%, *n* = 134) have been teaching in radiologic sciences for 1-15 years; however, 37.04% (*n* = 80) have been teaching for 16 years or more. Compared to the number of years the respondents have been teaching online courses in radiologic sciences, 87.44% (*n* = 188) have been teaching online courses for 1-15 years, with only 6.05% (*n* = 13) teaching online courses for 16 or more years. This comparison shows that while approximately 37% of radiologic science faculty have been teaching for 16 or more years, only 6% have been teaching online that long. Those who have been teaching a shorter period of time appear to have been teaching online just as long. These statistics provide evidence that, based on the respondents of this study, radiologic science faculty members are likely somewhere in the middle between early majority and late majority adopters, which make up two-thirds of the majority (Rogers, 2003). These findings are in line with the results reported by Kowalczyk and Copley (2013).

Adult Learning Theory

Based on the demographics, the respondents of this survey are adult learners by definition. The majority of respondents (57.87%, n = 125) were between the ages of 31-50, with 27.78% (*n* = 60) between the ages of 51-60, and 12.04% (*n* = 26) age 61 or older. Only 2.31% (*n* = 5) were under the age of 30. These respondents also have been teaching in radiologic sciences 1-15 years. Since the respondents of the survey are adults, and the learners taught by the faculty are also adults, it makes sense to explore the adult learning theory to ensure instruction meets the needs of the learners. Because radiologic science educators appear to make a slower transition incorporating online learning (Haugen & Metcalf, 2018; Kowalczyk & Copley, 2013), the faculty may find themselves becoming students when participating in training for online education, and exhibit the characteristics of adult learners: self-directed, motivated by internal factors, and adopt online learning based on independent self-concepts.

Implications for Future Research

Several opportunities for future research have been presented from this study. Since there were 156 respondents that were disqualified from the study because they had never taught an online course in radiologic sciences, the question becomes, why not? Kowalczyk and Copley (2013) discussed the fact that despite the push toward online education in radiologic sciences, many faculty members are slow to adopt this process, and this is evident by the number of disqualified respondents in this study. However, a future study could examine the reasons why these faculty members are not teaching online. Does it have to do with the institution, the program, or is it a personal choice not to teach online?

Another opportunity for further research comes from the analysis of the data in this study. The structure of many of the items caused them to have negative factor loadings. While the content of the questions still fits within the domain, in order to obtain a sum of the Likert-type questions to provide descriptive statistics, the negatively loaded items can be reverse coded. A study using the new validated, reliable, short form instrument could be conducted to present descriptive statistics and findings of the new items, including reverse coding the negative factor loadings.

It is also possible to have a future study using the alternate six and seven item scales that were produced. Since these scales were deemed to exhibit content and construct validity like the 8/7/8 item scale, a longitudinal study could be conducted to assess faculty perceptions of online education in radiologic sciences, and the 8/7/8 scale, followed by the seven item scale, and six item scale could be used, respectively, to prevent habituation of responses by participants.

When creating the 8/7/8 item scale, it was mentioned that Q15 could arguably be dropped from F3 creating an 8/7/7 item scale. This change to the structure could be accomplished, and additional data could be analyzed to determine if the goodness of fit improved with the new scale. The 8/7/8 scale could also be reassessed using a larger sample. This would make the goodness of fit measures even more favorable. Finally, replication studies could be performed to extend the analysis of both Cherry's (2015) instrument as well as the new short form developed by this dissertation.

Conclusions

The analysis of the original instrument confirmed that the factor loadings were not strong, and while it was deemed reliable by Cronbach's alpha, it did not possess construct or content validity. This was expected and substantiates the initial assumption that the field of radiologic science education needed a valid, reliable instrument to evaluate faculty perceptions of online education in radiologic science programs. The extensive statistical analysis that was conducted has provided not only a valid and reliable instrument, but also a shortened version that will likely increase the response rate in future studies. Also, while the 8/7/8 item, three factor instrument was decidedly the most appropriate, this study also produced two other instruments, a six item and seven item, that could be used as alternatives in future studies.

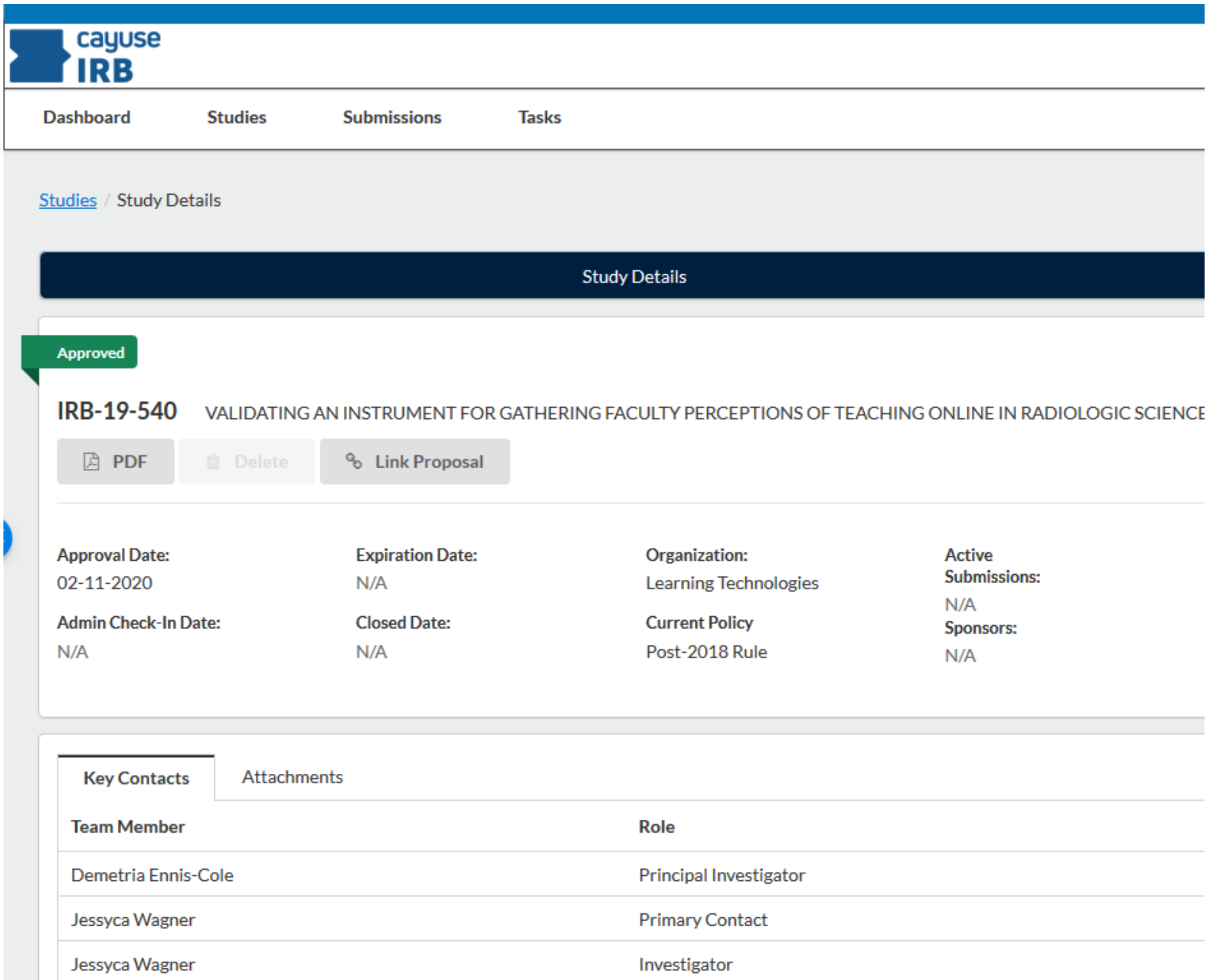
Although additional tests could be conducted to verify if in fact Q15 should be dropped to produce an 8/7/7 scale, this study was successful in producing a valid, reliable instrument that can now be utilized to conduct more extensive research in the field of radiologic sciences, and even other disciplines with slight modifications to the demographic questions. This instrument, as well as the alternative instruments produced, can be used to gather additional data regarding radiologic science faculty member use of online technology for education to possibly identify barriers that could be overcome so online education in radiologic sciences could be more prevalent.

Limitations of this study included a relatively low number of participants for such a large sample size, which slightly decreased the goodness of fit results. Future research could involve using the new validated, reliable short form instrument and, with a larger sample size, re-testing the confirmatory factor analyses and weighted regression analyses for a more accurate representation. Another limitation of the study was the group of participants used. The email list obtained from the JRCERT did not include all program faculty for all programs and had some errors in email addresses; therefore, there could have been a slightly larger participant pool if there were less constraints placed on the participant criteria. For example, future studies could evaluate any radiologic science faculty members across the country, not just those teaching in JRCERT accredited programs.

As with any research study, there are always ways to improve and expand on the research conducted for this study. However, it is a great milestone to have provided the field of radiologic science with an instrument that can be used in future studies. The amount of research in this field is slightly behind others, so it is the hope of the researcher that this will encourage future research.

APPENDIX A

IRB APPROVAL


cayuse IRB
Dashboard
Studies
Submissions
Tasks
Studies / Study Details
Study Details
Approved
IRB-19-540
VALIDATING AN INSTRUMENT FOR GATHERING FACULTY PERCEPTIONS OF TEACHING ONLINE IN RADIOLOGIC SCIENCE
PDF
Delete
Link Proposal
Approval Date:
02-11-2020
Expiration Date:
N/A
Organization:
Learning Technologies
Active Submissions:
N/A
Admin Check-In Date:
N/A
Closed Date:
N/A
Current Policy
Post-2018 Rule
Sponsors:
N/A
Key Contacts
Attachments
Team Member
Role
Demetria Ennis-Cole
Principal Investigator
Jessyca Wagner
Primary Contact
Jessyca Wagner
Investigator

APPENDIX B

SURVEY USE PERMISSION

From: Wagner, Jessyca [redacted]
Sent: Sunday, March 10, 2019 11:23 AM
To: Cherry, Shirley J. [redacted]
Subject: [EXTERNAL] Survey Information - Radiography Faculty Engaged in Online Education: Perceptions of Effectiveness, Satisfaction, and Technological Self-efficacy Article

Dr. Cherry and Dr. Flora,

My name is Jessyca Wagner and I am faculty at Midwestern State University in Wichita Falls, Texas. I am currently working on my dissertation at the University of North Texas, and my study is about attitudes of radiography faculty toward teaching online. I was wondering if I could look at the survey from your article "Radiography Faculty Engaged in Online Education: Perceptions of Effectiveness, Satisfaction, and Technological Self-efficacy" and possibly use it for my study. Also, if you have validation information, that would be great.

I appreciate any help you can provide.

Best,
Jessyca

Response Granting Access

Mon 3/18/2019 10:14 AM
Cherry, Shirley J. <[redacted]
RE: [EXTERNAL] Survey Information - Radiography Faculty Engaged in Online Education: Perceptions of Effectiveness, Satisfaction, and Technological Self-efficacy Article
To Wagner, Jessyca
Follow up. Completed on Tuesday, March 26, 2019.
You replied to this message on 3/26/2019 4:38 PM.

Message | Radiography Faculty Perceptions of Online Education Survey.pdf (115 KB)

Good morning Jessyca,

You are welcome to use the survey, and it is attached to this e-mail.

Best regards,

Shirley J. Cherry, Ed.D., R.T.(R)

Response Granting Permission to Modify and Providing Reliability Information

Mon 11/4/2019 3:37 PM
Cherry, Shirley J. [redacted]
RE: [EXTERNAL] Instrument for Dissertation
To Wagner, Jessyca
You replied to this message on 11/4/2019 3:40 PM.

[EXTERNAL]

Jessyca,

Good afternoon,

My dissertation is available at: https://dc.etsu.edu/cgi/viewcontent.cgi?article=3872&context=etd Please read pages 60-63 to view the information about the survey instrument. I've included information about the validity from the 3 survey instruments that I used. You may also modify the survey that I prepared.

Have a great day

Shirley J. Cherry, Ed.D., R.T.(R)

APPENDIX C

ORIGINAL SURVEY QUESTIONS

1. Which of the following categories best describes your position?
   A. Program Director
   B. Clinical Coordinator
   C. Other, please specify: ________________

2. At what type of institution are you currently employed?
   A. 4-year College-University
   B. Community College
   C. Technical College-Institute
   D. Hospital
   E. Proprietary
   F. Other, please specify: ________________

3. What is your age (today)?

4. How many years have you been teaching? (If applicable, include years teaching in areas other than radiography)

5. How many years have you been teaching online courses?

6. How many online courses have you taught in the past 5 years? (Include courses you are currently teaching. If you have taught the same course three times, count it as 3.)

7. How would you describe your level of competence with technology?
   A. Excellent
   B. Above Average
   C. Average
   D. Poor
   E. None

Indicate to what level you agree or disagree with the following statements regarding your role as a faculty member who has taught at least one asynchronous online course:

		SA	A	N	D	SD
8	I look forward to teaching my next online course.					
9	I am more satisfied teaching online as compared to other delivery methods.					
10	Assuming I have the opportunity, I teach online courses as much as possible.					
11	I embrace online learning technology in my workplace.					
12	Given the choice, I avoid teaching online courses. (R)					
13	Teaching online courses is rewarding.					
14	Teaching online courses is less rewarding than teaching face to face. (R)					
15	The flexibility provided by teaching in the online environment is important to me.					
16	I appreciate that I can access my online course any time it is convenient for me.					
17	I believe teaching online negatively impacts student evaluations of my instruction. (R)					
18	Online education does not enhance my teaching effectiveness. (R)					
19	Participating in online education will or has already increased my autonomy.					
20	Participating in online education enables greater achievement or success in my career.					
21	Teaching online courses provides me with opportunities to try innovative teaching techniques.					
22	It takes me longer to develop an online course than a traditional course. (R)					
23	I need more time to administer an online course than a traditional course. (R)					
24	I need more time to grade student assignments when teaching an online course. (R)					
25	I need more time to prepare for an online course on a weekly basis than for a traditional course. (R)					
26	I have a higher workload when teaching an online course than a traditional course. (R)					
27	Online teaching is gratifying because it provides me with the opportunity to reach students who otherwise would not be able to enroll in traditional courses.					

Indicate to what level you agree or disagree with the following statements regarding your role as a faculty member who has taught at least one asynchronous online course:

		SA	A	N	D	SD
28	The level of my interactions with students in an online course is higher than in a traditional face-to-face course.					
29	I miss face-to face contact with students when teaching online courses. (R)					
30	My online students are active in communicating with me when they have questions about course related matters.					
31	I can provide better feedback to my online students on their performance.					
32	My online students are somewhat passive when they contact me about course related matters. (R)					
33	Teaching online courses improves my ability to build relationships with my students.					
34	Student-to-instructor interactions are meaningful in my online course.					
35	I receive support to teach online courses (clerical support, graduate assistants, other).					
36	I have access to training resources from my college-university to teach online courses.					
37	I have access to technology resources from my college-university to teach online courses.					
38	I receive adequate financial resources from my college-university to teach online courses.					
39	I receive fair financial compensation for teaching online courses.					
40	Teaching online courses will (or has already) lead to greater recognition for me at work.					

Indicate to what level you agree or disagree with the following statements regarding your role as a faculty member who has taught at least one asynchronous online course:

		SA	A	N	D	SD
41	I find that online resources (course management software, etc.) at my institution are easy to use.					
42	I find it difficult to enhance my technology skills in to teach online courses. (R)					
43	I find it easy to teach using the course management software (Blackboard, D2L, or other) at my institution.					
44	I find that online learning technology is not flexible. (R)					

45	I am satisfied with the use of communication tools in the online environment (e.g., chat rooms, threaded discussions, etc.).					
46	Online courses are not useful in education. (R)					
47	Teaching online courses will decrease my effectiveness as a faculty member in the future. (R)					
48	Online education is not compatible with how I prefer to teach. (R)					
49	I believe that online education is an effective learning methodology for students.					
50	Faculty should use online learning technology.					

Indicate to what level you agree or disagree with the following statements regarding your self-efficacy related to technology use at home or work. The more confident you feel about each of these things, the higher your rating should be.

		SA	A	N	D	SD
51	I feel confident understanding terms/words related to Internet hardware.					
52	I feel confident understanding terms/words related to Internet software.					
53	I feel confident describing functions of Internet hardware.					
54	I feel confident troubleshooting Internet problems.					
55	I feel confident explaining why a task will not run on the Internet.					
56	I feel confident troubleshooting problems with technological tools.					
57	I feel confident troubleshooting problems with the course management system at my institution.					
58	I feel confident using the Internet to gather data.					
59	I feel confident learning advanced skills within a specific Internet program.					
60	I feel confident turning to an online discussion group when help is needed.					
61	I possess the knowledge to teach online courses.					
62	As an instructor, I am prepared to teach online courses.					

The following statements relate to the use or potential use of technology-enhanced learning in your asynchronous online course:

		SA	A	N	D	SD
63	I have limited time available for teaching development. (R)					
64	Using new technological tools is risky. (R)					
65	I am not aware of available methods and products. (R)					
66	I am satisfied with my current online teaching methods.					
67	There are limited institutional resources to permit use of technology-enhanced learning methods in radiography courses. (R)					
68	There are limited program/department resources to permit use of technology-enhanced learning methods. (R)					
69	Technology-enhanced learning methods are not suited for use in radiography courses. (R)					
70	Students do not react well to technology-enhanced learning methods in asynchronous online courses. (R)					
71	Teaching innovation is a relatively low priority in my institution. (R)					
72	There is limited support available (e.g. technical and/or administrative) for new learning methods. (R)					
73	Use of technology-enhanced learning methods increases my workload. (R)					
74	I lose ownership of my course materials when I use technology-enhanced learning methods. (R)					
75	In the future, student numbers will decline in face-to-face lectures. (R)					
76	I do not possess the skills necessary to use technology-enhanced learning methods. (R)					

The items in Radiography Faculty Perceptions of Online Education Survey were compiled from three surveys: the *Online Faculty Satisfaction Survey* (Wasilik & Bolliger, 2009), the *Technology Acceptance Survey* (Gibson et al., 2008), and the *Factors Affecting Faculty Use of Technology Survey* (Buchanan et al., 2013).

APPENDIX D

MODIFIED SURVEY QUESTIONS

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Radiologic Sciences Faculty Perceptions of Online Education Survey

Informed Consent for Studies with Adults

TITLE OF RESEARCH STUDY: VALIDATING AN INSTRUMENT FOR GATHERING FACULTY PERCEPTIONS OF TEACHING ONLINE IN RADIOLOGIC SCIENCE PROGRAMS

RESEARCH TEAM: PI: Dr. Demetria Ennis-Cole, Department of Learning Technologies, [redacted] demetria.ennis-cole@unt.edu; Student Investigator: Jessyca Wagner, PhD Candidate, Department of Learning Technologies, [redacted], jessycawagner@my.unt.edu; Key Personnel: Dr. Cathleen Norris, Department of Learning Technologies, 940-565-2185, cathie.norris@unt.edu

You are being asked to participate in a research study. Taking part in this study is voluntary. The investigators will explain the study to you and will any answer any questions you might have. It is your choice whether or not you take part in this study. If you agree to participate and then choose to withdraw from the study, that is your right, and your decision will not be held against you.

You are being asked to take part in a research study to provide a valid, reliable instrument that can be used to collect radiologic science faculty members' perceptions of teaching online.

Your participation in this research study involves completing a confidential online questionnaire about radiologic science faculty members' perceptions of teaching online. More details will be provided in the next section.

You might want to participate in this study if you are a current radiologic science faculty member with experience teaching online who would like to share your perceptions about your experiences. However, you might not want to participate in this study if you have no experience teaching online, or are not currently teaching in a radiologic science program.

You may choose to participate in this research study if you are a current faculty member teaching online courses in a JRCERT accredited radiologic science program for any of the ARRT primary pathway disciplines (magnetic resonance imaging, nuclear medicine, radiation therapy, radiography, or sonography).

The reasonable foreseeable risks or discomforts to you if you choose to take part is the potential for a loss of confidentiality, and the section below describes all precautions that will be taken to minimize this possibility, which you can compare to the possible benefit of aiding in the validation of a survey that can be added to the body of knowledge for the field of radiologic science education. You will not

receive compensation for participation.

DETAILED INFORMATION ABOUT THIS RESEARCH STUDY: The following is more detailed information about this study, in addition to the information listed above.

PURPOSE OF THE STUDY: The purpose of this study is to provide a valid, reliable instrument that can be used to collect radiologic science faculty members' perceptions of teaching online.

TIME COMMITMENT: Participation in this study should take approximately 10-15 minutes to complete.

STUDY PROCEDURES: Participants will be sent a link to a survey hosted by SurveyMonkey.com. At the beginning of the survey, participants will be required to provide consent to participate by reading the information provided and choosing to proceed with the survey. Once the survey has begun, participants are asked to complete all questions. All answers to the survey will be kept confidential.

POSSIBLE BENEFITS: There are no direct personal benefits associated with this survey; however, your participation will aid in the validation of a survey that can be added to the body of knowledge and instrumentation for the field of radiologic science education that may foster future, more extensive research.

POSSIBLE RISKS/DISCOMFORTS: There is a potential for a loss of confidentiality; however, precautions that will be taken to minimize this possibility. Remember that you have the right to withdraw any study procedures at any time without penalty, and may do so by informing the research team.

If you experience excessive discomfort when completing the research activity, you may choose to stop participating at any time without penalty. The researchers will try to prevent any problem that could happen, but the study may involve risks to the participant, which are currently unforeseeable. UNT does not provide medical services, or financial assistance for emotional distress or injuries that might happen from participating in this research. If you need to discuss your discomfort further, please contact a mental health provider, or you may contact the researcher who will refer you to appropriate services. If your need is urgent, helpful resources include the Denton County Crisis Hotline: 1-800-762-0157.

COMPENSATION: There is no compensation offered for this study. There are no alternative activities offered for this study.

CONFIDENTIALITY: Efforts will be made by the research team to keep your personal information private, including research study records, and disclosure will be limited to people who have a need to review this information. Your survey answers will be stored initially with SurveyMonkey.com in a password protected electronic format. All data collected from this study will be stored in a secure location in a password protected file on a password protected computer for at least three (3) years past the end of this research. The only identifier that will be collected is the IP address used when the survey is completed; however, no identifying information will be included in any publications or presentations based on these data, and your responses to this survey will remain confidential. All data will be aggregated before it appears in publications or presentation. This study uses a third party software called SurveyMonkey and is subject to the privacy policies of Survey Monkey noted here:
https://www.surveymonkey.com/mp/legal/privacy-policy/.

The results of this study may be published and/or presented without naming you as a participant. The data collected about you for this study may be used for future research studies that are not described in this consent form. If that occurs, an IRB would first evaluate the use of any information that is identifiable to you, and confidentiality protection would be maintained.

While absolute confidentiality cannot be guaranteed, the research team will make every effort to protect the confidentiality of your records, as described here and to the extent permitted by law. In addition to the research team, the following entities may have access to your records, but only on a need-to-know basis: the U.S. Department of Health and Human Services, the FDA (federal regulating agencies), the reviewing IRB, and sponsors of the study.

CONTACT INFORMATION FOR QUESTIONS ABOUT THE STUDY: If you have any questions about the study you may contact Jessyca Wagner: jessycawagner@my.unt.edu or Dr. Demetria Ennis-Cole: demetria.ennis-cole@unt.edu. Any questions you have regarding your rights as a research subject, or complaints about the research may be directed to the Office of Research Integrity and Compliance at 940-565-4643, or by email at untirb@unt.edu.

ELECTRONIC CONSENT: Please select your choice below. You may print a copy of this consent form for your records. Clicking on the "Agree" button indicates that:

You have read, or have had read to you all of the above.
You confirm that you have been told the possible benefits, risks, and/or discomforts of the study.
You understand that you do not have to take part in this study and your refusal to participate or your decision to withdraw will involve no penalty or loss of rights or benefits.
You understand your rights as a research participant and you voluntarily consent to participate in this study; you also understand that the study personnel may choose to stop your participation at any time.
You are not waiving any of your legal rights.

* 1. Please select your choice below.

- [ ] Agree
- [ ] Disagree

UNIVERSITY OF NORTH TEXAS®

Radiologic Sciences Faculty Perceptions of Online Education Survey

Radiologic Sciences Faculty Perceptions of Online Education

For the purposes of this survey, online education is defined as: an educational process characterized by the separation, in time or place, between instructor and students. Distance education courses are taught primarily (more than 50%) through the use of the TV, audio, or computer transmissions; audio or computer conferencing; video cassettes or disks; correspondence; and/or a combination of face-to-face instruction with a distance learning component (hybrid) (JRCERT, 2011).

* 2. Have you ever taught an online course in a radiologic sciences program?

- [ ] Yes
- [ ] No

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Radiologic Sciences Faculty Perceptions of Online Education Survey

For the purposes of this survey, online education is defined as: an educational process characterized by the separation, in time or place, between instructor and students. Distance education courses are taught primarily (more than 50%) through the use of the TV, audio, or computer transmissions; audio or computer conferencing; video cassettes or disks; correspondence; and/or a combination of face-to-face instruction with a distance learning component (hybrid) (JRCERT, 2011).

3. Which of the following categories best describes your position?

- ◯ Program Director
- ◯ Clinical Coordinator
- ◯ Program Faculty
- ◯ Other (please specify)

[ ]

4. At what type of institution are you currently employed?

- ◯ 4-year College-University
- ◯ Community College
- ◯ Technical College-Institute
- ◯ Hospital
- ◯ Proprietary
- ◯ Other (please specify)

[ ]

5

5. Which of the following best describes the entry-level radiologic science program you currently teach in?

- ◯ Certificate program with simultaneous didactic/clinical curriculum
- ◯ Associate Degree program with simultaneous didactic/clinical curriculum
- ◯ Associate Degree program with separate didactic/clinical curriculum
- ◯ Bachelor's Degree program with simultaneous didactic/clinical curriculum
- ◯ Bachelor's Degree program with separate didactic/clinical curriculum
- ◯ Other (please specify)

6. Which of the primary radiologic science disciplines do you currently teach in?

- ◯ Magnetic Resonance Imaging
- ◯ Nuclear Medicine
- ◯ Radiation Therapy
- ◯ Radiography
- ◯ Sonography
- ◯ Other (please specify)

7. What is your age (today)?

- ◯ 18 – 30
- ◯ 31 – 50
- ◯ 51 – 60
- ◯ 61 or older

8. How many years have you been teaching in radiologic sciences?

- ◯ Less than 1 year
- ◯ 1 – 5 years
- ◯ 6 – 10 years
- ◯ 11 – 15 years
- ◯ 16 or more years

6

9. How many years have you been teaching online courses in radiologic sciences?

- Less than 1 year
- 1 – 5 years
- 6 – 10 years
- 11 – 15 years
- 16 or more years

10. How many online courses in radiologic sciences have you taught in the past 5 years? (Include courses you are currently teaching. If you have taught the same course three times, count it as 3.)

- 1 – 5
- 6 – 10
- 11 – 15
- 16 – 20
- 21 or more courses

11. How would you describe your level of competence with technology?

- Excellent
- Above Average
- Average
- Poor
- None

12. Indicate to what level you agree or disagree with the following statements regarding your role as a faculty member who has taught at least one asynchronous online course:

	Strongly Agree	Agree	Disagree	Strongly Disagree
I look forward to teaching my next online course.	○	○	○	○
I am more satisfied teaching online as compared to other delivery methods.	○	○	○	○
Assuming I have the opportunity, I teach online courses as much as possible.	○	○	○	○
I embrace online learning technology in my workplace.	○	○	○	○

	Strongly Agree	Agree	Disagree	Strongly Disagree
Given the choice, I avoid teaching online courses.	◯	◯	◯	◯
Teaching online courses is rewarding.	◯	◯	◯	◯
Teaching online courses is less rewarding than teaching face to face.	◯	◯	◯	◯
The flexibility provided by teaching in the online environment is important to me.	◯	◯	◯	◯
I appreciate that I can access my online course any time it is convenient for me.	◯	◯	◯	◯
I believe teaching online negatively impacts student evaluations of my instruction.	◯	◯	◯	◯
Online education does not enhance my teaching effectiveness.	◯	◯	◯	◯
Participating in online education will or has already increased my autonomy.	◯	◯	◯	◯
Participating in online education enables greater achievement or success in my career.	◯	◯	◯	◯
Teaching online courses provides me with opportunities to try innovative teaching techniques.	◯	◯	◯	◯
It takes me longer to develop an online course than a traditional course.	◯	◯	◯	◯
I need more time to administer an online course than a traditional course.	◯	◯	◯	◯
I need more time to grade student assignments when teaching an online course.	◯	◯	◯	◯

	Strongly Agree	Agree	Disagree	Strongly Disagree
I need more time to prepare for an online course on a weekly basis than for a traditional course.	○	○	○	○
I have a higher workload when teaching an online course than a traditional course.	○	○	○	○
Online teaching is gratifying because it provides me with the opportunity to reach students who otherwise would not be able to enroll in traditional courses.	○	○	○	○
The level of my interactions with students in an online course is higher than in a traditional face-to-face course.	○	○	○	○
I miss face-to face contact with students when teaching online courses.	○	○	○	○
My online students are active in communicating with me when they have questions about course related matters.	○	○	○	○
I can provide better feedback to my online students on their performance.	○	○	○	○
My online students are somewhat passive when they contact me about course related matters.	○	○	○	○
Teaching online courses improves my ability to build relationships with my students.	○	○	○	○
Student-to-instructor interactions are meaningful in my online course.	○	○	○	○

	Strongly Agree	Agree	Disagree	Strongly Disagree
I receive support to teach online courses (clerical support, graduate assistants, other).	○	○	○	○
I have access to training resources from my college/university to teach online courses.	○	○	○	○
I have access to technology resources from my college-university to teach online courses.	○	○	○	○
I receive adequate financial resources from my college-university to teach online courses.	○	○	○	○
I receive fair financial compensation for teaching online courses.	○	○	○	○
I find that online resources (course management software, etc.) at my institution are easy to use.	○	○	○	○
I find it easy to teach using the course management software (Blackboard, D2L, or other) at my institution.	○	○	○	○
I find that online learning technology is not flexible.	○	○	○	○
I am satisfied with the use of communication tools in the online environment (e.g., chat rooms, threaded discussions, etc.).	○	○	○	○
Online courses are not useful in education.	○	○	○	○
Teaching online courses will decrease my effectiveness as a faculty member in the future.	○	○	○	○

	Strongly Agree	Agree	Disagree	Strongly Disagree
Online education is not compatible with how I prefer to teach.	○	○	○	○
I believe that online education is an effective learning methodology for students.	○	○	○	○
Faculty should use online learning technology.	○	○	○	○

13. Indicate to what level you agree or disagree with the following statements regarding your self-efficacy related to technology use at home or work. The more confident you feel about each of these things, the higher your rating should be.

	Strongly Agree	Agree	Disagree	Strongly Disagree
I feel confident understanding terms/words related to Internet hardware.	○	○	○	○
I feel confident understanding terms/words related to Internet software.	○	○	○	○
I feel confident describing functions of Internet hardware.	○	○	○	○
I feel confident troubleshooting Internet problems.	○	○	○	○
I feel confident explaining why a task will not run on the Internet.	○	○	○	○
I feel confident troubleshooting problems with technological tools.	○	○	○	○
I feel confident troubleshooting problems with the course management system at my institution.	○	○	○	○
I feel confident using the Internet to gather data.	○	○	○	○

	Strongly Agree	Agree	Disagree	Strongly Disagree
I feel confident learning advanced skills within a specific Internet program.	○	○	○	○
I feel confident turning to an online discussion group when help is needed.	○	○	○	○
I possess the knowledge to teach online courses.	○	○	○	○
As an instructor, I am prepared to teach online courses.	○	○	○	○

14. Indicate to what level you agree or disagree with the following statements related to the use or potential use of technology-enhanced learning in your asynchronous online course:

	Strongly Agree	Agree	Disagree	Strongly Disagree
I have limited time available for teaching development.	○	○	○	○
Using new technological tools is risky.	○	○	○	○
I am not aware of available methods and products.	○	○	○	○
I am satisfied with my current online teaching methods.	○	○	○	○
There are limited institutional resources to permit use of technology-enhanced learning methods in radiography courses.	○	○	○	○
There are limited program/department resources to permit use of technology-enhanced learning methods.	○	○	○	○
Technology-enhanced learning methods are not suited for use in radiography courses.	○	○	○	○

	Strongly Agree	Agree	Disagree	Strongly Disagree
Students do not react well to technology-enhanced learning methods in asynchronous online courses.	○	○	○	○
Teaching innovation is a relatively low priority in my institution.	○	○	○	○
There is limited support available (e.g. technical and/or administrative) for new learning methods.	○	○	○	○
Use of technology-enhanced learning methods increases my workload.	○	○	○	○
I lose ownership of my course materials when I use technology-enhanced learning methods.	○	○	○	○
In the future, student numbers will decline in face-to-face lectures	○	○	○	○
I do not possess the skills necessary to use technology-enhanced learning methods.	○	○	○	○

The items in this survey were modified from Radiography Faculty Perceptions of Online Education (Cherry, 2015) which was compiled from three surveys: Online Faculty Satisfaction Survey (Wasilik & Bolliger, 2009), Technology Acceptance Survey (Gibson et al., 2008), and Factors Affecting Faculty Use of Technology Survey (Buchanan et al., 2013).

REFERENCES

Aaron, L. (2015). Distance education standards. *Radiation Therapist, 24*(2), 220-222. Retrieved from https://media.asrt.org/pdf/publications/RTT/RTT_Vol24_No2.pdf

Allen, I. E., & Seaman, J. (2012). Conflicted: Faculty and online education, 2012. *Inside Higher Ed.* Retrieved from *https://files.eric.ed.gov/fulltext/ED535214.pdf*

Altany, A. (2012). Professional faculty development: The necessary fourth leg. *Faculty Focus.* Retrieved from https://www.facultyfocus.com/articles/faculty-development/professional-faculty-development-the-necessary-fourth-leg/

American Registry of Radiologic Technologists (ARRT). (n.d.a). About us. Retrieved from https://www.arrt.org/about/about-us

American Registry of Radiologic Technologists (ARRT). (n.d.b). Primary eligibility pathway requirements. Retrieved from https://www.arrt.org/earn-arrt-credentials/requirements/primary-requirements

American Society of Radiologic Technologists (ASRT). (n.d.). ASRT mission, vision, core values, value propositions and commitment to human rights. Retrieved from https://www.asrt.org/main/about-asrt/mission-vision

American Society of Radiologic Technologists (ASRT). (2019). Radiologic technologist wage and salary survey 2019. Retrieved from https://www.asrt.org/docs/default-source/research/radiologic-technologist-wage-and-salary-survey-2019.pdf?sfvrsn=92c931d0_4

Anderson, T. (2017). How communities of inquiry drive teaching and learning in the digital age. *Contact North Online Learning.* Retrieved from https://teachonline.ca/sites/default/files/tools-trends/insights/pdf/how_communities_of_inquiry_drive_teaching_and_learning_in_the_digital.pdf

Anderson, J. C., & Gerbing, D. W. (1984). The effect of sampling error on convergence, improper solutions, and goodness-of-fit indices for maximum likelihood confirmatory factor analysis. *Psychometrika, 49*(2), 155-173. Retrieved from https://link.springer.com/article/10.1007/BF02294170

Askov, E., Johnston, J., Petty, L., & Young, S. (2003). *Expanding access to adult literacy with online distance education*. Cambridge, MA: National Center for the Study of Adult Learning and Literacy. Retrieved from http://www.ncsall.net/fileadmin/resources/research/op_askov.pdf

Badia, A., Garcia, C., & Meneses, J. (2017). Approaches to teaching online: Exploring factors influencing teachings in a fully online university. *British Journal of Educational Technology, 48*(6), 1193-1207. doi:10.1111/bjet.12475

Baumgartner, L. M. (2003). Andragogy: A foundational theory/set of assumptions. In *Adult Learning Theory: A Primer.* (Information Series No. 392). Retrieved from files.eric.ed.gov/fulltext/ED482337.pdf

Bennett, S., & Lockyer, L. (2004). Becoming an online teacher: Adapting to a changed environment for teaching and learning in higher education. *Educational Media International, 41*(3), 231–248. doi: 10.1080/09523980410001680842

Bonnici, L. J., Maatta, S. L., Klose, M. K., Julien, H., & Bajjaly, S. (2016). Instructional style and learner-centered approach: A cross-institutional examination of modality preference for online course delivery in a graduate professional program. *Studies in Higher Education, 41*(8), 1389-1407. Retrieved from http://dx.doi.org/10.1080/03075079.2014.977860

Braun, T. (2008). Making a choice: The perceptions and attitudes of online graduate students. *Journal of Technology and Teacher Education, 16*(1), 63-92. Retrieved from https://www.learntechlib.org/p/21874/.

Britt, R. (2006). Online education: A survey of faculty and students. *Radiologic Technology, 77*(3), 183-190. Retrieved from https://www.radiologictechnology.org/content/77/3/183

Bronkey, K. (2015, July 13). Rethinking direct instruction in online learning. *Faculty Focus.* Retrieved from https://www.facultyfocus.com/articles/online-education/rethinking-direct-instruction-in-online-learning/

Buchanan, T., Sainter, P., & Saunders, G. (2013). Factors affecting faculty use of learning technologies: Implications for models of technology adoption. *Journal of Computing in Higher Education, 25*(1), 1-11. Retrieved from http://www.learntechlib.org/p/113873/

Bunk, J., Li, R., Smidt, E., Bidetti, C., & Malize, B. (2015). Understanding faculty attitudes about distance education: The importance of excitement and fear. *Online Learning, 19*(4), 1-11. Retrieved from http://dx.doi.org/10.24059/olj.v19i4.559

Burge, L. (1988). Beyond andragogy: Some explorations for distance learning design. *International Journal of E-Learning and Distance Education, 3*(1), 5-23. Retrieved from http://www.ijede.ca/index.php/jde/article/view/326/220

Cangur, S., & Ercan, I. (2015). Comparison of model fit indices used in structural equation modeling under multivariate normality. *Journal of Modern Applied Statistical Methods, 14*(1), 152-167. DOI: 10.22237/jmasm/1430453580

Carbonaro, M., King, S., Taylor, E., Satzinger, F., Snart, F., & Drummond, J. (2008). Integration of e-learning technologies in an interprofessional health science course. *Medical Teacher, 30*(1), 25-33. Retrieved from http://dx.doi.org/10.1080/01421590701753450

Chen, T.-L., & Chen, T.-J. (2006). Examination of attitudes towards teaching online courses based on theory of reasoned action of university faculty in Taiwan. *British Journal of Educational Technology, 37*(5), 683-693. doi:10.1111/j.1467-8535.2006.00590.x

Cherry, S. J. (2015). *Radiography faculty perceptions of the effectiveness of asynchronous online courses* (Doctoral dissertation). Retrieved from https://dc.etsu.edu/etd/2501

Childs, S., Blenkinsopp, E., Hall, A., & Walton, G. (2005). Effective e-learning for health professionals and students-barriers and their solutions. A systematic review of the literature-findings from the HeXL project. *Health Information and Libraries Journal, 22*(s2), 20-32. doi: 10.1111/j.1470-3327.2005.00614.x

Culatta, R. (2015a). Andragogy (Malcolm Knowles). Retrieved from http://www.instructionaldesign.org/theories/andragogy.html

Darden, D. C. (2014). Relevance of the Knowles theory in distance education. *Creative Education, 5*(10), 809-812. doi: 10.4236/ce.2014.510094

Dearing, J. W., & Cox, J. G. (2018). Diffusion of innovations theory, principles, and practice. *Health Affairs, 37*(2), 183-190. doi: 10.1377/hlthaff.2017.1104

de Jong, N., Savin-Baden, M., Cunningham, A. M., & Verstegen, D. M. L. (2014). Blended learning in health education: Three case studies. *Perspectives on Medical Education, 3*(4), 278-288. doi: 10.1007/s40037-014-0108-1

De Smet, C., Bourgonjon, J., De Wever, B., Schellens, T., & Valcke, M. (2012). Researching instructional use and the technology acceptation of learning management systems by secondary school teachers. *Computers & Education, 58*, 688-696. doi: 10.1016/j.compedu.2011.09.013

Dingfelder, H. E., & Mandell, D. S. (2011). Bridging the research-to-practice gap in autism intervention: An application of diffusion of innovation theory. *Journal of Autism and Developmental Disorders, 41*(5), 597-609. Retrieved from https://doi.org/10.1007/s10803-010-1081-0

Dunn, T. J., Baguley, T., & Brunsden, V. (2013). From alpha to omega: A practical solution to the pervasive problem of internal consistency estimation. *British Journal of Psychology, 105*(3), 399-412. Retrieved from https://doi.org/10.1111/bjop.12046

Esani, M. (2010). Moving from face-to-face to online teaching. *Clinical Laboratory Science, 23*(3), 187-190. Retrieved from https://doi.org/10.29074/ascls.23.3.187

Europass. (n.d.). What is the European qualification framework (EQF)? Retrieved from https://europass.cedefop.europa.eu/europass-support-centre/other-questions/what-european-qualification-framework-eqf

Fan, X., & Konold, T. R. (2010). Statistical significance versus effect size. In P. Peterson, E. Baker, & B. McGaw (Eds.) *International encyclopedia of education* (3rd ed., pp. 444-450). Burlington, MA: Elsevier.

Finch, W. H., Jr., & French, B. F. (2015). *Latent variable modeling with R*. New York, NY: Routledge.

Garrison, D. R., & Arbaugh, J. B. (2007). Researching the community of inquiry framework: Review, issues, and future directions. *Internet and Higher Education, 10,* 157-172. doi: 10.1016/j.iheduc.2007.04.001

Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education, 2*(2-3), 87-105. Retrieved from http://cde.athabascau.ca/coi_site/documents/Garrison_Anderson_Archer_Critical_Inquiry_model.pdf

Garrison, D. R., Anderson, T., & Archer, W. (2010). The first decade of the community of inquiry framework: A retrospective. *Internet and Higher Education, 13,* 5-9. doi:10.1016/j.iheduc.2009.10.003

Gibbons, H. S., & Wentworth, G. P. (2001). Andragogical and pedagogical training differences for online instructors. *Online Journal of Distance Learning Education, 4*(3), 1-4. Retrieved from http://www.westga.edu/~distance/ojdla/fall43/gibbons wentworth43.html

Gibson, S. G., Harris, M. L., & Colaric, S. M. (2008). Technology acceptance in an academic context: Faculty acceptance of online education. *Journal of Education for Business, 83*(6), 355-359. Retrieved from https://doi.org/10.3200/JOEB.83.6.355-359

Harrison, R., Hutt, I., Thomas-Varcoe, C., Motteram, G., Else, K., Rawlings, B., & Gemmell, I. (2017). A cross-sectional study to describe academics' confidence, attitudes, and experience of online distance learning in higher education. *Journal of Educators Online, 14*(2), 1-9. Retrieved from http://files.eric.ed.gov/fulltext/EJ1150576.pdf

Hartman, R. (2018). CFA in lavaan. *Understanding Data.* Retrieved from http://www.understandingdata.net/2017/03/22/cfa-in-lavaan/

Haugen, K., & Metcalf, K. L. (2018). Getting started putting courses online. *Radiologic Technology, 90*(2), 187-191. Retrieved from http://www.radiologictechnology.org/content/90/2/187

Herman, J. H. (2012). Faculty development programs: The frequency and variety of professional development programs available to online instructors. *Journal of Asynchronous Learning Networks, 16*(5), 87–106. Retrieved from http://files.eric.ed.gov/fulltext/EJ1000093.pdf

Hodges, C. B., Way, R., & Shepherd, S. S. (2013). Online teaching: Faculty perceptions at a research university. In A. Sigal (Ed.), *Advancing library education: Technological innovation and instructional design* (pp. 16-26). Hershey, PA: Information Science Reference.

Holmström, A., & Ahonen, S.-M. (2016). Radiography students' learning: A literature review. *Radiologic Technology, 87*(4), 371-379. Retrieved from http://www.radiologictechnology.org/content/87/4/371

Horvitz, B. S., Beach, A. L., Anderson, M. L., & Xia, J. (2015). Examination of faculty self-efficacy related to online teaching. *Innovative Higher Education, 40*(4), 305-316. doi: 10.1007/s10755-014-9316-1

Hsu, L. (2016). Diffusion of innovation and use of technology in hospitality education: An empirical assessment with multilevel analyses of learning effectiveness. *The Asia-Pacific Education Researcher, 25*(1), 135-145. Retrieved from https://doi.org/10.1007/s40299-015-0244-3

Huang, W., Hurt, A., Richardson, J. C., Swan, K., & Caskurlu, S. (2018). Community of inquiry framework. Retrieved from https://www.purdue.edu/innovativelearning/supporting-instruction/portal/files/4_Community_of_Inquiry_Framework.pdf

Hunt, H. D., Davies, K., Richardson, D., Hammock, G., Akins, M., & Russ, L. (2014). It is (more) about the students: Faculty motivations and concerns regarding teaching online. *Online Journal of Distance Learning Administration, 17*(2). Retrieved from http://www.westga.edu/~distance/ojdla/summer172/Hunt_Davies_Richardson_Hammock_Akins_Russ172.html

Indiana University. (n.d.). Types of presence: Teaching presence. *IU – Teaching Online* [MOOC]. Retrieved from https://canvas.ucdavis.edu/courses/34528/pages/types-of-presence-teaching-presence?module_item_id=5003

Jaschik, S., & Lederman, D. (2017). 2017 survey of faculty attitudes on technology: A study by Inside Higher Ed and Gallup. *Inside Higher Ed.* Retrieved from https://www.insidehighered.com/system/files/media/2017%20Survey%20of%20Faculty%20Atittudes%20on%20Technology_0.pdf

Johnson, T., Wisniewski, M. A., Kuhlemeyer, G., Isaacs, G., & Krzykowski, J. (2012). Technology adoption in higher education: Overcoming anxiety through faculty bootcamp. *Journal of Asynchronous Learning Networks, 16*(2), 63–71. Retrieved from http://files.eric.ed.gov/fulltext/EJ971045.pdf

Joint Review Committee on Education in Radiologic Technology (JRCERT). (n.d.). Mission statement. Retrieved from https://www.jrcert.org/mission/

Joint Review Committee on Education in Radiologic Technology (JRCERT). (2011). Alternative learning options: Policy statements. Retrieved from https://www.jrcert.org/resources/governance/accreditation-policies/10-800/

Joint Review Committee on Education in Radiologic Technology (JRCERT). (2014). Standards for an accredited educational program in radiography. Retrieved from https://www.jrcert.org/sites/jrcert2/uploads/documents/2014_Standards/Standards_2014-Radiography.doc

Jorgensen, T. (n.d.). mesEq.syntax: Syntax for measurement equivalence. *RDocumentation.* Retrieved from https://www.rdocumentation.org/packages/semTools/versions/0.5-2/topics/measEq.syntax

Jwaifell, M., & Gasaymeh, A.-M. (2013). Using the diffusion of innovation theory to explain the degree of English teacher's adoption of interactive whiteboards in the Modern Systems School in Jordan: A case study. *Contemporary Educational Technology, 4*(2), 138-149. Retrieved from https://eric.ed.gov/?id=EJ1105530

Kenny, D. A. (2015, November 24). Measuring model fit. Retrieved from http://www.davidakenny.net/cm/fit.htm

Kim, J.-O., & Mueller, C.W. (1978). *Introduction to factor analysis: What it is and how to do it.* Newbury Park: Sage.

Kline, R. B. (2016). Global fit testing. In D. A. Kenny & T. D. Little (Eds.), *Principles and practice of structure equation modeling* (4th ed., pp. 262-299). New York, NY: The Guilford Press.

Knapp, K. M., Wright, C., Clarke, H., McAnulla, S. J., & Nightingale, J. M. (2017). The academic radiography workforce: Age profile, succession planning, and academic development. *Radiography, 23*(2017), S48-S52. Retrieved from http://dx.doi.org/10.1016/j.radi.2017.05.012

Knowles, M. S. (1973). *The adult learner: A neglected species.* Houston, TX: Gulf Publishing Company.

Knowles, M. S. (1978). Andragogy: Adult learning theory in perspective. *Community College Review, 5*(3), 9-20. Retrieved from https://doi.org/10.1177/009155217800500302

Knowles, M. S. (1980). *The modern practice of adult education: From pedagogy to andragogy* (Rev. ed.). Englewood Cliffs, NJ: Cambridge Adult Education.

Knowles, M. S. (1984). *Andragogy in action: Applying modern principles of adult learning.* San Francisco: Jossey-Bass.

Knowles, M. S. (1990). *The adult learner: A neglected species* (4th ed.). Houston, TX: Gulf Publishing Company.

Kowalczyk, N. K. (2014). Perceived barriers to online education by radiologic science educators. *Radiologic Technology, 85*(5), 486-493. Retrieved from http://www.radiologictechnology.org/content/85/5/486

Kowalczyk, N., & Copley, S. (2013). Online course delivery modes and design methods in the radiologic sciences. *Radiologic Technology, 85*(1), 27-36. Retrieved from http://www.radiologictechnology.org/content/85/1/27

Laerd Statistics. (n.d.). Multiple regression analysis using SPSS statistics. Retrieved from https://statistics.laerd.com/spss-tutorials/multiple-regression-using-spss-statistics.php

LaMorte, W. W. (2018). Diffusion of innovation theory. Retrieved from http://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/BehavioralChangeTheories/BehavioralChangeTheories4.html

Lee, D., Paulus, T. M., Loboda, I., Phipps, G., Wyatt, T. H., Myers, C. R., & Mixer, S. J. (2010). A faculty development program for nurse educators learning to teach online. *TechTrends, 54*(6), 20-28. Retrieved from http://dx.doi.org/10.1007/s11528-010-0450-z

Lisko, S. A., & O'Dell, V. (2010). Integration of theory and practice: Experiential learning theory and nursing education. *Nursing Education Perspectives, 31*(2), 106-108. Retrieved from http://www.nln.org/newsroom/newsletters-and-journal/nursing-education-perspectives-journal

McQuiggan, C. A. (2012). Faculty development for online teaching as a catalyst for change. *Journal of Asynchronous Learning Networks, 16*(2), 27-61. Retrieved from *https://eric.ed.gov/?id=EJ971044*

Merriam, S. B. (2001). Andragogy and self-directed learning: Pillars of adult learning theory. *New Directions for Adult and Continuing Education, 2001*(89), 3-14. Retrieved from https://doi.org/10.1002/ace.3

Merriam, S. B. (2008). Adult learning theory for the twenty-first century. *New Directions for Adult and Continuing Education,* 2008(119), 93-98. Retrieved from https://doi.org/10.1002/ace.309

Milman, N. B. (2016). Instructor roles in next generation digital learning environments. *Distance Learning, 13*(4), 67-69. Retrieved from http://www.infoagepub.com/distance-learning

Minishi-Majanja, M. K., & Kiplang'at, J. (2005). The diffusion of innovations theory as a theoretical framework in library and information science research. *South African*

Journal of Libraries and Information Science, 71(3), 211-224. Retrieved from https://doi.org/10.7553/71-3-586

Molnar, A. L., & Kearney, R. C. (2017). A comparison of cognitive presence in asynchronous and synchronous discussions in an online dental hygiene course. *The Journal of Dental Hygiene, 91*(3), 14-21. Retrieved from http://jdh.adha.org/content/91/3/14

Moreira, J. A., Henriques, S., Goulão, M. D., & Barros, D. (2017). Digital learning in higher education: A training course for teaching online - Universidade Aberta, Portugal. *Open Praxis, 9*(2), 253-263. Retrieved from https://doi.org/10.5944/openpraxis.9.2.539

Murray, C. E. (2009). Diffusion of innovation theory: A bridge for the research-practice gap in counseling. *Journal of Counseling & Development, 87*(1), 108-116. Retrieved from https://doi.org/10.1002/j.1556-6678.2009.tb00556.x

Pappas, C. (2013, May 9). The adult learning theory – Andragogy. Retrieved from http://elearningindustry.com/the-adult-learning-theory-andragogy-of-malcolm-knowles

Papillion, E., & Aaron, L. (2017). Student perceptions of online radiologic science courses. *Radiologic Technology, 88*(4), 366-372. Retrieved from www.radiologictechnology.org/content/88/4/366

Parry, S. (n.d.). Fit indices commonly reported for CFA and SEM. *Cornell University, Cornell Statistical Consulting Unit.* Retrieved from www.cscu.cornell.edu › news › Handouts › SEM_fit

Raborn, A. (2019). ShortForm: Automatic short form creation (Version 0.4.4) [Software]. Available from https://CRAN.R-project.org/package=ShortForm

Raborn, A. W. (2020). antcolony.lavaan: A function to implement the ant colony optimization algorithm. Retrieved from https://rdrr.io/cran/ShortForm/man/antcolony.lavaan.html

Reeves, P. M., & Reeves, T. C. (2008). Design considerations for online learning in health and social work education. *Learning in Health and Social Care, 7*(1), 46-58. Retrieved from https://doi.org/10.1111/j.1473-6861.2008.00170.x

Revelle, W. (2019a). fa: Minres (minimum residual) factor analysis as well as factor analysis by principal axis, weighted least squares or maximum likelihood. *RDocumentation.* Retrieved from https://www.rdocumentation.org/packages/psych/versions/1.0-94/topics/fa

Revelle, W. (2019b). Omega: Calculate McDonald's Omega estimates of general and total factor saturation. *RDocumentation.* Retrieved from https://www.rdocumentation.org/packages/psych/versions/1.8.12/topics/omega

Revelle, W. (2019c). VSS: Apply the Very Simple Structure, MAP, and other criteria to determine the appropriate number of factors. *RDocumentation.* Retrieved from https://www.rdocumentation.org/packages/psych/versions/1.9.12.31/topics/VSS

Revelle, W. (2020). Package 'psych'. Retrieved from https://cran.r-project.org/web/packages/psych/psych.pdf

Rhode, J., & Krishnamurthi, M. (2016). Preparing faculty to teach online: Recommendations for developing self-paced training. *International Journal of Information and Education Technology, 6*(5), 376-382. Retrieved from http://dx.doi.org/10.7763/IJIET.2016.V6.717

Richter, S. L., & Schuessler, J. B. (2019). Nursing faculty experiences and perceptions of online teaching: A descriptive summary. *Teaching and Learning in Nursing, 14,* 26-29. https://doi.org/10.1016/j.teln.2018.09.004

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York, NY: Free Press.

Rosseel, Y. (2019). lavaan: Latent variable analysis (Version 0.6-5) [Software]. Available from https://CRAN.R-project.org/package=lavaan

Saha, S. (2018, October 5). Baffled by covariance and correlation??? Get the math and the application in analytics for both the terms. *Towards Data Science.* Retrieved from https://towardsdatascience.com/let-us-understand-the-correlation-matrix-and-covariance-matrix-d42e6b643c22

Scott, S., & McGuire, J. (2017). Using Diffusion of Innovation theory to promote universally designed college instruction. *International Journal of Teaching and Learning in Higher Education, 29*(1), 119-128. Retrieved from http://www.isetl.org/ijtlhe/pdf/IJTLHE2457.pdf

S Graham. (2017, May 22). A simple, easy to understand guide to andragogy [Web log post]. Retrieved from https://www.cornerstone.edu/blogs/lifelong-learning-matters/post/a-simple-easy-to-understand-guide-to-andragogy

Sheffield, S. L-M., McSweeney, J. M., & Panych, A. (2015). Exploring future teachers' awareness, competence, confidence, and attitudes regarding teaching online: Incorporating blended/online learning experience into the teaching and learning in higher education course for graduate students. *Canadian Journal of Higher Education, 45*(3), 1-14. Retrieved from http://files.eric.ed.gov/fulltext/EJ1085353.pdf

Smidt, E., McDyre, B., Bunk, J., Li, R., & Gatenby, T. (2014). Faculty attitudes about distance education. *The IAFOR Journal of Education, 2*(2), 1-29. Retrieved from http://digitalcommons.wcupa.edu/langcult_facpub/7

Spence, B. (2019). Practical applications in radiography education. *Radiologic Technology, 90*(4), 369-386. Retrieved from http://www.radiologictechnology.org/content/90/4/369

Tay, L., & Jebb, A. (2017). Scale creation. In S. Rogelberg (Ed), *The SAGE Encyclopedia of Industrial and Organizational Psychology* (2nd ed., Vol. 3, pp. 1381-1383). Thousand Oaks, CA: Sage.

The R Foundation. (n.d.). What is R? *The R Project for Statistical Computing.* Retrieved from https://www.r-project.org/about.html

Tough, A. (1971). *The adult's learning projects: A fresh approach to theory and practice in adult learning.* Toronto: Ontario Institute for Studies in Education.

Vanek, J., Simpson, D., Johnston, J., & Petty, L. I. (2018). *IDEAL distance education and blended learning handbook* (6th ed.). Retrieved from https://edtech.worlded.org/wp-content/uploads/2018/08/IDEAL-Handbook-6th-Edition-2-4-19.pdf

van der Linden, W. J. (2005). *Linear models for optimal test design.* New York, NY: Springer.

Wang, Q., Quek, C. L., & Hu, X. (2017). Designing and improving a blended synchronous learning environment: An educational design research. *International Review of Research in Open and Distributed Learning, 18*(3), 99-118. Retrieved from www.irrodl.org/index.php/irrodl/article/view/3034

Wasilik, O., & Bolliger, D. U. (2009). Faculty satisfaction in the online environment: An institutional study. *Internet and Higher Education, 12*(3), 173-178. Retrieved from https://www.learntechlib.org/p/105511/

Wertz, C. I., Hobbs, D. L., & Mickelson, W. (2014). Integrating technology into radiologic science education. *Radiologic Technology, 86*(1), 23-31. Retrieved from http://www.radiologictechnology.org/content/86/1/23

Wu, H., & Estabrook, R. (2016). Identification of confirmatory factor analysis models of different levels of invariance for ordered categorical outcomes. *Psychometrika, 81*(4), 1014-1045. doi:10.1007/s11336-016-9506-0

Zhao, Y., Lei, J., Yan, B., Lai, C., & Tan, H. S. (2005). What makes the difference? A practical analysis of research on the effectiveness of distance education. *Teachers College Record*, *107*(8), 1836– 1884. doi:10.1111/j.1467-9620.2005.00544.x

Zhen, Y., Garthwait, A., & Pratt, P. (2008). Factors affecting faculty members' decision to teach or not to teach online in higher education. *Online Journal of Distance Learning Administration, 11*(3), 1-21. Retrieved from https://www.westga.edu/~distance/ojdla/fall113/zhen113.html

Zinbarg, R. E., Revelle, W., Yovel, I., & Li. W. (2005). Cronbach's Alpha, Revelle's Beta, McDonald's Omega: Their relations with each and two alternative conceptualizations of reliability. *Psychometrika, 70*(1), 123-133. doi: 10.1007/s11336-003-0974-7