Virtual Technology in Radiologic Technology Classrooms: The Educational Impact of the COVID-19 Pandemic

by

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Keywords: Technology integration, radiologic technology, technology acceptance model, theory of planned behavior, education, impact, pandemic, COVID-19

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Abstract

During the COVID-19 pandemic, many educators were forced to convert their courses to a virtual format with very short notice. Radiologic technology educators have the responsibility to prepare the future generation of medical imaging professionals, which results in the need to prepare students to enter the workforce.

An explanatory mixed methods cross-sectional survey design was conducted to evaluate virtual technology integration and intention for continued use (CITU) in the radiologic technology classroom. A total of 255 participants completed an online survey through Qualtrics. The survey measured the constructs of behavior, perceived behavioral control (PBC), perceived ease of use (PEU), perceived usefulness (PU), attitude, and CITU. The study also evaluated pre-COVID and post-adjustment uses of virtual technology and perceived barriers. Lastly, the study also contained a pseudo-qualitative component to add meaning to the quantitative data. Results found that the overall regression model (combination of attitude, behavior, PEU, PU, & PBC on CITU) was statistically significant ($F_{5, 230} = 59.167$, $p < .001$) and explained about 56% of the variance in CITU ($R^2 = .563$, Adj. $R^2 = .553$). Attitude was the strongest predictor and mediated the effects of the other predictors on CITU. The pseudo-qualitative component allowed the challenges, rewards, and future intentions to be examined in-depth as reported by the current sample of radiologic technology educators.

Keywords: Technology integration, radiologic technology, technology acceptance model, theory of planned behavior, education, impact, pandemic, COVID-19

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I. NATURE OF THE PROBLEM

Virtual Technology in Radiologic Technology Classrooms: The Educational Impact of the COVID-19 Pandemic

The COVID-19 pandemic, which hit the United States in the year 2020, created a quick need to transition education to a virtual format. This affected educational institutions of all kinds, including those with radiologic technology programs. The field of radiologic technology is vast and diverse. It involves the acquisition of diagnostic images for medical purposes with the intent to obtain a diagnosis. Radiologic technology is utilized in hospitals, clinics and involves the use of technological equipment on a daily basis. As technology quickly advances, so does its' use in the medical field, particularly for diagnostic imaging equipment. "The history of radiology is particularly interesting and exciting; it is marked by constant change and advances" (Gurley & Callaway, 2011, p. 3).

Significant advancement in the technology and software used for medical imaging has occurred. In computed tomography (CT), for example, scan time per slice in 1972 was 300 seconds, but had dropped to 0.005 seconds by the year 2005 (Romans, 2019). Digital imaging was even used and received notable developments by the United States National Aeronautics and Space Administration (NASA) space program to "improve visualization of the surface of the moon" (Seeram, 2019, p. 22). Current topics in imaging technology include the use Artificial Intelligence (AI) which involves computer algorithms that learn and predict. In radiology, this can be used to aid in diagnosis and analyzing large medical data sets. Some even feel AI is a threat to the field of radiology. Chockley and Emanuel (2016) predicted "in a few years, there may be no specialty called radiology" (p. 1419). Technologies used in radiologic technology education may include energized x-ray equipment in simulation labs, anatomage tables (Ward et al., 2018), reconstruction software, simulation software, and 3D printers, to name a few. The advancement of technology in Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) has allowed accurate 3D models to be built and specifically tailored to a patient (Chia & Wu, 2015). The advancement has been immense, and the current trajectory suggests it will continue to advance at a rapid pace.

Marie Curie was the first to provide education in radiologic sciences through the Army School of Roentgenology from 1916-1918 at the front during World War I (Gurley & Callaway, 2011). The first formal education training in the United States began with Eddy Clarence Jerman in 1917 (Callaway, 2020). In 1975, the Association for Collegiate Educators in Radiologic Technology (ACERT) was established as an organization for radiology educators in the Western United States, it further expanded as a national organization in 1991. According to their website, the purpose of ACERT is to address the educational needs, issues, and leadership in the field of radiologic technology (ACERT.org). The rate at which technology has been advancing makes it necessary for working technologists and educators alike to stay up to date with the current trends and uses of technology. The American Registry of Radiologic Technologists (ARRT, n.d.) implementation of continuing education requirements began in 1995 requiring registered radiologic technologists (RT's) to complete 24 hours of continuing education every biennium (every 2 years). The ARRT reviews board-examination content every 5 years in an effort to keep board certification exams up-to-date and relevant to current practice. For example, in 2017, although generally considered obsolete, information regarding the use of film and film processing was finally removed from the board certification content specifications (ARRT, 2016). The use of film has become obsolete but many technologists working in the field today were trained using film and have witnessed the changes in technology usage. Breed (2014) emphasized the need for leadership in radiology education due to the nature of constant change experience in the profession.

The American Society for Radiologic Technologists (ASRT) is the national organization for medical imaging professionals in the U.S. with the mission of advancing and elevating the profession. The ASRT provides practice standards, accreditation standards, and educational curriculum guidelines. The ASRT practice standards state the importance of engaging in continuing education as a way to "enhance patient care, safety, public education, knowledge, and technical competence" (ASRT Practice Standards, 2019, p. 3). Radiologic technology educators are required to complete the same types of continuing education that practitioners are, to keep their licenses current, but that may not always translate into the use of technology in the classroom. Beyrouti (2017) suggested that although there is great potential for the use of technology for educational purposes, educators have been generally slow to respond and implement technology usage. Many institutions may not have the most up to date equipment for their students to utilize in the classroom. Additionally, without an active approach to stay current, it is easy for educators to quickly fall behind on current practice. Furthermore, the COVID-19 pandemic may have forced otherwise reluctant educators to try new virtual technologies and tools, which may or may not have changed their pedagogical practices.

We are currently in a digital world, where information and technology is available at the touch of a finger. For educators specifically, technologies for educational delivery may vary significantly. When Universities were transitioned to a virtual format in the COVID-19 pandemic, many virtual teaching companies advertised and offered free services to educators, providing a copious, albeit overwhelming, number of virtual technology options. Therefore, there is a lack of data addressing the impact of the COVID-19 pandemic on educational virtual technologies. More specifically, an understanding of the impact this virtual technology has had on educators of radiologic science is valuable.

Statement of the Problem

As important as it is for technologists working in the field to be up to date in clinical practice, it is equally important for educators to provide up to date curriculum that matches the technological progress of the field. “Regardless of how faculty learned, the way they will teach radiologic sciences in the future will differ markedly” (Martino & Odle, 2008 p. 133). Technology is advancing rapidly, and it is the professional responsibility of educators to provide the most current technology and practices in the didactic setting (Kowalczyk, 2014). As a result of the COVID-19 pandemic, many educators were forced to convert their coursework to a virtual and/or remote format with very short notice, adding an additional complication to the issue. Although many institutions offer a variety of virtual learning tools and professional development opportunities for faculty members, the nature and speed of the traditional-to-virtual transition created a forced environment to learn, undoubtedly influencing educators’ experience, pedagogy, and attitudes. It is possible that some educators found great benefit from virtual learning tools and/or platforms, which could result in continued use of these technologies even after the pandemic has ended. Alternatively, others may have continued to resist the transition to a newer digital and/or virtual form of pedagogy. Furthermore, some educators may have found it difficult to adopt certain technologies over such a short period of time, regardless of their desire to learn, and may not continue use once they are no longer required to do so. Regardless of the individual scenarios, one thing is sure, education will undoubtedly be different because of the COVID-19 pandemic. The forced use of virtual technologies by educators as a result of the

COVID-19 pandemic may be a catalyst in educational delivery that many educators have been advocating for.

The unique nature of radiologic technology education is that students in radiologic technology programs incorporate internships in clinical settings in addition to didactic learning. The didactic training should provide students with experience using cutting-edge technology, which will allow them to integrate these technologies in clinical practice. During the COVID-19 pandemic, many students were unable to participate in clinical experiences, were unable to attend campus for laboratory experiences, and were therefore reliant on virtual and simulation learning experiences to supplement their academic progress. Educators of radiologic science have always faced the challenge of finding balance between current practice and anticipating the future trajectory of clinical practice. The implementation of new technology, in both face-to-face and virtual/remote formats, has added to this challenge. As indicated by Gillan et al. (2010), adoption and implementation of transformative technologies have the intention and potential to improve overall patient outcomes. In medical imaging, the advancements in technology and software are occurring at a rapid rate, requiring a constant learning process and collaboration among imaging professionals and physicians. These needs can only be met through the anticipatory nature of educational delivery. Wertz et al. (2014) noted that:

> Because individuals working in the field of radiologic technology continually work with new equipment and innovative technological advances, it is reasonable to expect that new educational technologies—if found to be effective—could play an important role in both educational delivery and learning. This integration of educational technologies could enable students to incorporate such methods into their daily practice. (p. 30)

It can be difficult to maintain the most up to date equipment because of the rate at which the technologies become outdated. Not only are the technologies advancing quickly, but they are also expensive to purchase and would require significant effort to remove and replace old technological units to install new ones on a regular basis. As the newer generation of students enter radiologic technology programs, more students are comfortable and receptive to digital forms of learning. New students entering college have grown up using technology and are sometimes referred to as the *iGeneration* (Rosen, 2010). Although the nature of a radiologic technology educational program is not possible in an entirely virtual format, the delivery of didactic coursework in virtual formats may be better received by students who are accustomed to virtual educational delivery methods. The COVID-19 pandemic forced many educators to transition to virtual teaching, a phenomenon that may not have occurred otherwise. This presented various challenges for educators to provide students with learning experiences to help them thrive in the clinical setting, to pass their national board certification exam, and ultimately to positively influence patient outcomes in the workforce. Therefore, the statement of the problem is that the COVID-19 pandemic has forced educators to teach virtually and the educational impact (both current and future) has yet to be investigated in the radiologic science classroom.

Significance of the Problem

As a result of the COVID-19 pandemic, educational delivery transitioned into a virtual format. It is the responsibility of educators to provide high-quality learning experiences that will not compromise students' opportunities for educational and career advancement. It is important to understand how the forced use of virtual learning technologies affected educators and how those changes will shape the pedagogical practices of these educators in the future. Radiologic science is a rapidly advancing field because of the rate that technology is advancing. Students going through educational programs should be educated and trained on cutting-edge equipment, as well as equipment that is most relevant to clinical practice. The students of radiologic technology programs will eventually serve their communities as healthcare providers when they enter the workforce. Their experience and knowledge gained during their education should provide them with the skills and knowledge to provide the highest quality of healthcare to their patients. The availability and use of these new technologies may vary between radiologic technology educational programs.

Furthermore, the use of virtual learning and simulation provides educational programs with the opportunity to reach more students, particularly those in rural communities. Although a stressful and difficult transition (for many) due to the urgency presented by the pandemic, it is possible that the forced transition to virtual learning practices could improve student learning experiences and outcomes. Therefore, the significance of the problem is that radiography students need to pass not only didactic, but clinical competencies in order to pass industry-specific certification exams. This is directly impacted by the educational delivery they received. Due to the COVID-19 pandemic, educators have been forced to change many practices for educational delivery, many in a virtual format, which could impact the ability for students to pass certification exams. Understanding the current impact, as well as the potential impact for future educational practices is crucial for the success of students.

Purpose of the Study

The purpose of the study was to investigate the educational impact of the COVID-19 pandemic on virtual technology use in the radiologic technology classroom. This incorporated specifically investigating: (a) the pre-COVID-19 versus post-adjustment uses of virtual technology, (b) the pre-COVID versus post-adjustment perceived barriers preventing integration of virtual technology, and (c) the continuance intentions to use virtual technologies post-COVID-19. The information from this study provided valuable insight that may be utilized to improve radiologic technology programs across the country. The findings of the study have highlighted areas in which improvement can be made and assist administration in implementing virtual technology in radiologic technology programs. The improvement of radiologic technology programs would produce students that are more competent and ready to begin in their field of study upon graduation. This not only helps the students to be proficient in their careers upon (and often before) graduation, but it also improves the quality of the care to patients in their respective communities. Therefore, the purpose of the study was to investigate and gain an understanding of the current impact of COVID-19 and future trajectory of virtual technology use in the radiologic science and allied health classrooms.

Theoretical Framework

The theoretical framework for the study builds upon a combination of the 1991 (Ajzen) theory of planned behavior (TPB) and the 1989 (Davis) technology acceptance model (TAM). Both models incorporate the measurements of intentions and behaviors. The models were chosen after a thorough review of the literature was conducted to best identify the theoretical framework that meets the needs of the proposed study. The study was conducted using a researcher-designed combination of the two theoretical frameworks.

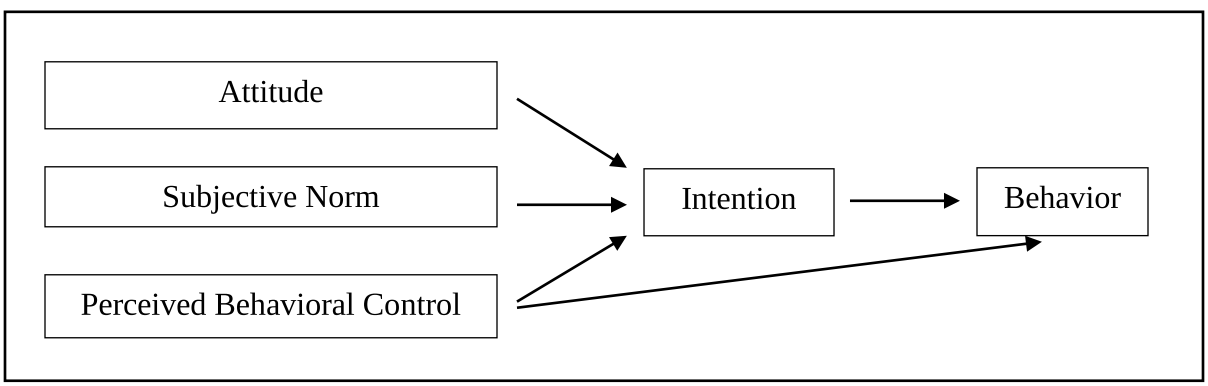
Theory of Planned Behavior

The original theory of planned behavior (Ajzen, 1991) suggested that attitudes, subjective norms, and perceived behavioral control are predictors of intentions. The intentions and perceived behavioral control were posited to predict behavior. PBC was also identified as having a direct relationship for predicting behavior, therefore mediating intention. Ajzen (1991) also asserted that measuring past behaviors in the regression equation was a useful measurement to include in the model for predicting intention and behavior (see Figure 1).

Fishbein and Ajzen (2005) further posited that behavior stems from the influence of an individual's attitudes, beliefs, and intentions. Cheng and Chu (2016) utilized an extended TPB and found that attitude, subjective norms, and perceived behavioral control explained intention and suggested that past experience/behavior should be investigated as another influencing construct for intention. Cheng et al. (2016) examined an extended TPB model to evaluate student intentions for e-collaboration. It was found that attitudes, perceived behavioral control, and past experience had significant direct effects on intentions which aid in predicting behavior. The study also found that subjective norms were not significantly associated with intentions for e-collaboration, which also aligns with other findings in the literature (Ma et al., 2005; Teo, 2011).

Figure 1

Theory of Planned Behavior Model



(Ajzen, 1991)

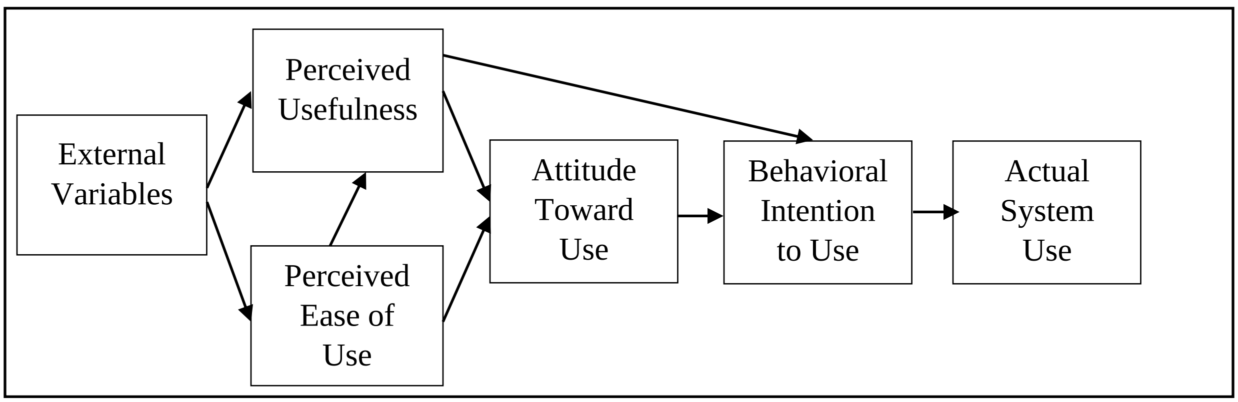
Technology Acceptance Model

The technology acceptance model (TAM) described by Davis (1989) suggested the constructs of 'perceived usefulness' and 'perceived ease of use' play a vital role in the implementation of technology into practice. Davis (1989) focused on the behaviors of the user and utilized a self-reporting survey to create a model for measuring attitude towards use, behavioral intention to use, and user acceptance (see Figure 2). Davis (1989) proposed that perceived ease of use could be predictive of perceived usefulness and attitudes. Furthermore, the perceived usefulness was found to be predictive of attitudes and intentions. Ultimately, it was posited that attitudes were predictive of intentions (Davis, 1989). Knowledge of the TAM may be useful for successful implementation of technology use in educational programs. Ma et al. (2005) utilized an expanded variation of the TAM model and found that although perceived usefulness and perceived ease of use were significant in explaining (whether by direct or indirect means) intention to use computer technology, subjective norm did not have any direct or indirect effects on intention to use computer technology. It was found that perceived usefulness had a significant direct effect on intention, whereas perceived ease of use only had a direct effect on perceived usefulness. Furthermore, Wu and Chen (2017) integrated the TAM and the task technology fit (TTF) model to evaluate continuance intention to use massive open online courses (MOOCs). It was found that attitude and perceived usefulness were critical in terms of continuance intention. Perceived usefulness was found to be a mediator for perceived ease of use, and perceived ease of use was found to have no effect on attitude (Wu & Chen, 2017).

Siegel (2017) extended the TAM and introduced the Motivation Acceptance Model (MAM). This study evaluated the usage and resistance of new technology implementation for faculty in the College of Education at a higher education institution. The study found that perceived ease of use, attitude, and perceived usefulness were significant predictors of actual usage. Perceived ease of use had significant effects on attitude and perceived usefulness, and perceived organizational support was not found to be a significant predictor of actual use or attitude (Seigel 2017). The study also found that technological and motivational factors influence the usage and acceptance of the technology and can be greatly influenced by how administration facilitates the introduction, usage, and support for using the technology. Using the TAM lens to view the current study indicates the use of virtual technology in the classroom should be applicable to student learning and clinical practice if user acceptance is to occur. This can be applied to both educators' and students' acceptance of the technology.

Figure 2

Technology Acceptance Model (TAM)



(Davis, 1989)

Note. Model reprinted with permission (see Appendix A)

Theory of Planned Behavior versus Technology Acceptance Model

A study by Cheng (2019) evaluated the TAM, TPB, and an integrated model of the two, and found that although attitudes was a significant predictor of intentions in the TAM, it was not in the TPB and the integrated model. Furthermore, "subjective norms and perceived behavioral control greatly reduced the explanatory power of attitudes" (p. 32). It was suggested that the TPB is the better tool for measuring intention especially when social influences are present (Cheng, 2019) and for e-learning and the adoption of collaborative tools (Biasutti, 2011), whereas the TAM may be a better tool for evaluating personal adoption and use (Cheng, 2019).

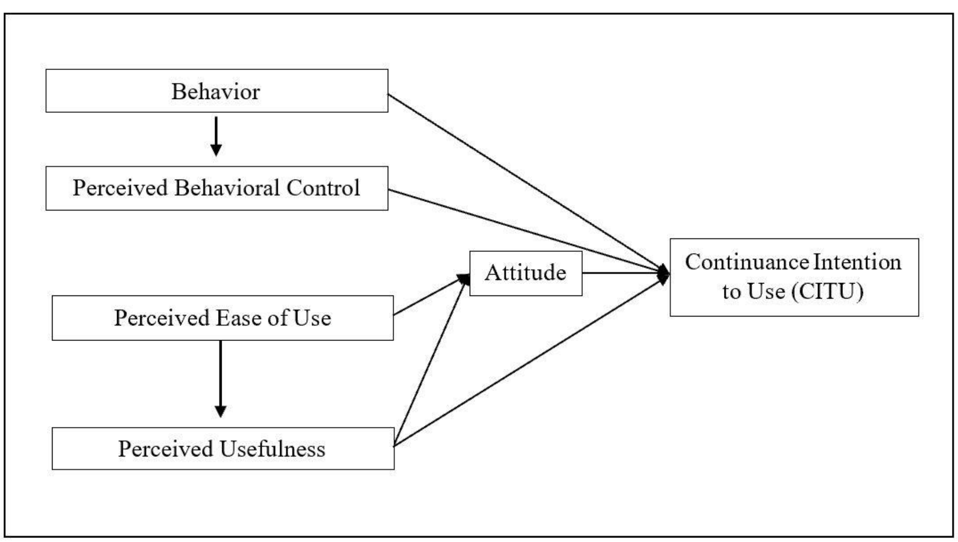
Both the TAM and the TPB have been widely adopted in studies evaluating behavior and intentions for technology use. Dalvi-Esfahani et al. (2020) took an additional step by using an extended TAM to evaluate continuance intention of Web 2.0 learning in students. The study utilized the TAM and TPB, in addition to other models such as the technology-to-performance chain model and the uses and gratifications theory (U&G), to understand students' continuance intention to use Mobile Web 2.0 learning. It was found that among several factors, perceived ease of use and perceived usefulness from the TAM, and attitude, perceived behavioral control, and subjective norm from the TPB were all significant in explaining intention to continue use, and that student learning was ultimately determined by the significant predictor of behavioral intention (Dalvi-Esfahani et al., 2020).

Model for Study

To meet the specific needs and purpose of the study, the TPB and TAM were modified and combined to focus on the constructs that predict continuance intention and apply it to the intention for continued use of virtual technology past the COVID-19 pandemic (see Figure 3). The model for the current study builds upon the literature to best fit the purpose of the study. The model included the constructs of attitude, behavior, perceived behavioral control (PBC), perceived usefulness (PU), perceived ease of use (PEU) and continuance intention to use (CITU). Nearly all studies found that attitude had a significant direct relationship with intention (Cheng et al., 2016; Cheng & Chu, 2016; Cheng 2019; Dalvi-Esfahani et al., 2020; Teo, 2011; Wu & Chen, 2017). Past experience and behavior have been found to predict intention and/or perceived behavioral control (Cheng et al., 2016, Davis, 1989) and has been identified as a construct to be evaluated in future research (Cheng & Chu, 2016; Davis, 1989). For the purpose of this study, the construct of Behavior was used as a measurement of past behavior. Perceived behavioral control was also found to be an important construct in explaining and/or predicting intention in several studies (Cheng et al., 2016; Cheng & Chu, 2016; Cheng 2019; Dalvi-Esfahani et al., 2020). Perceived usefulness has been found to explain intention (Dalvi-Esfahani et al., 2020; Ma et al., 2005; Teo, 2011; Wu & Chen, 2017) but has also been found to have an effect on attitude (Cheng, 2019) and is a mediator for perceived ease of use (Cheng, 2019; Ma et al., 2011; Teo, 2011; Wu & Chen, 2017). Although perceived ease of use appears to have an indirect effect on intentions, it has been shown to directly predict attitude (Cheng, 2019; Teo, 2011) and perceived usefulness (Cheng, 2019; Ma et al., 2005; Teo, 2011; Wu & Chen, 2017). Subjective norm had mixed results, with some studies indicating a significant effect on intention (Cheng & Chu, 2016; Cheng, 2019; Dalvi-Esfahani et al., 2020) but many also indicated no effect (Cheng et al., 2016; Ma et al., 2005; Teo, 2011). Furthermore, the immediate need for virtual technology use and remote learning as a result of the COVID-19 pandemic has created an environment where it was no longer subjective and/or an option, but rather a forced transition and was therefore not used in the current study.

Figure 3

Hypothesized Model for Current Study



Research Questions

The research questions for the study were:

1. To what extent does educators' CITU of virtual technology differ based on demographic categories (i.e. title, level of education, etc.)?
2. Does the combination of the constructs Behavior, Perceived behavioral control (PBC), Perceived ease of use (PEU), Perceived usefulness (PU), and Attitude explain educators' CITU of virtual technologies?
3. How does the pre-COVID-19 virtual technology degree of use differ from the post-adjustment virtual technologies used?
4. How does the pre-COVID-19 perceived barriers to integration of virtual technology differ from the post-adjustment perceived barriers?
5. How does the post-adjustment virtual technology degree of use differ from the post-COVID-19 intentions for future virtual technology use?
6. What themes were presented in the open-ended questions?

Definition of Terms

Allied Health Professions: A group of "highly specialized, complex, and highly technical professions" (Callaway, 2020, p. 129).

American Registry of Radiologic Technologists (ARRT): The credentialing organization that certifies radiologic technologists in the United States.

American Society of Radiologic Technologists (ASRT): National society for radiologic technologists. The ASRT oversees legislation within the field of Radiologic technology and provides the curriculum that educational programs must meet. The ASRT provides many benefits for members including opportunities for continuing education, and peer-reviewed journal.

Artificial Intelligence (AI): The computer predicts and diagnoses images based on past patterns and algorithms.

Attitude: The value placed on and/or the response to a specific behavior, whether negative or positive (Ajzen, 1991; Ajzen, 2019).

Behavior: An observable response (Ajzen, 2019).

Career and Technical Education (CTE): According to the Association for Career and Technical Education (ACTE), CTE is an education that is rigorous, cutting-edge, and relevant with the overarching goal of preparing students and adults for careers that are high-demand, high-wage, and high-skill (https://www.acteonline.org/why-cte/what-is-cte/).

Computed Radiography (CR): The term used for radiologic equipment that utilizes computed radiography cassettes that must be processed prior to viewing the x-ray image.

Continuance Intention to Use (CITU): An individual's intention to continue use of a technology/tool/etc. (Wu & Chen, 2017; Dalvi-Esfahani et al., 2020). For the purpose of this study, it will be applied to the educators' intention to continue to use virtual technology in the classroom past the COVID-19 pandemic (i.e. when all methods of teaching such as face-to-face, hybrid, and online/distance are available without restrictions).

Direct Digital Radiography (DR): The term used for radiologic technology equipment that acquires the image without the need to process a cassette. The data is processed directly from the imaging plate and is processed to the computer monitor within seconds.

Intention: Measure of an individual's readiness to perform a behavior (Ajzen, 2019).

Perceived Behavioral Control (PBC): A person's perception of their ability to perform a behavior (Ajzen, 1991; Ajzen, 2019).

Perceived Ease of Use (PEU): Defined by Davis (1989) as "the degree to which a person believes that using a particular system would be free of effort" (p. 320).

Perceived Usefulness: Defined by Davis (1989) as "the degree to which a person believes that using a particular system would enhance his or her job performance" (p. 320).

Picture Archiving and Communication System (PACS): The system in which diagnostic images and patient information is stored, retrieved, and archived.

Post-Adjustment: Self-reported perceptions of virtual technology use in the classroom after the COVID-19 pandemic affected Universities. This is applicable to the current time at which the data collection will occur.

Post-COVID-19: When all methods of teaching such as face-to-face, hybrid, and online/distance are available without restrictions.

Pre-COVID-19: Self-reported perceptions of virtual technology use in the classroom before the COVID-19 pandemic.

Radiologic Technologist (RT): Radiologic technologist who performs diagnostic x-rays.

Technology Integration: The use of new and/or emerging technologies in the classroom as a way to enhance educational delivery.

Technology Acceptance Model (TAM): Theory that states perceived ease of use and usefulness contribute the success of technology acceptance and use (Davis, 1989).

Theory of Planned Behavior (TPB): Theory that measures attitudes, perceived behavioral control, and subjective norms as predictors of intentions and behavior (Ajzen, 1991).

Virtual Technology: The use of technology to provide virtual learning experiences.

Limitations

Limitations to this study which may have impacted the results included a) self-report data, b) no *true* pre-COVID-19 data, and c) low survey response rate. Due to the fact that the COVID-19 pandemic had already started and affected nearly all Universities across the United States, and it was impossible to gather true pre-COVID-19 perceptions. Self-report data is inherently considered to be a limitation because there is always a possibility for error. Therefore, this study must rely on self-report and recall data of pre-COVID-19 perceptions and is therefore subject to recall bias. People are often poor judges of past or future behavior; there are many factors, such as desirability, that can impact the recall and/or predictions for future behavior. The survey response rate was not within the control of the researcher and therefore allowed for the risk of non-response bias. Due to the additional requirements put on educators as a result of the COVID-19 pandemic, it is possible that educators did not have the time and/or willingness to complete the survey. The survey invitation was sent to the ACERT and ASRT national organizations to distribute to their educator members. The researcher was not in control of the survey distribution beyond the national organizations invitation to participate via email notification. After the national organizations sent out email invitations to participate, the researcher received several emails from individuals who stated they were retired but would have otherwise liked to participate. This is a limitation because out of the 4,075 invited participants, it is unknown how many may still be involved in the national societies and listed as 'educator' members even though they are retired and are no longer teaching.

Delimitations

Delimitations are the boundaries beyond which the study is concerned and are set by the researcher. The study only included educators of postsecondary radiologic technology programs in the United States. There were no limitations placed on the sub-specialty areas of medical imaging. Participants who were exclusively practicing as clinicians and not teaching at a post-secondary institution as a faculty member were not included in the study.

II. REVIEW OF LITERATURE

The review of literature consists of the following major sections:

1. Introduction
2. Integration of Technology in Education
3. Technology in Radiologic Science Education
4. Virtual Learning and the COVID-19 Pandemic
5. Barriers to Technology Integration
6. Theoretical Framework
7. Summary

Introduction

Technology has advanced very rapidly over the last several years. The use of technology has become an integral component of nearly all aspects in life, including personal cellular devices, Bluetooth software, artificial intelligence, military equipment, the automotive industry, and medical technologies. The medical field, in particular, has reaped many benefits of technological advancements and utilizes technology to provide better care to patients. For example, the development and advancement of 3D printing is a valuable tool in the medical field. This is promising because it allows for pre-operative planning and individualized prosthetic devices for patients. It also provides invaluable teaching and learning opportunities in the educational setting.

The advancement of technology throughout history has profoundly changed the state of humanity. In 2014, Brynjolfsson and McAfee described the Industrial Revolution (also referred to as the first machine age) as the "the first time our progress was driven primarily by technological innovation" (p.7). The development of the steam engine allowed what was previously achieved with human ‘muscle power’ to be done by automated machines. Furthermore, Brynjolfsson and McAfee presented the idea of the *Second Machine Age*, to describe computers and digital advancements as relieving ‘mental power’ through technological automation, therefore providing the potential for humanity to advance even further as a society (2014).

Integration of Technology in the Classroom

Among educators, technology integration has been a topic of discussion for nearly 40 years (Ertmer et al., 2012; Lowther et al., 2008). The younger generation of college students have grown up using technology in several (if not most) aspects of their lives. Because of this, they can often learn new tasks at amazing rates. The use of technology in the workforce further highlights the importance for students to learn industry specific skills as part of their educational experience. Not only does this equip students with the skills and knowledge that are relevant and necessary in the 21st century, but it also provides them with the tools to succeed as they pursue their careers.

During the growth of Career and Technical Education (CTE) there were five major phases of technology development which were: 1) application of power to machines, 2) introduction of mass production, 3) influence of automation, 4) miniaturization, and 5) global network/technological explosion (Gordon, 2014, p.20-21). The fifth phase, global network/technological explosion, involved the increased advancements in technology, computers, etc. which were used in business, industry, and education. For CTE, in particular, vocational schools quickly started using technology in the classroom in order to better prepare students for the new technological workforce (Gordon, 2014).

In 2008, Congress jointly passed the nonprofit Digital Promise to support research and development to compete in a global economy (Digital Promise, 2014) with the goal to improve innovation and access to learning opportunities in education. In 2010, the U.S. Department of Education (USDOE) created the Blueprint for Reform, identifying technology as an essential component of a complete education. In 2013, the USDOE and the Federal Communications Commission produced the leading education by advancing digital commission (LEAD) report and blueprint which encouraged schools to incorporate technology at a more rapid rate (LEAD Commission, 2013). The National Board for Professional Teaching Standards (NBPTS) also established standards for accomplished teaching in order to advance the quality of teaching and learning for career and technical education (NBPTS, 2014). Of the current standards, CTE Standard IV, Learning Environment and Instructional Practices specifically addressed the utilization of technology.

In 2017, the Office of Educational Technology (OET) emphasized the importance of technology use in creating a student-centered approach to education, engaging and empowering learning through technology, blended learning, utilizing assessments with technology, creating an infrastructure that bridges the formal, informal, workplace, and mobile learning environments, and enabling innovation and change through leadership. It also emphasized the need to look to the future and what education will look like in coming years (OET, 2017). Furthermore, the current International Society for Technology in Education (ISTE) standards have updated the focus to facilitating the learning of and with technology to inspire students to responsibly and positively contribute in a digital world (ISTE, 2019).

According to Riedel (2014), mobile devices for schoolwork is a trend that has emerged and has already had a significant impact on shaping education. Mobile devices have advanced significantly with the advancement of smart phones, iPads, and tablets, which allow users to access the internet and perform many functions related to academic coursework. As mobile devices have become more easily accessible, their use as an educational tool has become a relevant trend. Padmo et al. (2019) reported that the “types of mobile devices used in both in developed and developing countries are smartphones” (p. 157). This highlighted the importance and need for educators to make course materials more easily accessible on mobile devices, especially for online and distance education. The study found that students found motivation and satisfaction in the use of mobile devices for educational purposes and suggested that “the use of mobile devices to access online learning could be linked empirically to the level of motivation of the respondents” (p. 155).

The convenience of access anywhere at any time has been found to improve the effectiveness of mobile devices as a whole (Beyrouti, 2017; Bidin & Ziden, 2013; Louhab et al., 2018; Padmo et al., 2019). The improvements in technology for communication and access to the internet have facilitated this trend from the traditional classroom to the mobile device. According to the 2013 Speak Up Survey as discussed by Reidel (2014), 89% of high school students have access to internet-connected smart phones and common uses of their mobile devices include anytime research, educational games, collaboration with peers, reminders and notifications related to academic coursework, taking photos of assignments, in-class polling, and communication with teachers.

A longitudinal study conducted by Pyörälä et al. (2019) evaluated the effectiveness and patterns of study use of mobile devices for medical and dental students. The study followed medical and dental students who were given iPads for their educational programs. The researchers followed these students for a total of five years. The data collection occurred by the conduction of questionnaires and focus-group interviews throughout the duration of the students' education program. The iPads allowed students to take digital notes and file them for convenient access later. The results found that students reported note taking and online information seeking were the most common uses for mobile devices as study tools (Pyörälä et al., 2019).

Stoerger and Krieger (2016) conducted a study that involved the redesigning of an information technology course to utilize new instructional strategies, be more technology-mediated, more student-centered, and utilized a blended web-enhanced component. The web-enhanced component involved virtual teams for post-class work, discussion boards, peer reviews, social technologies, and providing students with the hands-on experience using technologies taught in the class. At the conclusion of the class, student participants were asked to complete a survey on Qualtrics. It was found that the real-world experiences, technology use, and collaboration provided for a rigorous, valuable, relevant, and deeper learning experience for students. However, the assumption that young people are all comfortable with technology did not apply in this study as the "course instructor observed that students' skills gap extended beyond following course instructions (and meeting clearly stated assignment deadlines) to also effectively using technology for academic purposes" (p.23). Regardless of the challenges, Stoerger and Krieger (2016) concluded that technology aids in enhancing learning for students by promoting collaboration, hands-on experience, critical thinking, and higher-order learning skills.

Valler-Jones et al. (2011) discussed the benefits and disadvantages of using simulation in a nursing educational environment. The study suggested that "the introduction of sophisticated computerized programmes into clinical simulation education has enabled realism to enter the teaching environment to prepare the student" (p. 629). This advancement in technology allows for a more realistic simulation that more accurately prepares the student to work with real patients. The study also discussed possible disadvantages, which include student demotivation, unpredictable responses, financial implications, physical space, and the time and expertise to facilitate properly trained staff.

A mixed-methods study involving multiple sites, case studies, focus groups, interviews, observations, and an online survey was conducted to evaluate the technology use of teachers (McKnight et al., 2016). It was found that technology enhanced communication, feedback, access, extended purpose and audience, shifted teacher-student roles, and restructured teacher time for the better. This was supported by the works of Levin and Schrum (2013) who found that teaching practices changed from technology use, resulting in a more efficient, interactive, and relevant delivery of curriculum.

Furthermore, a study by Tondeur et al. (2017) utilized a meta-aggregative approach to evaluate qualitative data and better understand the relationship between teachers' pedagogical beliefs and their technology usage. It was found that "past programs aimed at increasing technology integration in education have often failed due to a mismatch between the educational change and the meanings attached to that change by those involved in the instructional process" (p. 571). The study found that technology use and the pedagogical beliefs of educators demonstrates a bi-directional relationship, may hinder or prevent technology, that a multi-dimensional approach should be used, that the "role of pedagogical beliefs is needed for teachers to benefit from professional development aimed at increasing educational technology use" (p. 565) and that the context of the school environment is an important factor to take into account. These findings demonstrated the importance of addressing the relationship between teacher's beliefs in order to facilitate a higher likelihood of technology implementation.

Technology in Radiologic Science Education

In the field of radiologic technology, the rate of technological advancement requires technologists to stay up to date on current practice (ARRT, 2016). There are currently 735 ARRT-approved radiography programs in the United States (ARRT). Radiologic technology education programs implement both didactic and clinical work to provide students with the needed experience to be competent in their profession. It is of utmost importance that radiologic technology educators provide experiences and information that will prepare students for both the current and future work in the field.

Linaker (2015) conducted a review of literature to explore how radiology is taught and learned. Radiology was described as a clinical skill requiring problem-solving skills, integration of technology and clinical knowledge, application of basic anatomy and physiology knowledge, independent learning, and utilization with various interactive software. It was also stated that "radiology, with its multitude of rapidly developing imaging techniques and associated escalating costs, demands that students become proficient medical decision makers" (p. 10). Furthermore, Linaker (2015) emphasized that the literature regarding radiology education is sparse, inconsistent, sometimes contradictory, complex, and in need of further research to evaluate the effectiveness of educational programs and student learning. Spence (2019) emphasized that the clinical and didactic nature of radiologic technology education requires an educational approach that incorporates active learning, technology integration, team and peer-based learning, simulation, virtual tools, reflective writing, and the promotion of professionalism. These practical applications are stated as important in the education and preparation of high-quality students who are ready to enter the profession, provide high-quality care to patients, and be lifelong learners.

To evaluate technology use in the profession, Aarts, et al. (2017) conducted a qualitative study, which interviewed radiographers, nuclear medicine, and radiation therapy technologists regarding their opinions in technology. The study found that radiographers highly value their education in new technologies, as it is a necessary component of their job and aids in patient care. The study concluded that radiographers want access to more education about emerging technologies that are introduced. This study focused on radiographers currently working in the field, presenting the significance of continued technological training for new and emerging technologies.

Furthermore, Akers (2019) emphasized the importance of integrating virtual technology in the radiology classroom, stating that 'by using alternative programs through Web 2.0 technology, the radiology classroom can become a new place for students to learn" p. 79). In regard to students in radiologic science programs, an educational institution should provide students with information needed to perform their job currently, but would benefit to also introduce them to newer emerging technologies that are likely to be implemented during their careers in the clinical setting. This would prepare students to transition from school into practice and agrees with the results derived from Aarts et al. (2017).

Applegate (2010) identified mobile electronic devices (MEDs) as a useful educational tool which could enhance the learning of radiography students and that the integration into the clinical setting could also provide for educational opportunities such as documenting student progress, interesting cases, and even as an additional resource of information while in their clinical rotations. Wertz et al. (2014) also highlighted some of the beneficial uses of mobile devices in radiologic technology education to include the retrieval and storage of textbooks, audio recordings, video recordings, and other files. It was suggested that because the younger generation of students are comfortable and familiar using technology, educators "must adapt to fluctuating learning styles and preferences, stay current with educational and radiologic science trends, and integrate new educational technologies into their teaching" (p. 29). The study reviewed the literature regarding the use of mobile electronic devices, podcasts, online education, and social media. The study explored the possibilities available for providing convenient and quality education to students in many formats rather than the traditional lecture method. The study concluded that the technology available can be used to meet the demand of technology use driven by students (Wertz et al., 2014) which also aligned with the notions of Martino and Odle (2008).

A report by Ward et al. (2018) discussed the implementation of an Anatomage table and the benefits for use in a radiologic science program. The paper explained the advantages of this technology, which include the ability to virtually dissect a life-sized human cadaver, toggle between cadaver and radiography mode, enhance sectional anatomy learning, and the interactive nature and hands-on usefulness for students. The study used student course evaluation comments to suggest the positive experience students had with the technology but did not collect and/or report data to support the claims.

Tam et al. (2010) conducted a randomized control trial to evaluate the effectiveness of learning anatomy using an imaging-based resource. The study utilized a computer-based imaging program that provided interactive DICOM images of sectional anatomy to students in an undergraduate medical anatomy course. The program utilized CT radiological images, which demonstrated anatomy in 3D and allowed for user interaction to create image reconstructions. Participants were taught how to use the computer-based imaging program and asked to complete a questionnaire. The participant scores on an examination were also collected to compare knowledge between the control and intervention groups. The results found that students reported positive feedback using the program. However, the quantitative data on anatomical knowledge did not show a difference between groups, which the authors suggested may be due to the small sample size (Tam et al., 2010).

Alternatively, Rizzolo et al. (2010) conducted a multi-year study which involved an innovative redesign of an anatomy course to make it more clinically engaged. The clinically engaged course involved dissection laboratories, lectures, and supplemental resources including an electronic dissector and web activities. The study found that initially students demonstrated dissatisfaction due to the adjustments required of both faculty and students, but that after the first year, attitudes and satisfaction increased. It was also found that those completing the clinical course compared to the original course demonstrated better effectiveness for students retaining long-term knowledge of anatomy and application of knowledge as measured by section examination scores.

Binder et al. (2019) evaluated students' opinions of utilizing new radiologic imaging technology, Cinematic Rendering, for anatomical education. Students' opinions suggested the use of this new technology enhanced their learning of anatomy. Furthermore, Heptonstall et al. (2016) stated that the integration of anatomy and radiology increases student interest, improved clinical application of anatomy, and improves the skill of interpretation from radiological images. The use of cinematic rendering and other radiological imaging technologies have the potential to improve education (Binder et al., 2019).

Gunn et al. (2017) conducted a study comparing the use of a virtual reality (VR) simulation software to the traditional laboratory simulation. The study involved first year radiography students at an academic institution in Australia and divided the students into two groups. Students were given the task of completing a role-play simulation of two difficult radiography exams that are commonly a challenge for new students. The first group performed the first radiography exam using the VR technology, and the second exam with a phantom in the traditional laboratory setting. The second group performed the two exams in reverse order. The results indicated that the increased technical skill gained by students was attributable to the VR software usage. Results of the study suggest that VR simulation can enhance the technical skills of radiography students, especially in the pre-clinical stage of their education. The study concluded that the use of VR simulation is comparable and possibly more valuable than traditional simulations and that future studies would benefit from evaluating the students' perceptions of confidence gained by using the software (Gunn et al., 2017).

Additionally, Hyde and Strudwick (2017) conducted a qualitative study of radiography students at two UK Universities to evaluate the perceived readiness to enter the workforce. The study utilized focus groups and identified five main themes. These themes included: 1) service users with dementia, 2) service users in pain, 3) emotional labour, 4) service users who needed more complex care, and 5) service users requiring mobile examinations (Hyde & Strudwick, 2017). The study found that generally, most students felt they had a good knowledge of what to expect upon entering the workforce but did not feel confident in the five themes mentioned above. The study suggested that simulation sessions would benefit students by providing a safe environment to practice dealing with situations they may encounter in a clinical setting. This highlighted the importance for use of simulation technology in the educational setting.

The use of 3D printing is another rapidly advancing technology that some radiologic science programs have begun to implement. 3D printing can be used for surgical planning, practice, research of modeling and testing implants, customization of medical products, educational purposes, and even bioprinting of issues and organs (Macko et al., 2017; Vaccarezza & Papa, 2015; Ventola, 2014). Macko et al. (2017) suggested that 3D printing applications are

> Supplementary now, but they can fill an existing gap between the traditional approach and biomedical technologies and methods, increasing their efficiency, shortening hospitalization, lowering cost, and increasing patient's health-related quality of life. (p. 116)

Collinsworth and Clark (2017) performed a literature review of 3D printing models in radiologic science education. From the literature review at the time of publishing, Collinsworth and Clark (2017) reported that there were no published literature regarding 3D printing specifically in radiologic science education and curriculum. However, Collinsworth and Clark (2017) did suggest a variety of uses for the technology as part of a radiologic technology curriculum. These uses included identification of anatomic landmarks commonly used for positioning, identification of pathologies, direct visualization of anatomy, and enhanced learning of reconstructive software and segmentation. These advanced skills would provide students with a cutting-edge skill set upon entering the workforce.

Virtual Learning and the COVID-19 Pandemic

Distance and/or virtual education has grown in popularity and function in recent years (Yildiz & Erdem, 2018), and with it, the use of virtual learning and technology. Virtual reality programs have been documented as useful, cost-effective, and associated with positive student attitudes (Estai & Bunt, 2016; McNulty et al., 2009; Rizzolo et al., 2010; Tam et al., 2010). There are many advantages and disadvantages of distance learning. Some advantages include greater reach (particularly to rural communities and nontraditional students), cost-effectiveness, and convenience. Arnett (2019) emphasized that technology allows for teacher capacity to be unlocked. However, disadvantages to distance education include the decreased connection between teachers and students, lack and/or decreased social interactions among students, access issues, lack of motivation for students to stay on task, and the fact that a face-to-face classroom experience just cannot wholly be replaced (De Silva, 2020; Goldstein, 2020; Mumford & Dikilitaş, 2020).

Carriero et al. (2012) conducted a multi-center study that designed, delivered, and evaluated an e-learning teaching program for post-graduate radiology students in 51% of Universities in Italy. The results of the study indicated that technology has a positive impact on teaching, that the economic cost was minimal, and that the diagnostic e-learning activities should be integrated in educational programs and shared among educators to better improve the learning of students. It was also highly emphasized that the low cost of e-learning activities and remote teaching were advantageous when the physical gathering of professionals is unattainable or limited (Carriero et al., 2012). The time remaining for limited physical gathering of students and/or professionals is not known, and therefore it could be assumed that distance learning will continue to be used more frequently in coming years. Furthermore, the idea of breaking down national barriers could be achieved by the "coordination and integration of diagnostic imaging e-learning projects…in the spirit of 'cultural sharing' and the exchange of teaching experiences" (p. 3941).

Ogura et al. (2018) evaluated the effectiveness of an e-learning platform for image interpretation of chest radiographs in medical staff and students. The e-learning platform was found to be effective, specifically for identifying the ground-glass shadow and nodular shadow pathologies, with increased correct diagnosis after only two weeks of the e-learning period. It was also emphasized that e-learning is beneficial for students who are working or are otherwise considered nontraditional students because it can be accomplished in the student's free time rather than missing learning experiences due to the difficulty of being able to attend face-to-face learning experiences.

Cherry and Flora (2017) conducted a study to evaluate radiologic technology educators' perceptions of online courses. The study measured perceptions of effectiveness, satisfaction, and technological self-efficacy. The findings indicated that positive perceptions and satisfaction increased with faculty years of experience teaching in the online format. Furthermore, perceived ease of use and perceived usefulness had positive effects on the acceptance of online technology (Cherry & Flora, 2017).

In 2019, Jansen et al. discussed the labor market effect of technology advancements and emphasized the need to anticipate these changes and how they will affect different sectors. Although Jansen et al. (2019) focused primarily on unemployment and skill gaps in the workforce as a result of technology disruption, it can be argued that the forced transition from face-to-face teaching to virtual teaching requires the same anticipatory measures in higher education. The technological skills of students, younger educators, and experienced educators may differ, and therefore the effects from the transition to virtual teaching is important to understand.

It has even been suggested that the commercially available advancements in virtual immersive and augmented reality technology used in entertainment and gaming industries "hold potential for education and clinical use in medicine and the field of medical imaging" (Uppot et al., 2019, p. 570). The use of virtual reality, particularly the use of holographic images, has been found to be an effective tool for anatomy education (Gunn et al., 2017; Vatansever & Demiryürek, 2019; Vatansever et al., 2019). The rapidly advancing field of radiologic technology has embraced new technologies in clinical practice, which has slowly resulted in the implementation of technology use in the classroom. However, when the COVID-19 pandemic hit the United States in the spring of 2020, most Universities were forced to transition all courses to an entirely virtual and/or online format. Many educators had only a few days' notice and were therefore required to revamp their courses in a short period of time. Li et al. (2020) suggested the potential benefits of using videoconferencing for radiology trainees applying virtual readouts, in addition to didactic educational sessions. Furthermore, Camera (2020) speculated on the expected changes in schools, identifying the continued use of virtual technology for educational delivery as both a possibility and a challenge for educators to anticipate.

Russell and Spence (2018) noted that "although virtual learning is not a new trend in higher education, integrating virtual simulation environment in healthcare education remains relatively new pedagogical strategy" (p. 169). It was stressed that the use of virtual reality software for radiologic technology students provides them a safe environment to develop skills, generate virtual images, and receive feedback. Ultimately, Russell and Spence (2018) indicated that the use of virtual learning has the potential to increase students' application of knowledge to the clinical setting.

Although many distance learning programs have incorporated virtual teaching and learning prior to the COVID-19 pandemic, the need for virtual technology significantly increased as a result of the rapid shift to e-learning. Although the pandemic will not last forever, it is likely that educational delivery for some programs will forever be changed. The access and use of technology for both educators and students are likely here to stay. It is possible that the online format may result in similar improvements in knowledge compared to on-site formats as indicated by the study of Aggarwal et al. (2011). The study involved the random placement of students in either a traditional on-site format or an online distance learning format. Knowledge scores were measured for the classes and compared between on-site and online formats. Aggarwal et al. (2011) found that both formats led to similar improvements in knowledge from baseline. These findings indicate that an online format has the potential to be just as effective in helping students gain knowledge than a traditional face-to-face format. This may help address the challenges associated with the COVID-19 pandemic, but also may be useful in expanding educational delivery to rural communities with limited resources due to the flexibility, convenience, and accessibility of the online format (Aggarwal et al., 2011). Similarly, Durán-Guerroro et al. (2019) found that blended learning (a combination of traditional and online/technological) formats was found to be a more effective in radiology medical students than the traditional format alone.

The New York Times reported on the issues associated with the COVID-19 forced remote learning, identifying learning loss, lack of engagement, and increased racial and economic gaps (Goldstein, 2020). For students in rural areas, the access to technology has been problematic. Although the reach associated with technology provides opportunities to these communities, it is pointless if the students do not have the technology and/or access to the internet to participate in distance education. In response to these needs, companies such as AT&T and Verizon have stepped up to provide access to low-income students (Tyree, 2020). Additionally, the U.S. Department of Agriculture has distance learning and telemedicine grants (Rural Development, n.d.) which aim to assist rural communities in participating in the beneficial opportunities associated with distance learning and telemedicine. A meta-analysis conducted by Cook et al. (2011) evaluated internet-based learning (IBL) for health professions education. The findings from the study identified interactivity, practice exercises, repetition, and feedback as important factors for improving learning outcomes. Furthermore, interactivity, online discussion, and audio were identified as factors that have the potential to improve satisfaction.

The forced transition to online teaching (from the COVID-19 pandemic) also created a phenomenon where educators who had previously resisted online formats were now relying on it. The transition might convince educators hesitant to online courses to be more accepting, even if they do not prefer or enjoy it. Furthermore, technology use "may be different from a general attitude to technology for personal or even professional use. Previous experiences, negative or positive, may determine their attitude to online communication" (Mumford & Dikilitaş, 2020, p. 10). The technologies developed to facilitate distance learning have improved immensely to meet the technological demands of schools, making distance learning possible and sustainable. It is also possible that there will be administrative expectations to continue and/or increase the use of distance learning. Even at lower tuition costs, it would still be increasing revenue for higher education institutions.

To meet the evolving demands, educators must draw on strategies that have proven to be successful for the distance learning environment. Van Wyk (2018) found that flipped classrooms improve online teaching for student teachers. Dyment and Downing (2018) utilized weekly web conferences and found they increased engagement, satisfaction, sense of achievement, and aided in the development of professional attributes in teacher education students. Furthermore, Forbes and Khoo (2015) found that the use of podcasts for assessment empowered students to use technology as a means to enhance their own pedagogical practices. Additionally, the engagement of stakeholders (Quan-Baffour et al., 2018) and teaching student self-regulation skills (De Silva, 2020) have been identified as crucial for successful distance learning implementation and increasing access.

In response to the COVID-19 pandemic, the NBPTS issued a brief titled *Teacher Leadership in Uncertain Times: Recommendations from Board-Certified Teachers for School, District, and State Leaders* (2020). The brief addressed the challenges educators have been faced with as a result of the COVID-19 pandemic and provided recommendations for policy. This brief highlighted several educators and their demonstrated leadership in the early stages of the pandemic. The recommendations for policy from the brief are reprinted as follows:

> 1) Seek out and listen to teachers at scale,
>
> 2) Trust, Support, and Encourage Teachers Leaders' Ambitions
>
> 3) Invest in teachers, particularly in solutions that strengthen practice and build leadership capacity. (NBPTS, 2020)

The 2020 NBPTS brief highlighted the current crisis as an opportunity for teachers to become leaders, become inspired to be the best they can be, rise to the challenge, and "achieve their highest potential so that teachers, in turn, can inspire the same of their students" (p.19). This sentiment is complimentary to Breed's (2014) call for educational leadership in radiologic sciences and is applicable to the current crisis. Furthermore, the integration of virtual technology using a variety of tools that increase both the quantity and variety of interactive experiences to engage students are critical in increasing the academic success of students (Metcalf & Haugen, 2018).

Barriers to Technology Integration

Rosen (2010) argued that the lack of technology integration in the classroom has caused for an alienation of students from the school setting. Due to the time (Kopcha, 2012; Stoerger & Krieger, 2016; Wachira & Keengwe, 2011), effort (Nicol et al., 2018; Stoerger & Krieger, 2016), access (Ertmer et al., 2012; Inan & Lowther, 2010; Ritzhaupt et al., 2012), planning (Stoerger &

Krieger, 2016), and instructional support/professional development (Ertmer et al., 2012; Kopcha, 2012; Stoerger & Krieger, 2016) needed to redesign courses for technology integration and active learning pedagogies, it has been challenging for educators to adapt and transition and integrate technology in the classroom. Nicol et al. (2018) also suggested that attitudes, personality and learning styles (McNulty et al., 2019) could impact both the educator and the student in the success of technology integration. The pedagogical beliefs of teachers are thought to be an important factor (and a potential barrier) for technology integration and has been well documented in the literature (Chen, 2008; Ertmer et al., 2012; Ertmer et al., 2015; Inan & Lowther, 2010; Kopcha, 2012; Lim and Chai, 2008; Tondeur et al., 2017). Furthermore, McKnight et al. (2016) found that teachers who had been teaching for 10 or more years reported a "lack of comfort or fluency with technology" (p.198).

In the medical setting, although the attitudes towards mobile devices as effective learning tools was found to be positive, a lack of buy in from teachers and patients (Wallace et al., 2012), the potential for looking unprofessional or inept in front of patients (Fisher & Koren, 2007; Pyörälä et al., 2019), and the slow nature in which educators embrace and implement new technologies in the classroom (Beyrouti, 2017; Martino & Odle, 2008) have been identified as barriers to the mobile device usage in education trend. Specifically, the study by Pyörälä et al. (2019) found that medical students displayed a decline and resistance to iPad usage and digital note taking once they entered the clinical setting due to a combination of clinical teachers' resistance, discouragement of using mobile devices at patient bedsides, and inability for iPad to fit in white coat pockets. Additionally, constraints associated with the use of mobile devices were identified by Padmo et al. (2019) to include smaller screen size, cost, connectivity, battery duration, device memory space, and small keyboard. In order to address the evolving needs of students, it is imperative that educators embrace the nature of the mobile learning environment (Martino & Odle, 2008; Padmo et al., 2019; Wertz et al., 2014).

Kowalczyk (2014) conducted a study of radiologic science educators to determine the perceived barriers to online education. The study identified three main themes, which included IT training and support barriers, student related barriers, and institutional barriers. Although educators in radiologic sciences have increasingly implemented online and blended courses, Kowalczyk reported that most radiologic science educators who participated in the study were more focused on technology competence than increasing interactive learning experiences for students, a finding that is ironic "because this population is employed in professions that require the use of highly technical healthcare delivery equipment" (p. 492). The rapid pace of technological advancement in this field makes it concerning that the technological competence of radiologic science educators is not necessarily translating to an educational context.

Furthermore, the assumption that all students are comfortable with technology in an educational environment is speculative and does not apply to all students as indicated by Stoerger and Krieger (2016). Factors such as students' personality (McNulty et al., 2009), attitudes (Corredor & Olarte, 2019; Courtois et al., 2014; Dündar & Akçayır, 2014; Venkatesh et al., 2012), social influences and family environment (Dündar, H., & Akçayır, 2014; Moran et al., 2010), anxiety (Moran et al., 2010), and self-efficacy (Courtois et al., 2014; Moran et al., 2010), have been found to influence the acceptance of technology.

Summary

In summary of the review of literature, there were a few main observations that were identified. One common theme was that most sources expressed the promise in the use of technology for educational purposes. Technology was identified as a way to enhance communication, feedback, access, extended purpose and audience, shifted teacher-student roles, restructured teacher time for the better, and production of a more efficient, interactive, and relevant delivery of curriculum (McKnight et al., 2016; Levin & Schrum, 2013).

There have been legislative acts and recommendations from national organizations to encourage the use of technology in education (Digital Promise, 2014; ISTE, 2019; LEAD Commission, 2013; NBPTS, 2014; OET, 2017; USDOE, 2010). However, many sources also expressed that educators have generally been slow to implement its' use in the classroom (Beyrouti, 2017; Kowalczyk, 2014; Martino & Odle, 2008; Wertz et al., 2014). This indicated the need for more effective implementation of technology in the classroom, specifically the radiologic science classroom.

The younger generation of students entering college are, for the most part, accustomed to using technology and it is therefore important for educators to integrate technology usage driven by students (Ertmer et al., 2012; Lowther et al., 2008; Rosen, 2010). The integration of technology is also important for providing students with the skills to succeed in the workforce (Aarts, et al., 2017; Hyde & Strudwick, 2017; Kowalczyk, 2014). However, it should not be assumed that all students are comfortable using technology in an educational setting (Corredor & Olarte, 2019; Courtois et al., 2014; Dündar & Akçayır, 2014; McNulty et al., 2009; Moran et al., 2010; Stoerger and Krieger, 2016; Venkatesh et al., 2012).

The integration of technology in education has incorporated mobile devices (Applegate, 2010; Beyrouti, 2017; Bidin & Ziden, 2013; Louhab et al., 2018; Padmo et al., 2019 Pyörälä et al., 2019; Riedel, 2014; Wertz et al., 2014), virtual reality and simulation software (Estai & Bunt, 2016; Gunn et al., 2017; McNulty et al., 2009; Rizzolo et al., 2010; Tam et al., 2010; Uppot et al., 2019; Valler-Jones et al., 2011; Vatansever & Demiryürek, 2019), 3D printing (Collinsworth & Clark, 2017; Macko et al., 2017; Vaccarezza & Papa, 2015; Ventola, 2014), imaging-based technologies (Binder et al., 2019; Tam et al., 2010), and use of virtual technology, e-learning, hybrid, and/or blended course formats (Aggarwal et al., 2011; Akers, 2019; Carriero et al., 2012; Cherry & Flora, 2017; Cook et al., 2011; Durán-Guerroro et al., 2019; Li et al., 2020; Ogura et al., 2018; Rizzolo et al., 2010; Russell & Spence, 2018).

Barriers identified in the review of literature included access (Ertmer et al., 2012; Inan & Lowther, 2010; Ritzhaupt et al., 2012) attitude (Corredor & Olarte, 2019; Courtois et al., 2014; Dündar & Akçayır, 2014; Nicol et al., 2018; Venkatesh et al., 2012), pedagogical beliefs (Chen, 2008; Ertmer et al., 2012; Ertmer et al., 2015; Inan & Lowther, 2010; Kopcha, 2012; Lim and Chai, 2008; Tondeur et al., 2017), time (Kopcha, 2012; Stoerger & Krieger, 2016; Wachira & Keengwe, 2011), social influences (Dündar, H., & Akçayır, 2014; Moran et al., 2010), personality and learning styles (McNulty et al., 2019; Stoerger & Krieger, 2016), self-efficacy (McKnight et al., 2016; Courtois et al., 2014; Moran et al., 2010), effort (Nicol et al., 2018; Stoerger & Krieger, 2016), anxiety (Moran et al., 2010) and support/professional development (Ertmer et al., 2012; Kopcha, 2012; Kowalczyk, 2014; Stoerger & Krieger, 2016).

Due to the COVID-19 pandemic and forced use of virtual educational delivery methods, it is imperative that the intended continuance of use is evaluated to better understand the potential impact of educational delivery in the future. As indicated by Linaker (2015) the research of diagnostic imaging education is lacking and therefore needs to be evaluated further to understand effectiveness in educational delivery formats. The limited number of studies specifically focused on radiologic technology and lack of studies that evaluated use of actual radiologic technology equipment or software in educational settings identified an apparent gap in the research specifically regarding radiologic science education. This identified the need to evaluate the current state of radiologic technology programs in the U.S. regarding radiology-specific virtual technology use and its' impact on students' likelihood to pass board examinations, obtain jobs, and transition to practice.

Another observation is that many of the radiology-specific sources found were not original research and did not collect data. Rather, they were either reviews of literature and/or generalized assumptions based on trends, opinions, or speculations. Of the radiology-specific studies that did collect data, most studies found were qualitative in nature; not quantitative. It would be beneficial to obtain more quantitative data to better understand the educational environment in radiologic technology. This data would help solidify the benefits of technological use in radiologic technology programs. Furthermore, mixed methods would likely support quantitative data with perceived effectiveness of participants.

III. METHODS AND PROCEDURES

Purpose of the Study

The purpose of the study was to investigate: (a) the pre-COVID-19 versus post-adjustment uses of virtual technology, (b) the pre-COVID versus post-adjustment perceived barriers preventing integration of virtual technology, and (c) the continuance intentions to use virtual technologies past COVID-19 among radiologic science educators. This chapter presents an overview of the methodology used for this study.

Research Design

The study utilized an explanatory mixed methods cross-sectional survey design. The study was non-experimental in nature, as no intervention and/or manipulation of the variables occurred. The study was cross-sectional because the survey was distributed at one time to participants. There was a retrospective element in which participants were asked to provide recall information from pre-COVID-19 after the pandemic had already begun. However, the entire study was not retrospective because participants were also asked to provide perspectives from the current (post-adjustment) and anticipate the future (post-COVID). It was explanatory mixed methods because both quantitative and pseudo-qualitative data was collected from participants, and the pseudo-qualitative data was "used to explain the quantitative data" (Privatera & Ahlgrim-Delzell, 2019, p. 433). The use of open-ended questions at the end of the survey instrument were treated as pseudo-qualitative data. The data were considered pseudo-qualitative because no interaction or dialogue occurred between the researcher and the participants. This allowed participants to share their personal insights/experiences, which enhanced the meaning derived from the quantitative data. Advantages of this study design included ease of use, cost-effectiveness, and no more than minimal risks for participation in the study.

Participants

The target population for the study was radiologic technology educators in the United States. A convenience sampling approach was utilized to recruit participants through the professional organizations with which the researcher belongs/has access to. The educators had to be at least 18 years old and employed at a postsecondary institution. Participants had to be involved in didactic education of students in radiologic sciences education; clinical instructors who exclusively operate within a clinical setting with no didactic component were excluded. Permission was granted by both the Association for Collegiate Educators in Radiologic Technology (ACERT) and the American Society of Radiologic Technologists (ASRT) to distribute the survey upon approval from the IRB (see Appendix B). Emails were sent to ACERT to distribute to their institutional memberships for radiology educators. ACERT sent out 61 email invitations to all their institutional memberships (each of which have multiple faculty members). The institutional members were asked to pass the survey on to each of their faculty members. The survey was also distributed to ASRT member educators. The most recent ASRT annual report (ASRT, 2020) reported 133,191 active memberships and 157,622 total memberships (which included technologists, students, graduate bridge, associate, other, and retired members). There are 4,014 ASRT members listed in the Educator Chapter. The researcher provided the survey to the ASRT, from which it was administered to their members who were categorized as 'educators'. The ASRT sent out email invitations to all 4,014 educator members. Therefore, between the ASRT (4,014) and ACERT (61) organizations, a total of 4,075 email invitations were sent to potential participants. There was a total of 342 participants who responded to the survey, for a response rate of 8.39%. There were 87 surveys that were incomplete, and therefore a total of 255 participants were retained for data analysis. The valid response rate was 6.26%. A listwise deletion was performed because imputation was not possible as those data were not missing at-random. Participants who only skipped some demographic questions remained in the data set.

Instrumentation

The data was collected by means of a researcher-designed survey titled "Educational Virtual Technology Use in the COVID-19 Pandemic" (see Appendix C). The instrument was designed by the researcher after a thorough literature review was performed and failed to find an appropriate instrument for the proposed study. The survey utilized a combination of components from the technology acceptance model (TAM) (Davis, 1989) and the theory of planned behavior (TPB) (Ajzen, 1991; Ajzen & Fishbein, 2005). The components were chosen and adjusted based off the literature as discussed in Chapter 1 (Cheng, 2019; Cheng et al., 2016; Dalvi-Esfahani et al., 2020; Ma et al., 2005; Seigel 2017; Teo, 2011; Wu & Chen, 2017). The survey instrument consisted of a demographic section (11 questions), a pre-COVID-19 virtual technology section (32 questions), a post-adjustment virtual technology use section (58 questions), an intention for continued use section (36 questions), and a pseudo-qualitative section incorporating three open-ended questions regarding educators' experiences teaching and adjusting in the COVID-19 pandemic. The survey consisted of a total of 140 questions, six of which were multiple choice, four of which were multiple selection, six of which were open-ended questions (three demographic and three pseudo-qualitative), and 124 questions were Likert-type items. Additional information on the specific scales is discussed below and on page 54. Example multiple selection questions included: "What barriers do you think may be preventing your program from integrating technology in the classroom? (Check all that apply)". Example multiple choice questions included: "What is your highest level of education?". Example open-ended questions included: “How many years of experience do you have as an educator in your current field?” and “Describe what has been the most challenging aspect of teaching in the COVID-19 pandemic and why?”

The demographic section was broken down into the demographic data of the participant and demographic data of the program at which the participant is employed. The participant demographics included age, gender, years as an educator, position/title, years of clinical experience (clinical practice in medical imaging), and highest level of education attained. The program demographics included geographical region, school type, level of degree offered, and program size (in number of students).

The three question sets for virtual technology use (pre-COVID, post-adjustment, and future intentions) utilized a five-point Likert-type scale (“1-Never”, “2-Rarely”, “3-Sometimes”, “4-Often”, and “5-Always”). Each question had a list of 31 virtual technologies for which participants rated their degree of use for each technology listed. There was also an ‘Other’ category that allowed participants to write-in technologies not listed. Virtual technology use (VTU) was calculated as a score using the mean of their responses for all items and was used in the paired-samples *t*-tests. A higher mean score indicated higher use of virtual technologies whereas a lower mean score indicated lower use of virtual technologies. Additionally, the barriers to technology integration pre-COVID and post-adjustment were calculated as a score using the sum, with a higher score indicating more barriers to virtual technology use.

The constructs of attitude, behavior, perceived behavioral control, perceived ease of use, perceived usefulness, and continuance intentions incorporated a five-point Likert-type scale indicating their level of agreement or disagreement with statements regarding virtual technology integration (“1-Strongly Disagree”, “2-Disagree”, “3-Neutral”, “4-Agree”, and “5-Strongly

Agree”). Negatively worded items were reverse coded prior to the score being computed. These constructs were measured in scales. The scaled items for each construct were calculated as a score using the mean and computed into variables for use in data analysis. The basis for questions used for these constructs were derived from similar studies (Cheng, 2019; Cheng et al., 2016; Dalvi-Esfahani et al., 2020; Wu & Chen, 2017). The behavior construct was measured using three items. An example behavior question is “I use virtual technology in one or more of the courses I teach”. Perceived behavioral control was measured using six items. An example question for PBC is “I am confident using virtual technology to teach my course(s)”. Perceived ease of use was measured using six items. A sample question is “I find it difficult to implement new technologies in the course(s) I teach” (reverse coded). Perceived usefulness utilized six items such as “using virtual technology improves the quality of student learning experiences”. Attitude was measured with five items. A sample question for attitude is “I enjoy learning new technologies for educational purposes”. The final construct of continuance intention to use (CITU) was measured using five items such as “I intend to use virtual technology in future courses after the pandemic”.

The open-ended questions added a pseudo-qualitative component to the study, in which participants were able to describe their experiences teaching in the COVID-19 pandemic and their adjustments to using virtual technology. These questions were analyzed by the researcher for common themes.

Validity and Reliability

The validity is a property of the interpretation and use of scores, or the accuracy. Reliability, a property of scores, measures the internal consistency of scores from a dataset. The survey instrument underwent systematic rounds of the Delphi Method (Eggers & Jones, 1998) to establish face and content validity. A panel of subject matter experts in the fields of radiologic technology education, statistical analysis of data, and career and technical education were asked to evaluate the survey instrument and content items for relevance, clarity, organization, and concepts. The panel provided suggestions for revisions regarding the clarity of questions, edits regarding the relevance, and the addition of questions for quantification.

Pilot Study

After suggestions and edits to the survey instrument were made, a pilot study was conducted to evaluate the psychometric properties of the scales and perform an initial analysis for internal consistency. A total of 34 participants responded to the pilot survey. The scales were analyzed using Cronbach's alpha. Behavior ($\alpha = 0.805$), PBC ($\alpha = 0.848$), PU ($\alpha = 0.712$), Attitude ($\alpha = 0.849$), and CITU ($\alpha = 0.858$) displayed a score of 0.7 or higher, therefore demonstrating acceptable reliability (Creswell & Guetterman, 2018). However, PEU ($\alpha = .515$) did not. Due to the theoretical importance of PEU in the literature, this scale remained in the survey instrument and the items were updated. Two items were added to PEU with the intention to improve the internal consistency. Updates and additions to the PEU items were derived from similar TAM literature (Davis, 1989; Ma et al., 2005; Teo, 2011; Wu & Chen, 2017).

Current Study

The modified instrument was provided to the researcher's committee for review. The recommendations from the review of the dissertation committee were applied prior to IRB submission and approval and was thereafter administered to participants. The scores were again tested for reliability. In order to get additional structural validity on the data collected, a principal components analysis (PCA) was conducted on both the Theory of Planned Behavior and the Technology Acceptance Model after data was collected from the sample population.

The PCA analysis for the Theory of Planned Behavior was used to determine the structure and/or if it aligned with the theorized structure. The sampling adequacy was good (*KMO* = .905) and passed Bartlett's Test of Sphericity ($p < .001$). Based on the scree plot and eigenvalues, four components were extracted using direct Oblimin rotation, which aligned with the pre-existing subscales. The communalities were all above 0.5, with only one (PBC3) less than 0.6 (see Table 1 for TPB Communalities).

Table 1

PCA – Theory of Planned Behavior Communalities and Structure Coefficients

Item	h^2	Component (r_{st})			
		1	2	3	4
Continuance Intention to Use					
CITU1	.84	**.91**	.26	.34	.41
CITU2	.80	**.84**	.29	.33	.61
CITU3	.87	**.93**	.32	.34	.47
CITU4R	.82	**.89**	.39	.21	.30
CITU5R	.81	**.90**	.34	.26	.41
Behavior					
Behavior1	.73	.47	.22	**.82**	.11
Behavior2	.68	.15	.22	**.80**	.19
Behavior3	.73	.36	.22	**.84**	.03
Perceived Behavioral Control					
PBC1	.72	.40	**.76**	.47	.16
PBC2	.64	.27	**.72**	.48	.28
PBC3	.53	.27	**.71**	.31	.28
PBC4	.74	.79	**.79**	-.03	.52
PBC5R	.74	.32	**.85**	.07	.39
PBC6R	.67	.28	**.80**	.05	.22
Attitude					
Attitude1	.69	.43	.43	-.06	**.79**
Attitude2R	.74	.67	.40	.09	**.75**
Attitude3	.75	.60	.43	.13	**.80**
Attitude4	.70	.47	.29	.35	**.78**
Attitude5	.74	.68	.29	.36	**.72**

Note. $N = 255$. *PCA* = principal components analysis. r_{st} = structure coefficient. R indicates the item was reverse coded prior to calculation. The extraction method was principal components analysis with direct Oblimin rotation. Bolded items indicate the coefficients that were interpreted.

The PCA analysis for the Technology Acceptance Model was used to determine the structure and/or if it aligned with the theorized structure. The sampling adequacy was good (*KMO* = .899) and passed Bartlett's Test of Sphericity ($p < .001$). Based on the scree plot and eigenvalues, in addition to the theoretical support from the existing literature, four components were extracted using direct Oblimin rotation. The communalities were all above 0.3, with only four less than 0.5, and eight total under 0.6 (see Table 2 for TAM Communalities).

Table 2

PCA – Technology Acceptance Model Communalities and Structure Coefficients

Item	h^2	Component (r_{st})			
		1	2	3	4
Continuance Intention to Use					
CITU1	.84	**.91**	.28	.12	.48
CITU2	.78	**.86**	.34	.12	.58
CITU3	.88	**.93**	.32	.15	.52
CITU4R	.79	**.88**	.31	.07	.36
CITU5R	.81	**.90**	.31	.12	.44
Perceived Ease of Use					
PEU1	.45	.25	**.65**	.18	.04
PEU2R	.53	.31	**.72**	.28	.21
PEU3	.34	.12	**.54**	.29	-.05
PEU4	.62	.35	**.76**	.34	.23
PEU5	.69	.23	**.82**	.10	.27
PEU6R	.53	.35	**.70**	.04	.33
Perceived Usefulness					
PU1	.67	.51	.20	.20	**.79**
PU2	.75	.14	.19	**.87**	.06
PU3	.64	.15	.27	**.79**	.17
PU4	.33	.17	.22	**.50**	.32
PU5R	.43	.40	.19	.21	**.63**
PU6	.60	.41	.11	.20	**.76**
Attitude					
Attitude1	.58	.32	.62	-.01	**.52**
Attitude2R	.72	.68	.50	.08	**.70**
Attitude3	.70	.63	.53	.04	**.71**
Attitude4	.54	.52	.34	.03	**.69**
Attitude5	.70	.72	.37	.13	**.72**

Note. $N = 255$. *PCA* = principal components analysis. r_{st} = structure coefficient. R indicates the item was reverse coded prior to calculation. The extraction method was principal components analysis with direct Oblimin rotation. Bolded items indicate the coefficients that were interpreted.

Attitude exhibited some cross-loading between components one and four in the PCA for both the TPB and the TAM. The results from the PCA supported the theoretical models of the TPB and TAM and added structural validity to the instrument.

The scales were computed to new variables using the mean. For Behavior there were no negatively worded items and therefore no reverse coding was required. For PBC items five and six were reverse coded. For PEU items two and six were reverse coded. For PU item five was reverse coded. For Attitude item two was reverse coded. Lastly, for CITU, items four and five were reverse coded prior to computation.

To evaluate the reliability of scores, the internal consistency was measured using Cronbach's alpha, which measures the proportion of shared versus unique variance in a set of scores. The scales for behavior, PBC, PEU, PU, Attitude, and CITU were measured for internal consistency. The scores showed adequate internal consistency, with all exceeding 0.7 (Creswell & Guetterman, 2018). CITU had the highest measure ($\alpha = 0.943$), which is considered excellent (George & Mallery, 2003). Four of the scales displayed good reliability, which included Behavior ($\alpha = 0.834$), PBC ($\alpha = 0.872$), PEU ($\alpha = 0.806$), and Attitude ($\alpha = 0.874$). Lastly, PU demonstrated acceptable reliability ($\alpha = 0.711$). The designation of excellent, good, and acceptable reliability was defined according to the George and Mallery (2003) rules of thumb for Cronbach's alpha.

Procedure

Permission from the Auburn University IRB was obtained prior to collecting data for this study (Appendix D). Participants were invited to participate via email and were provided with an informational letter and a link to the survey (see Appendix E). Participation was completely voluntary, data collection was anonymous, and all participants were provided with all necessary information to provide informed consent. If the participant provided consent, they were prompted to complete the survey by accessing the survey link (see Appendix F for email recruitment letter). The study presented no more than minimal risk to the participants for either their participation in or decision to not participate in the study.

To protect the confidentiality of participants, the email template data was stored in a secure database and will only be accessed by the researcher. The data gathered was anonymous and no personally identifying information was collected. Data was downloaded into a data file for analysis. Descriptive statistics and advanced analyses were performed utilizing IBM Statistical Package for Social Sciences (SPSS) version 25.

Data Analysis

Analysis of the data was performed utilizing SPSS version 25. Descriptive statistics were performed for a basic analysis, organization, and summary of the data collected. Statistical analyses included paired samples *t*-test, one-way analysis of variance (ANOVA), multiple regression analysis, and path analysis.

The data underwent three sets of analyses. The first was group comparisons utilizing one-way ANOVAs. The second was a multiple regression analysis for the relationship between continuous predictors and the continuous dependent variable (CITU). The last was paired *t*-tests for change from pre-COVID-19 to post-adjustment, post-adjustment to future intentions of virtual technology use and pre-COVID to post-adjustment barriers (see Table 3).

Table 3

Research Questions Data Analysis

Research Question	Survey Question(s)	Statistical Analysis
1. To what extent does educators' CITU of virtual technology differ based on demographic categories (i.e. title, level of education, etc.)?	1-11; 102-106	One-way ANOVA
2. Does the combination of the constructs Behavior, Perceived behavioral control (PBC), Perceived ease of use (PEU), Perceived usefulness (PU), and Attitude explain educators' CITU of virtual technologies?	76-106	Multiple Regression; Path Analysis
3. How does the pre-COVID-19 virtual technology degree of use differ from the post-adjustment virtual technologies used?	12-42; 44-74	Paired-samples *t*-test; Descriptive statistics
4. How does the pre-COVID-19 perceived barriers to integration of virtual technology differ from the post-adjustment perceived barriers?	43; 75	Paired-samples *t*-test; Descriptive statistics
5. How does the post-adjustment virtual technology degree of use differ from the post-COVID-19 intentions for future virtual technology use?	44-74; 107-137	Paired-samples *t*-test; Descriptive Statistics
6. What themes were presented in the open-ended questions?	138-140	Pseudo-qualitative Analysis

Research question one (to what extent does educators' CITU of virtual learning technologies differ based on demographic categories?) was analyzed using one-way ANOVAs. The one-way ANOVA compared the means of CITU between the demographic categories of educators such as title, gender, level of education, etc.

Research Question two (does the combination of the constructs Behavior, Perceived behavioral control (PBC), Perceived ease of use (PEU), Perceived usefulness (PU), and Attitude explain educators' CITU of virtual learning technologies?) was analyzed using a multiple regression analysis. The multiple regression analysis measured the effect of continuous predictors on the continuous dependent variable (continuance intention to use virtual technology). A path analysis was also conducted to provide a visual representation of the direct and indirect relationships of predictors on continuance intention to use virtual technology.

Research question three (how does the pre-COVID-19 virtual technology degree of use differ from the post-adjustment virtual technologies used?) was analyzed using a paired samples *t*-test to determine if a difference existed between pre- COVID and post-adjustment virtual technology use. Descriptive statistics were also used to further evaluate the specific technologies used.

Research question four was to determine how the pre-COVID-19 perceived barriers to integration of current/industry-specific technology differed from the post-COVID-19 perceived barriers. This was analyzed using a paired samples *t*-test to determine if a difference existed between pre- and post-COVID perceived barriers. Descriptive statistics were also used to further evaluate the specific perceived barriers.

Research question five (how does the post-adjustment virtual technology degree of use differ from the post-COVID-19 intentions for future virtual technology use?) was analyzed using a paired samples *t*-test to determine if a difference existed between post-adjustment and intentions for future use of virtual technologies. Descriptive statistics were also used to further evaluate the specific technologies used.

Research question six (What themes were presented from the open-ended questions?) was analyzed as a pseudo-qualitative element to identify common themes from the open-ended questions (#23-25). The pseudo-qualitative data may enhance the understanding obtained from the quantitative data.

Summary

The purpose of the research study was to evaluate the educational impact of the COVID-19 pandemic on virtual technology use in radiologic technology educators. Radiologic technology educators throughout the United States were asked to participate in the research study by participating in an online survey via Qualtrics. The survey instrument, containing the constructs of behavior, perceived behavioral control, perceived ease of use, perceived usefulness, and attitude, were analyzed as predictive variables for CITU of virtual technologies. Demographics and pseudo-qualitative elements were also analyzed. Understanding the impact of the COVID-19 pandemic on educational delivery of radiologic sciences education is crucial and has the potential to improve educational pedagogy in the future, with the ultimate goal of students' success and improved patient care in industry.

IV. STATISTICAL ANALYSIS AND RESULTS

The purpose of the research study was to evaluate the educational impact of the COVID-19 pandemic on virtual technology use in radiologic technology educators. This was evaluated with the use of a quantitative cross-sectional survey design utilizing a researcher designed survey based on the review of literature and a combined model integrating the Theory of Planned Behavior (TPB) and the Technology Acceptance Model (TAM). Descriptive analysis and advanced statistical analyses were used to address each research question. Descriptive statistics were conducted on the demographic characteristics of the participants to better understand the sample population. The use of one-way ANOVAs were utilized to compare means of CITU based on demographic categories. Paired samples *t*-tests were use evaluate virtual technology use and barriers. A multiple regression analysis and path analysis were used to measure the explanatory and/or predictive power of the constructs on CITU. Finally, the open-ended questions were organized into themes to better supplement the quantitative results.

Descriptive Analysis and Results

Participant Demographics:

The age of participants ranged from 25 to 75 (M = 49.76, SD = 10.77). The average years of experience as an educator was 15.59 years (SD = 10.79), with the average years in clinical practice prior to teaching being 10.38 years (SD = 6.99) (see Table 4 for demographic descriptives for participant age and years of experience).

There were 198 (77.65%) women and 53 (20.78%) men who participated, and 4 who did not report gender (1.57%). Although the item wording in the survey that was administered and presented to participants included ‘gender’, the options (Male, Female, Other, and Prefer not to answer) were better aligned with sex as assigned at birth.

Table 4

Demographic Descriptives for Age and Years of Experience

Characteristics	*N*	*M*	*SD*	*Min*	*Max*
Age	252	49.76	10.77	25	75
Years of Experience as Educator	229	15.59	10.79	0	48
Years of Clinical Experience	235	10.38	6.99	0	33

Note. N = 255. Age, years of experience as educator, and years of clinical experience prior to teaching were all measured as continuous variables.

Table 5

Demographic Characteristics of Participants

Characteristics	*n*	%
Gender*		
Female	198	77.65
Male	53	20.78
Prefer not to answer	4	1.57
Title		
Adjunct	21	8.24
Instructor	56	21.96
Assistant Professor	50	19.61
Associate Professor	41	16.08
Professor	34	13.33
Other[a]	53	20.78
Level of Education		
Certificate	1	0.39
Associate Degree	12	4.71
Bachelor's Degree	41	16.08
Master's Degree	150	58.82
Doctoral/Professional Degree (Ph.D., Ed.D., M.D.)	48	18.82
Specialist	3	1.18

Note. N = 255.

*Although the item text used the word 'gender' the options (Male, Female, Other, Prefer not to answer) were better aligned with sex as assigned at birth.

[a] Other titles included program directors, chairs, visiting professors, staff radiologists, associate dean, applications specialist, and clinical supervisor.

There were 21 adjuncts (8.24%), 56 instructors (21.96%), 50 assistant professors (19.61%), 41 associate professors (16.08%), 34 professors (13.33%), and 53 who indicated other

(20.78%). Under the “Other” category, 33 indicated they were Department/Program Chair/Director/Coordinators, 11 were Clinical Coordinators, and 9 others. For the highest level of education, 4.71% had an associate degree, 16.08% had a bachelor’s degree, 58.82% had a master’s degree, 18.82% had doctoral/professional degrees, and 1.18% indicated specialist (see Table 5 for demographic characteristics of participants).

For modality certifications, the majority of participants (86.27%) were certified in Radiography, followed by Computed Tomography (21.57%) and Mammography (15.29%). See Table 6 for the frequency and percentages of all modality certifications among the present sample.

Table 6

Modality Certifications of Participants

Modality	n	%
Bone Densitometry	6	2.35
Breast Sonography (BS)	3	1.18
Cardiac Interventional (CI)	5	1.96
Cardiovascular Interventional (CV)	6	2.35
Computed Tomography (CT)	55	21.57
Magnetic Resonance Imaging (MRI)	31	12.16
Mammography (M)	39	15.29
Nuclear Medicine	16	6.27
Quality Management	15	5.88
Radiation Therapy (T)	21	8.24
Radiography	220	86.27
Radiologist Assistant (RA)	5	1.96
Sonography (S) or RDMS	17	6.67
Vascular Interventional (VI)	2	0.78
Vascular Sonography (VS)	4	1.57
Other[a]	16	6.27

Note. N = 255.
[a] Other certification types included certified imaging informatics professional (CIIP), medical dosimetry, magnetic resonance safety officer (MRSO), radiologist, and registered cardiovascular invasive specialist (RCIS).

Department Demographics

The demographic information of the departments focused on geographic region, institution type, program size, and level of degree offered in the program (see Table 7 for demographic characteristics of department). For geographical region, the largest number of participants were located in the Southeast (29.80%), followed by Midwest (24.31%), Southwest (18.04%), Northeast (17.25%), and Northwest (8.24%).

Table 7

Demographic Characteristics of Department

Characteristics	*n*	%
Region		
Northwest	21	8.24
Southwest	46	18.04
Midwest	62	24.31
Northeast	44	17.25
Southeast	76	29.80
Institution Type		
Community/Junior College	91	35.69
Vocational/Technical School	21	8.24
4-Year University	100	39.22
Other[a]	42	16.47
Level of Degree Offered		
Certificate	40	15.69
Associate of Applied Science	98	38.43
Associates	53	20.78
Baccalaureate	94	36.86
Masters	22	8.63
Doctorate	4	1.57
Other[b]	13	5.10
Program Size		
50 or less students	179	70.20
50-100 students	45	17.65
100-200 students	18	7.06
200+ students	13	5.10

Note. N = 255.
[a] Other Institution types included hospital-based programs, career institutes, veteran affairs, and vendor training.
[b] Other Level of Degree offered included variations of continuing education.

For Institution Type: 39.22% were at a 4-Year University, 35.69% at a Community/Junior College, 8.24% at a Vocational/Technical School, and 16.47% indicated 'Other' (majority of which were hospital-based programs). For the Level of degree earned upon completion of program, 36.86% offered Baccalaureate, 38.43% Associate of Applied Science, 20.78% Associate, 15.69% certificate, 8.63% Masters, 1.57% Doctorate, and 5.10% Other. The approximate size of educational programs indicated that the majority (70.20%) had 50 or less students, followed by 17.65% who had 50-100 students, 7.06% with 100-200 students, and only 5.10% had 200+ students (see Table 7).

Research Question 1

Research question one (to what extent does educators' CITU of virtual learning technologies differ based on demographic categories?) was analyzed using one-way ANOVAs. The one-way ANOVAs compared the means of CITU between the demographic categories of educators such as title, gender, level of education, etc. For all the one-way ANOVAs, CITU was negatively skewed (*skew* = -1.04, *SE* = .16) and leptokurtic (*kurtosis* = 1.68, *SE* = .31). This is likely due to the high desirability to use more technology in the future. The only demographic category that had a significant result was level of education (LOE). There was a significant difference in CITU based on LOE ($F_{3,234} = 3.20$, $p = .024$), with about 2.7% of the variance in CITU attributable to LOE ($\omega^2 = .027$). To follow-up on the significant omnibus test, Tukey pairwise comparisons were used. Those with Associate degrees scored significantly lower in CITU than those with Master's ($p = .042$) and Doctoral/professional degrees ($p = .012$). There was no significant difference between educators with Associate and Bachelor's degrees ($p = .073$). There was also no significant difference between educators with Bachelor's degrees and those with Masters ($p = 1.00$) or Doctoral/professional degrees ($p = .771$). See Table 8 for descriptive statistics by group. Among the present sample, those Associate degrees were associated with the lowest CITU scores, while there was no difference between Bachelor's, Master's, and Doctoral/professional degrees.

Table 8

One-way ANOVA Descriptive Statistics by Demographic Group

Demographic Group	*n*	*M*	*SD*	*SE*
Gender (*n* = 238)				
Male	50	4.08	.69	.10
Female	188	4.05	.80	.06
Title (*n* = 244)				
Adjunct	16	3.88	.68	.17
Instructor	49	3.98	.86	.12
Assistant Professor	46	4.21	.77	.11
Associate Professor	38	4.06	.81	.13
Professor	32	4.18	.66	.12
Other	63	3.97	.81	.10
Level of Education (*n* = 238)				
Associate Degree	11	3.44	.70	.21
Bachelor's Degree	39	4.06	.90	.14
Master's Degree	143	4.05	.79	.07
Doctoral/Professional Degree (Ph.D., Ed.D., M.D.)	45	4.22	.54	.08
Geographical Region (*n* = 238)				
Northwest	20	4.14	.95	.21
Southwest	44	4.15	.71	.11
Midwest	60	4.03	.82	.11
Northeast	42	3.81	.82	.13
Southeast	72	4.13	.73	.09
Institution Type (*n* = 243)				
Community/Junior College	86	3.96	.84	.09
Vocational/Technical School	21	4.10	.69	.15
4-Year University	98	4.15	.74	.08
Other	38	3.98	.84	.17
Program Size (*n* = 244)				
50 Students or Less	168	3.97	.77	.06
50-100 Students	45	4.18	.74	.11
100-200 Students	18	4.14	1.03	.24
200+ Students	13	4.51	.58	.16

Note. $N = 244$. ANOVA = analysis of variance.

The rest of the one-way ANOVAs were not significant. There was no significant difference in CITU based on gender ($F_{1,238} = .04$, $p = .809$, $\omega^2 = .003$), Title ($F_{5,238} = .95$, $p =$

.450, ω^2 = - .001), Geographical Region ($F_{4,233}$ = 1.42, p = .227, ω^2 = .007), Institution Type ($F_{3,239}$ = 1.01, p = .387, $\omega^2 < .001$), or Program Size ($F_{3,240}$ = 2.61, p = .052, ω^2 = .019).

Research Question 2

Research question two (does the combination of the constructs behavior, PBC, PEU, PU, and attitude explain educators' CITU of virtual technologies?) was analyzed using a multiple regression analysis and path analysis. A multiple regression analysis was used to determine if the combination of Behavior, Perceived behavioral control (PBC), Perceived ease of use (PEU), Perceived usefulness (PU), and Attitude explains educators' continuance intention to use (CITU) of virtual learning technologies. The overall regression model was statistically significant ($F_{5, 230}$ = 59.17, $p < .001$). The model explained about 56% of the variance in CITU (R^2 = .56, Adj. R^2 = .55). Behavior (B = .21, β = .22, t = 4.65, $p < .001$), PU (B = .18, β = .13, t = 2.49, p = .014) and Attitude (B = .72, β = .57, t = 9.56, $p < .001$) were significant predictors. However, PBC and PEU were not significant predictors. See Table 9 for the regression results. Attitude was a stronger predictor than behavior or PU. Among the present sample of radiologic technology educators, higher scores for attitude, behavior, and PU were associated with higher intentions for continued use of virtual technologies.

Table 9

Regression Table for Continuance Intention to Use (CITU) Virtual Technology

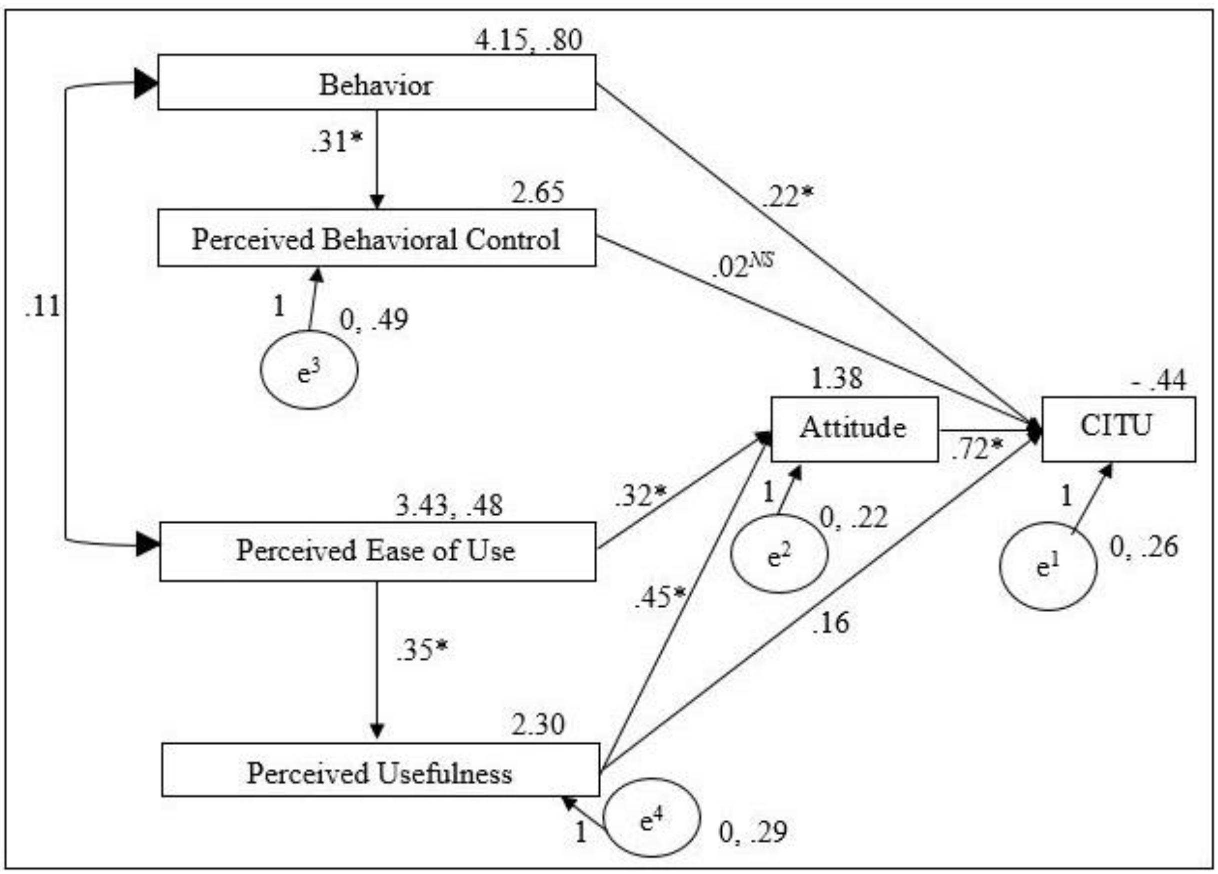
Predictor	*B*	*SE*	β	*t*	*p*
Intercept	-.38	.28			
Behavior	.21	.05	.22	4.65	.000
PBC	.04	.07	.03	.49	.622
PEU	-.04	.08	-.04	-.52	.604
PU	.18	.07	.13	2.49	.014
Attitude	.72	.08	.57	9.56	.000

Note. N = 236. PBC = perceived behavioral control. PEU = perceived ease of use. PU = perceived usefulness.

A path analysis was also conducted to provide a visual representation of the direct and indirect relationships of predictors on continuance intention to use virtual technology. Because the hypothesized model was over-identified, path analysis was conducted using SPSS AMOS 25. Behavior ($p < .001$), Attitude ($p < .001$), and PU ($p = .016$) were all significant predictors of CITU whereas PBC ($p = .733$) was not (see Figure 4). Behavior, Attitude, and PU all had a direct effect on CITU. Attitude mediated the effects of PEU and PU on CITU (see Table 10 for direct and indirect effects on CITU in the Hypothesized model).

Figure 4

AMOS Path Analysis on Hypothesized Model (Standardized Path Coefficients)



*Note. Standardized Path Coefficients. *Indicates p < .001. ^NS^Indicates the path coefficient was nonsignificant*

Table 10

Direct and Indirect Effects on CITU in Hypothesized Model

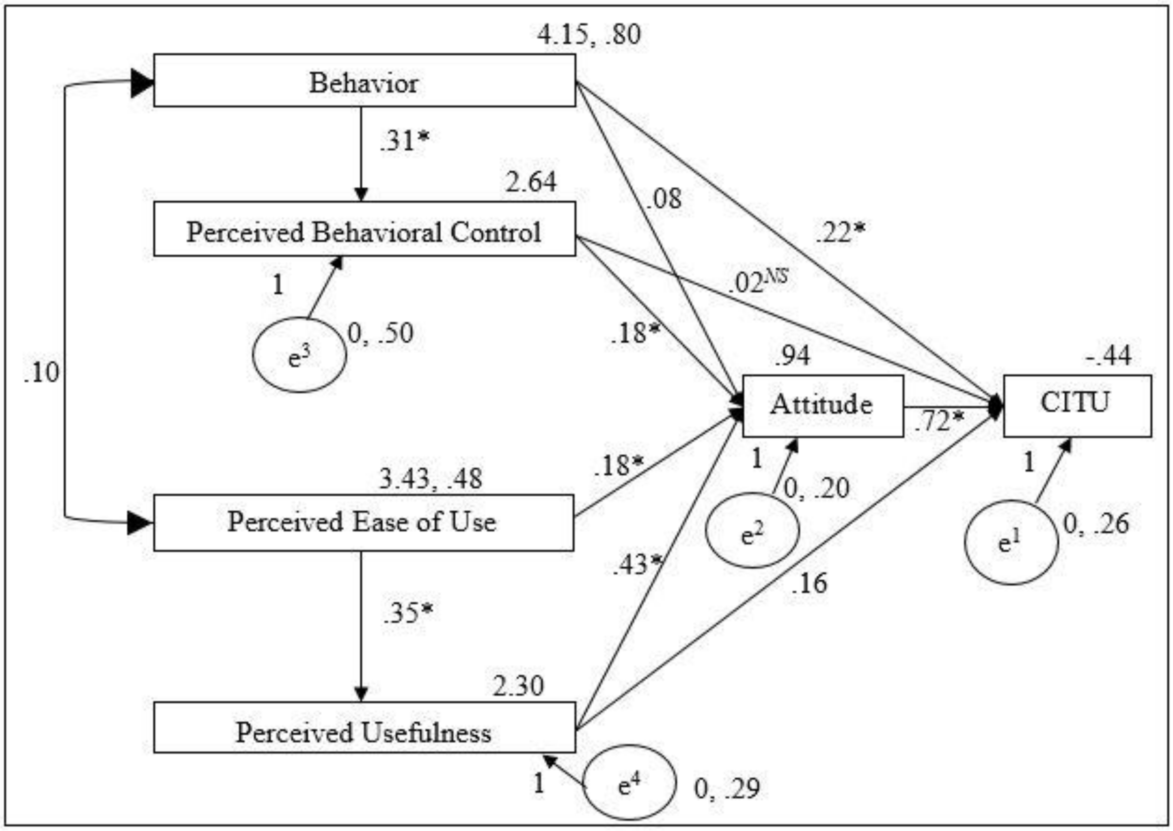
	Direct	Indirect	Total
Behavior	.22	.01	.23
PBC	.02	.00	.02
PEU	.00	.40	.40
PU	.16	.33	.49
Attitude	.72	.00	.72

Note. CITU = continuance intention to use. PBC = perceived behavioral control. PEU = perceived ease of use. PU = perceived usefulness.

Because attitude mediated the effects of PEU and PU in the hypothesized model, we conducted a second Path Analysis utilizing SPSS AMOS 25 to determine if Attitude also mediated the effects of Behavior and PBC on CITU. In the updated path analysis model, Behavior ($p < .001$), Attitude ($p < .001$), and PU ($p = .014$) were again significant predictors of CITU whereas PBC ($p = .736$) was not (see Figure 5). However, PBC ($p < .001$), PEU ($p < .001$), PU ($p < .001$), and Behavior ($p = .028$), were all significant predictors of Attitude (see Table 11 for direct and indirect effects on Attitude). Furthermore, the new model indicated that PEU, Behavior, PU, and PBC all had an indirect effect on CITU (see Table 12 for direct and indirect effects on CITU in Updated Model). This indicated that although PBC does not have a direct significant effect on CITU (which was also indicated in the multiple regression analysis), it does have an indirect effect mediated through attitude. Attitude was still the strongest predictor for CITU.

Figure 5

AMOS Path Analysis on Updated Model (Standardized Path Coefficients)



*Note. Standardized Path Coefficients. *Indicates p* < .001. [NS]*Indicates the path coefficient was nonsignificant*

Table 11

Direct and Indirect Effects on Attitude

	Direct	Indirect	Total
Behavior	.08	.06	.13
PBC	.18	.00	.18
PEU	.18	.15	.33
PU	.43	.00	.43

Note. CITU = continuance intention to use. PBC = perceived behavioral control. PEU = perceived ease of use. PU = perceived usefulness.

Table 12

Direct and Indirect Effects on CITU in Updated Model

	Direct	Indirect	Total
Behavior	.22	.10	.32
PBC	.02	.13	.14
PEU	.00	.29	.29
PU	.16	.31	.47
Attitude	.72	.00	.72

Note. CITU = continuance intention to use. PBC = perceived behavioral control. PEU = perceived ease of use. PU = perceived usefulness.

Research Question 3

Research question three (how does the pre-COVID-19 virtual technology degree of use differ from the post-adjustment virtual technologies used?) was analyzed using a paired samples *t*-test. A paired samples *t*-test was used to determine if virtual technology use (VTU) scores changed from the pre-COVID to post-adjustment. VTU scores were positively skewed (*skew* = 2.82, *SE* = .11) and leptokurtic (*kurtosis* = 9.04, *SE* = .22). This is likely due to the lack of technology use pre-COVID-19. There was a significant difference from the pre-COVID to post-adjustment VTU scores ($t_{249} = -9.76$, $p < .001$). About 27.4% of the variance in VTU scores was explained by the change from pre-COVID to post-adjustment ($\omega^2 = .274$). Virtual technology use increased from pre-COVID to post-adjustment.

Descriptive statistics were also utilized to further evaluate the specific technologies used from pre-COVID-19 to post-adjustment (see Table 13 for the descriptives for virtual technology use). For pre-COVID-19, the use of Canvas (*M* = 2.78, *SD* = 1.89), 'Other' lecture capture technology (*M* = 2.6, *SD* = 1.69), and Kahoot (*M* = 2.48, *SD* = 1.34) had the highest scores and indicated the most use. In the post-adjustment scores, Zoom (*M* = 3.91, *SD* = 1.34), ASRT Clinical Refreshers (*M* = 2.54, *SD* = 1.44), RadTechBootCamp (*M* = 2.11, *SD* = 1.56), and PPT

Voiceover (*M* = 2.02, *SD* = 1.42) showed increased use. In the other categories, participants were able to write in their technologies used that may not have been indicated on the list provided in the survey. Some of the most commonly mentioned technologies included Blackboard, Echo, Go-to Meetings, Camtasia, Moodle, YouTube, GoogleMeet, Techsmith, and Microsoft Teams.

Table 13

Descriptives for Virtual Technology Use

Virtual Technology Use	Pre-COVID-19		Post-Adjustment		Future Intentions	
	M	*SD*	*M*	*SD*	*M*	*SD*
Anatomage Table	1.27	.79	1.19	.67	1.49	1.03
ASRT Clinical Refresher Modules	1.91	1.18	2.54	1.44	2.67	1.35
ASRT Roadmaps	1.82	1.22	1.92	1.34	2.18	1.37
ASRT Ziltron Simulators	1.13	.54	1.21	.72	1.41	.90
Augmented Reality (AR)	1.11	.49	1.08	.46	1.21	.62
Big Blue Button	1.19	.68	1.26	.83	1.29	.84
Canvas	2.78	1.89	2.98	1.94	3.13	1.94
Diigo	1.02	.20	1.01	.45	1.05	.27
Evernote	1.14	.52	1.09	.45	1.16	.55
Google Hangout	1.25	.70	1.39	.97	1.51	1.00
Kahoot	2.48	1.34	2.60	1.44	2.86	1.39
Kaltura	1.32	.89	1.36	.98	1.43	1.01
Meducoach	1.02	.16	1.00	.066	1.08	.42
Mindomo	1.03	.21	1.04	.30	1.07	.35
Panopto	1.32	.89	1.43	1.09	1.50	1.15
PB works	1.03	.27	1.00	.00	1.08	.42
Piktochart	1.08	.39	1.06	.34	1.10	.42
Poll Everywhere	1.64	1.04	1.58	1.034	1.77	1.16
PPT Voiceover	1.68	1.07	2.02	1.42	2.07	1.39
Prezi	1.46	.85	1.39	.84	1.54	.99
Quizziz	1.25	.77	1.27	.82	1.42	1.00
RadTechBootcamp	1.76	1.30	2.11	1.56	2.35	1.58
Screencast-o-matic	1.40	.94	1.45	1.11	1.55	1.12
Shaderware	1.24	.75	1.22	.71	1.40	.92
Virtual Reality (VR)	1.2	.69	1.22	.76	1.45	.99
VoiceThread	1.22	.72	1.24	.78	1.34	.86
YuJa Videos	1.06	.44	1.10	1.54	1.17	.67
Zoom	1.95	1.43	3.91	1.34	3.34	1.41
Other Lecture Capture Technology	2.60	1.69	3.42	1.76	3.18	1.73
Other Virtual Simulation Software	1.67	1.29	2.07	1.56	2.20	1.63
Other	2.07	1.61	2.51	1.77	2.55	1.75

Note. A 5-Point Likert Scale was used (1-Never, 2-Rarely, 3-Sometimes, 4-Often, 5-Always).

Research Question 4

Research question four (how does the pre-COVID-19 perceived barriers to integration of virtual technology differ from the post-adjustment perceived barriers?) was analyzed using a paired samples *t*-test. A paired samples *t*-test was used to determine if perceived barriers scores changed from the pre-COVID to post-adjustment. Perceived barriers scores were positively skewed (*skew* = 1.16, *SE* = .11) and leptokurtic (*kurtosis* = 1.92, *SE* = .23). There was a significant difference from the pre-COVID to post-adjustment perceived barriers scores (t_{223} = 4.04, $p < .001$). About 6.1% of the variance in perceived barriers scores was explained by the change from pre-COVID to post-adjustment ($\omega^2 = .061$). Educators' perception of barriers to technology integration decreased from pre-COVID to post-adjustment.

Descriptive statistics were also used to further evaluate the specific perceived barriers pre-COVID-19 to post-adjustment (see Table 14 for the descriptives for Perceived Barriers). From the present sample of pre-COVID-19 scores, the most commonly reported barrier was 'Cost/Funding' (*N* = 178, 34.90%), followed by 'Hard to Keep up with Rapid Technological Advancements' (*N* = 81, 15.88%), and 'Faculty Resistance to use Technology' (*N* = 80, 15.69%). The lowest scores were indicated for 'Student Resistance to use Technology' (*N* = 32, 6.27%). For the post-adjustment scores, 'Cost/Funding' (*N* = 154, 30.19%) 'Hard to Keep up with Rapid Technological Advancements' (*N* = 71, 13.92%), still had the highest scores, and 'Student Resistance to use Technology' (*N* = 26, 5.10%) still had the lowest score. All categories of Barriers had decreased scores from pre-COVID-19 except the 'Other' category (*N* =46, 9.02%) which increased slightly. The 'Other' category allowed participants to write in other perceived barriers not indicated on the list. Some of the common comments pre-COVID-19 included time, no need/interest, and director/administrative resistance. The most common comments noted post-adjustment were time, 'tech fatigue', availability, awareness of tech, administrative processes, and the returning of students to face-to-face classes.

Table 14

Descriptives for Perceived Barriers Pre-COVID and Post-Adjustment

Barrier	Pre-COVID-19		Post-Adjustment	
	n	%	n	%
Cost/Funding	178	34.90	154	30.19
Availability of Physical Space	55	10.78	47	9.22
Lack of Professional Development Opportunities	63	12.35	51	10.00
Hard to Keep up with Rapid Technological Advancements	81	15.88	71	13.92
Faculty Resistance to use Technology	80	15.69	58	11.37
Student Resistance to use Technology	32	6.27	26	5.10
Other	41	8.04	46	9.02

Note. *N* = 510. Participants could select all that apply from the list of barriers.

Research Question 5

Research question five (how does the post-adjustment virtual technology degree of use differ from the post-COVID-19 intentions for future virtual technology use?) was analyzed using a paired samples *t*-test. A paired samples *t*-test was used to determine if VTU scores changed from the post-adjustment to future intentions. VTU scores were positively skewed (*skew* = 2.58, *SE* = .11) and leptokurtic (*kurtosis* = 7.15, *SE* = .22). There was a significant difference from the post-adjustment to future intentions VTU scores ($t_{233} = -3.29$, $p = .001$). About 4.2% of the variance in VTU scores was explained by the change from post-adjustment to future intentions ($\omega^2 = .042$). In the present sample, radiologic technology educators indicated intentions for overall increased virtual technology use in the future compared to their post-adjustment use.

Descriptive statistics were also utilized to further evaluate the specific technologies used from post-adjustment to future intentions of use (see Table 13 above for the descriptives for virtual technology use). The scores for post-adjustment virtual technology use indicated that Zoom (*M* = 3.91, *SD* = 1.34), ‘Other’ Lecture Capture Technology (*M* = 3.42, *SD* = 1.76), and Canvas (*M* = 2.98, *SD* = 1.94) had the highest use. Kahoot (*M* = 2.60, *SD* = 1.44), ASRT Clinical Refreshers (*M* = 2.54, *SD* = 1.44), RadTechBootCamp (*M* = 2.11, *SD* = 1.56), and PPT Voiceover (*M* = 2.02, *SD* = 1.42) also indicated higher use than the rest of the technologies listed. For future intentions, Zoom (*M* = 3.34, *SD* = 1.41) and ‘Other’ Lecture Capture Technology (*M* = 3.18, *SD* = 1.73) still had the highest scores for intentions for continued use but had decreased overall means from post-adjustment. However, Canvas (*M* = 3.13, *SD* = 1.94) was still the third highest score but exhibited an increased overall mean, indicating educators anticipated to increase use of canvas in the future.

In the other categories where participants could write in technologies used that were not indicated on the list provided in the survey, the same commonly mentioned technologies included: Blackboard, Echo, Go-to Meetings, Camtasia, Moodle, YouTube, GoogleMeet, Techsmith, and Microsoft Teams. Additionally, ‘Other’ Virtual technology simulations that were commonly mentioned included VERT and Simtics.

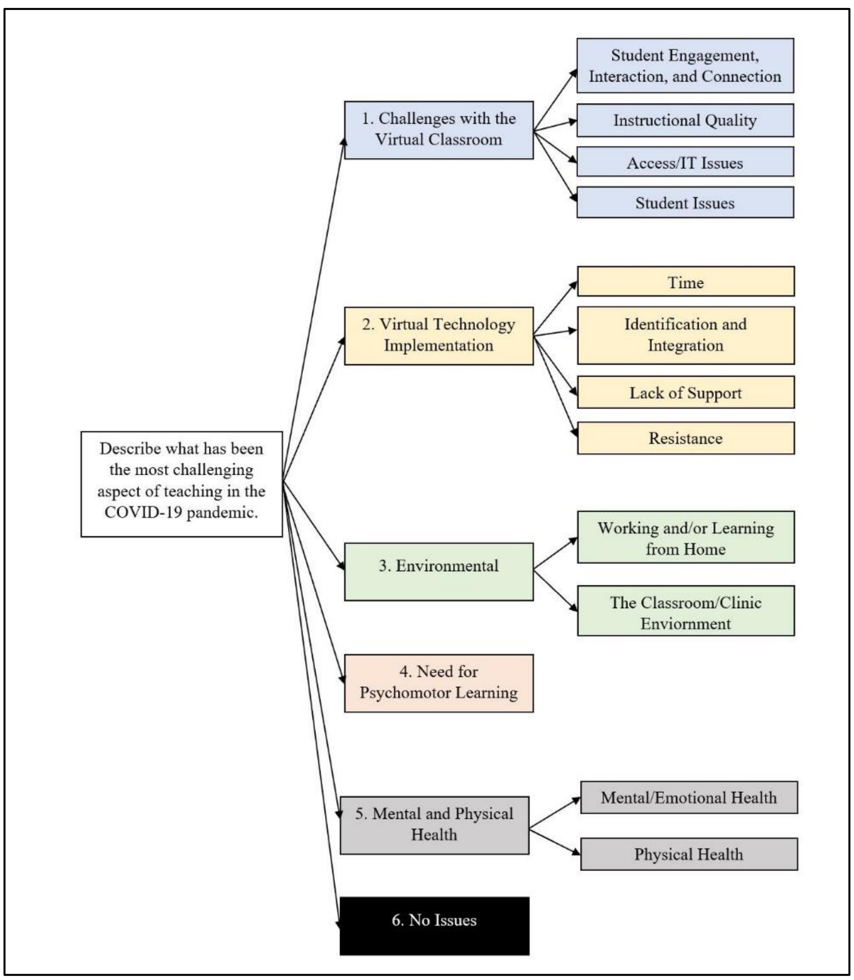
Research Question 6

The final research question (What themes were presented in the open-ended questions?) was analyzed as a pseudo-qualitative element to identify common themes from the open-ended questions (#23-25). The pseudo-qualitative data enhanced the understanding obtained from the quantitative data. The open-ended nature of the questions allowed participants to share their individual insights and experiences. The pseudo-qualitative results and themes for each question will be addressed individually.

Challenges. The first open-ended pseudo-qualitative question (Describe what has been the most challenging aspect of teaching in the COVID-19 pandemic) had a total of 224 comments. The comments were organized according to similar responses and seven main themes emerged: 1) Challenges of the Virtual Classroom, 2) Virtual Technology Implementation, 3) Environmental, 4) Need for Psychomotor Learning, 5) Mental and Physical Health, and 6) No Issues (see Figure 6 for summary of Challenge Themes and Subthemes).

Figure 6

Challenge Themes and Subthemes



Challenges of the Virtual Classroom. Radiologic technology educators indicated several challenges with the virtual classroom itself. Among this theme, there were four sub-themes that were identified: 1) Student Engagement, Interaction and Connection, 2) Instructional Quality, 3) Access/IT Issues, and 4) Student Issues. The first theme (student engagement) had the most comments of any other theme (84 comments), followed, student issues (16 comments), Instructional quality (15 comments), and Access/IT issues (10 comments).

Student Engagement, Interaction, and Connection. This challenge was easily identified as the most common challenge of teaching in the COVID-19 pandemic, as reported by radiologic technology educators. They found it difficult to engage students in lectures and class discussions.

'I feel like students are less engaged and more likely to lose focus when receiving the information virtually'

'Keeping the students engaged has been difficult. I do not feel online learning is effective for RT learning.'

'I feel I do not have the interpersonal relationships that increase student engagements yet I have spent many more hours working for that engagement than when I have traditional classroom time with students.'

'Students are disengaged when they have to stare at the screen all class.'

Furthermore, many expressed the difficulty of engagement in the virtual classroom when students had their cameras off.

'Teaching large groups via zoom is the most difficult especially when students don't turn on their cameras. It is much harder to know if they are engaged or completely doing

something else. Seeing their faces in person can help with how you teach and to adjust when necessary when body language shows differently'

'Lack of interpersonal interaction with the students, many of them have their cameras turned off and are slow to participate in discussions'

The educators' described the need to see student's faces and body language as an important assessment for student understanding. This feedback was described as a crucial indicator for educators as they gauged the classroom and was detrimental in providing appropriate instruction and learning experiences.

'Not knowing if students really understand if you are unable to see face expressions as you would in person.'

'Not seeing students faces hinders my ability to tell if they are understanding the material'

'Connecting to the individual and immediate needs of students. Getting to know the students. Observing in-person reactions. Nuance is missing with technology. Diversion and story telling is not easily possible.'

'The lack of connection with the students in the classroom. The communication is difficult when faculty are unable to see nonverbal cues during instruction.'

Instructional Quality. From the comments of radiologic technology educators' most seemed to be of the opinion that virtual learning was inferior to face-to-face learning. It was expressed that the quality of education was not equivalent across delivery methods.

'Face to face learning is much easier on the students. No face to face has been difficult, both on educators and on students, but especially on students. There is no better way to learn than in person.'

'I felt the quality of the virtual instruction was not as beneficial as in-person learning"

'Lack of usual "side" conversations that easily occur in a live classroom setting. It is hard to pick up subtle signals when someone is NOT getting the point of a topic and there seems to be a reticence to ask unprompted questions.'

'Fully remote/online teaching. My students did not care for it and I did not either. Very difficult to teach (and for students to learn) certain concepts without face-to-face interaction, labs, etc.'

'I feel like information can get lost in translation online no matter how hard the professor tries.'

'I felt that the virtual classrooms inhibited my ability to reinforce certain concepts'

'Sitting in front of the computer to Zoom class; I am animated and like to walk around the room.'

*Access/IT Issues***.** Several issues of accessibility were addressed by radiologic technology educators. These access issues often stemmed from issues with IT and/or internet connectivity. These issues were mentioned for both students and faculty alike.

'Not all students have the necessary resources to learn from home.'

'Students lack of reliable technology and internet.'

'Supporting students with wifi/connectivity issues.'

'Internet services that are consistently working. Rural broadband is terrible

'Access to college was limited. Accessing files from shared drives was challenging. Internet access created limitations with 2 school aged children in the house using wifi.'

'IT department restrictions'

'Slow speed internet, institutional firewalls'

Student Issues. Many student issues of accountability and academic dishonesty arose from the comments. Educators indicated that accountability of students seemed to suffer as a result of the COVID-19 pandemic.

'I don't feel they spent the necessary amount of time outside of class reading the assigned materials and really trying to understand it.'

'having students taking "zoom" seriously. It became necessary to implement professional points into grading system due to the number of computer that "weren't working".'

'Getting students to care about their role in the pandemic'

'Student's dedication and commitment to their own learning.'

'You can no longer go to class and expect students to be there.'

'Preparing students to be professionals in health care means holding them accountable for their behaviors. Teaching courses virtually gave students opportunities to put in less effort and with teachers less opportunities to counsel students.'

There were also a small amount of educator's who expressed concern for academic dishonesty that arose, especially early in the transition to virtual learning and teaching.

'cheating has been a concern with online testing.'

'there is cheating with online assessments going on. I choose not to use a browser lockdown software because I want to be able to answer student questions during timed exams, but they are not being academically honest'

'We also had issues with proctoring exams remotely...had some cheating issues in the beginning.'

Virtual Technology Implementation. The second theme derived from radiologic technology educators' reported challenges indicated several issues associated with the implementation of virtual technology. There were four sub-themes that emerged under this category: 1) Time, 2) Identification and Integration, 3) Lack of Support, and 4) Resistance.

Time. The most common challenge reported under the virtual technology implementation theme was time. Due to the abrupt nature of the COVID-19 pandemic, educators were forced to transition to virtual learning, often with little to no notice.

> *'TIME needed to create and implement it in courses. Converting traditional face to face courses to 100% online was frustrating for both instructors and students. Quality of education suffered as a result.'*
>
> *'Learning the technology while simultaneously attempting to teach. There was no, and has not been, any time to really learn the technology before having to put courses together and hit the ground running. It has all bee simultaneous throughout the entire past year and I am only just now getting to the point where I can look at what I did last year and how I can improve it or do it differently. It's like teaching the subject matter, which is already difficult for students to grasp, and learning how to teach it to them in Russian having never had a class on how to speak Russian.'*
>
> *'The lack of time to research, train, and become proficient in some of the resources I used prior to implementation was a huge stressor'*
>
> *'The rush to get it all done. When COVID hit, we were there one day and the next week we were out! I recorded over 100 short videos preparing to teach labs online.'*
>
> *'The most challenging was just having to change the course overnight in the case of the spring last year. Students went from never hearing of zoom to being on it all the time and I was not aware that I needed to lay out ground rules and behavior expectations prior to utilizing it.'*

'Transitioning to all-online courses without adequate time to prepare.'

'Implementing and converting in-person class to a virtual platform with no time to prepare. In person classes were cancelled due to pandemic so one had to scramble to convert to a virtual course format with no lead time to prepare or become fully comfortable with the tools available in advance. Initiation by fire as the expression goes.'

Identification and Integration. Many educators also expressed difficulty with the process of finding technology that would best meet the needs of their classrooms. Not only was it difficult to decide on technologies to use, but they were often limited by their institutional approval.

'The wide variety of choices in technology to use as a means of course content delivery was extremely overwhelming'

'I had to plead my case to administration for our need of the resource in the first place (I felt my students suffered a bit because of the lack of resources I was able to provide)'

'Legal hoops to jump through for approval to use/purchase software that would benefit my students like simulation software.'

'I am not really aware of what virtual teaching options are out there.'

The integration of virtual technologies was also a challenge expressed by many educators as they had to learn to use the technologies themselves, in addition to redesigning their courses to accommodate the virtual learning environment.

'Trying to learn programs such as Zoom or Teams'

'More work since we have had to completely redesign our courses to meet online delivery requirements.'

'Learning the new technology on the fly was the most difficult part.'

‘Getting used to screen sharing with zoom’

‘Redeveloping my courses to respond better in a virtual environment.’

Lack of Support. The lack of support was a compelling sub-theme reported by radiologic technology educators. The lack of support for training of technology use was indicated by many.

‘lack of my institution to train me in the newer technologies’

‘not having the correct infrastructure available and the training to complement it”

‘Not having the support for adjunct staff who were working at the hospital during the beginning of the pandemic. While college staff was given a week of training and classes were "paused" during this training to learn how to transfer teaching face to face to virtual..., there was no additional invitations for support for non-fulltime workers, or instructors who were adjunct and busy during that week given for training, working in crisis mode at a hospital.’

Additionally, a lack of support in the form of funding was identified by many of the radiologic technology educators.

‘Lack of funding to fully integrate best technologies’

‘I would have loved to use additional online resources such as ASRT modules and RadTechBootCamp; however, cost is an issue.’

‘Not having funding or access for certain technologies to help students learn especially online’

Resistance. The last sub-theme for Virtual Technology Integration was Resistance. This was indicated by educators in the form of resistance from students and also resistance from faculty to embrace virtual technology.

'Student resistance to the use of technology in class. Some students struggle with the use of technology and prefer to be face-to-face with instructors.'

'Faculty buy-in to the virtual world.'

'one instructor is often unwilling to learn new technology. Most students learn the technology fairly quickly (more difficult for older students). Being in the position that we were, of being completely shut down, we HAD to learn it and use it.'

Environmental. The third main theme for challenges reported by radiologic technology educators was the challenges associated with certain environments. This theme was broken down into two subthemes: 1) Working and/or Learning from Home, and 2) The Classroom/Clinic Environment.

Working and/or Learning from Home. The challenges associated with working from home were reported by radiologic technology educators. Many indicated the challenges associated with distractions in the home, time management, and the need to establish a functional work/life balance, while working from home.

'Time management and time of availability of myself to the students. I felt like I was always on call for the students to make sure they were OK.'

'Balancing work and home life responsibilities! Being a parent of young children in addition to my full time faculty role/responsibilities has been a lot to balance'

'My biggest challenge has been working from home. I rarely follow the 8am-5pm approach and find myself working into the evening and night hours. I also am concerned what my employer's expectations are for remote working'

'Teaching physics remotely with limited faculty support.'

Others reported issues associated with students learning from home and the challenges of the home environment associated with student learning.

'the students are very distracted while at home.'

'Students attendance and their focus from an outside location.'

'Helping students who struggle learning in the remote learning environment. And not all students have a quiet place at home to learn.'

Classroom/Clinic Environment. The radiologic technology educators expressed challenges with the clinical and classroom requirements as a result of the COVID-19 pandemic. These challenges included issues of space for social distancing, the use of masks, and combined classroom formats with some students Face-to-Face while simultaneously having students attending virtually.

'Social distancing in the classrooms due to classroom sizes.'

'Lecturing in zoom and in the live classroom simultaneously was very challenging.'

''Wearing a mask in the clinical site and hearing'

'Half of the class being in masks in class and the other half being home on ZOOM. Group activities were not done or were not as successful as previous classes.'

Furthermore, the constant changing of protocols and standards was described as a challenge by some educators.

'implementation of uniform standardization of COVID-19 pandemic protocols has been minimal at best (a lot of confusion and misinformation).'

'Lack of consistency'

'The ever changing atmosphere leads to the need to consistently adapt to new guidelines.'

Need for Psychomotor Learning. The unique format of radiologic technology education requires the combination of both didactic and clinical competency. This was expressed in the comments of radiologic technology educators as a challenge. These challenges were identified for both the laboratory environment and the clinical environment which require psychomotor learning.

'The biggest challenge is teaching a hands-on principle in a virtual format'

'We are a hands on interactive profession and the COVID-19 pandemic circumstances dictate that we do not touch or occupy the same space with others.'

"teaching positioning class via Zoom. It is hard to teach a 3D, hands on approach across a computer screen'

'It is nearly impossible to teach entirely virtually, and simulation software doesn't help. My students can hear the lecture and memorize the steps all they want, but to really learn it, they'll need to put their hands on the equipment and actually position a real patient'

'Inability to use the radiographic equipment in the classroom. The inability to use psychomotor skills to learn.'

'Incorporating Lab activities! It is truly difficult to teach and assess things such as positioning virtually. When students were finally allowed on campus we could see a huge difference.'

'Not being able to get in the x-ray lab to practice.'

Among these challenges was an abundance of comments specifically regarding the challenge that nearly all students faced at the beginning of the pandemic, which was the temporary suspension of clinical rotations. This was due to clinical partners not only being overwhelmed with the pandemic, but also the increased liability of having students in clinicals and facing possible exposure to COVID-19 in the clinical environment. Many students had extensive pauses and delays on their clinical education, a requirement for board certification.

'it is hard for my students to get the mandatory and even elective competencies that they need, when there are limitations to the facilities that we use.'

'The extended pause on clinical rotations at the onset of the pandemic. This put our 2020 cohort of learners behind in the number of hours of clinical education that they received, and their performance clinically has suffered.'

'I had to come up with a way for the students to keep their clinical skills sharp'

'Lack of access to clinical sites for hands on experience'

'students getting kicked out of clinicals was especially challenging'

'Getting students clinical time so as to relate what they are reading/ or virtually learning about vs the real thing.'

'Finding new ways to continue application of clinical knowledge while students were not allowed in the clinical setting.'

'Clinical education limitations due to restrictions.'

'Providing clinical scenarios and situations that would prepare our students to enter the clinical setting. It is hard to simulate this environment since patient care is something that needs to be experienced and can't be taught.'

'Provide clinical education experiences in the actual clinical setting. You cannot completely replace actual clinical education with patients in hospital and clinic settings with all simulation.'

Mental and Physical Health. Although this fourth theme was small (10 comments), the comments indicated a need to address this theme separately. The theme of mental and physical health was indicated in radiologic technology educator comments and indicated the need to address the negative health effects the pandemic has brought on radiologic technology educators and students. Some of the comments were focused on COVID-19 itself, exposures, quarantine, and physical illness.

'Students in and out of quarantine and getting them caught back up once they can return to campus.'

'With possible exposures, our student blocks were affected'

'students getting ill with COVID-19'

The other aspect that was addressed was the mental health. Radiologic technology educators indicated the mental, emotional, and psychosocial aspects that have affected educators and students alike.

'This has been traumatic and want a break from technology.'

'Psycho-Social issues more than technological issues.'

'the isolation the students feel'

'Keeping up student morale and being aware of their mental health statuses.'

'Health and mental presence due to grief of patient or family members, social aspect of the life'

'isolation from colleagues'

No Issues. The last theme that emerged was that of no reported issues. There were a number of radiologic technology educators that indicated no change and/or no expressed challenges teaching during the COVID-19 pandemic.

'I have not found it to be challenging.'

'I have not had any issues with tech. I have been one to support the adoption of tech'

'to be honest, I have not felt the challenges like many educators have.'

'I have not had changes because I was teaching synchronously online prior to the pandemic.'

Technology Learned and Intentions for Future Use. The second open-ended pseudo-qualitative question (Describe what virtual technology you started using as a result of the COVID-19 pandemic that you plan to continue using and why) had a total of 254 comments recorded from the present sample. The comments were organized and resulted in three main themes: 1) Educational Delivery, 2) Radiology-Specific Technologies, and 3) None (see Figure 7 for summary of Technology Intentions Themes).

Educational Delivery. The first and largest theme identified was that of educational delivery technologies. The most common subtheme was video conferencing technologies, with the largest being that of Zoom (102 mentions). Other common video conferencing technologies commonly mentioned included WebEx and Big Blue Button. Furthermore, the Microsoft and Google Platforms such as Microsoft Teams and Google Meet were commonly cited. Radiologic technology educators indicated these video conferencing technologies were valuable in providing opportunities for virtual teaching opportunities.

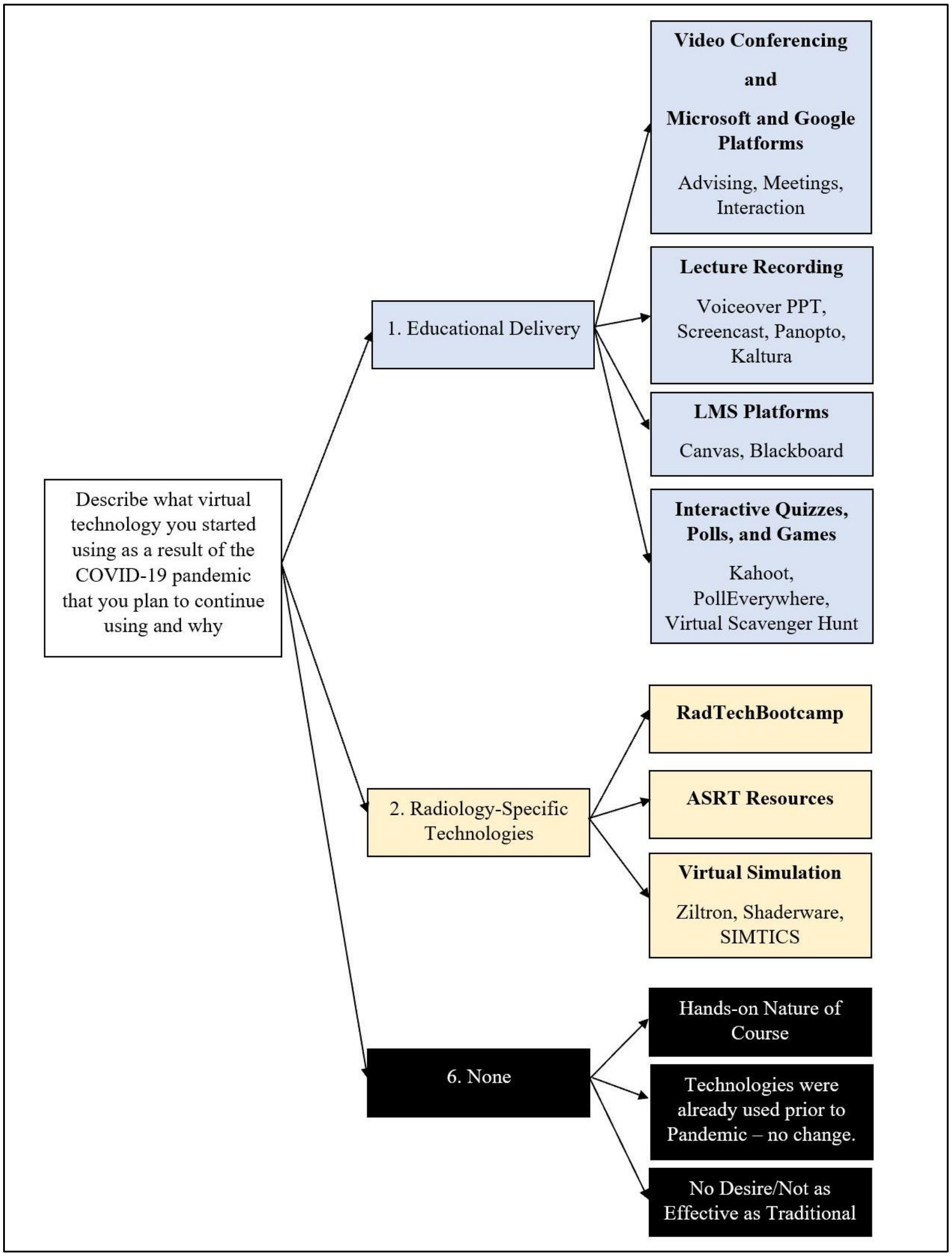
'Both Zoom and Echo 360 are easy to use and allow course content to be conveyed efficiently. I will continue to use these for the remainder of my career.'

'Zoom as a hybrid - possibly when students are sick and cannot make it to campus or have a long commute.'

'Google meets. Easy to use and very accessible to all students and faculty. It shows the screen presentation, it allows for real-time presentation and feedback and recording capabilities.'

Figure 7

Technology Intentions Themes



'It made it very easy for all students to be able to schedule and join a class. We can now have class at any time (snow days, covid days, etc).'

'Teams. This makes meeting with students easier and offers more flexibility in scheduling and privacy.'

'Zoom, to include breakout rooms. It provides students with the opportunity to have a short lecture presented and then work in small groups. Saves time but still allows for teacher/student interactions.'

'This can be used in conjunction with in-person lecture for life situations or sickness when students cannot make it to class.'

Educators also highlighted the benefit of using and video conferencing as a way to provide interactions for advising opportunities and for meetings.

'It will continue to be offered as an option for advising. Works well for student schedules that are hard to meet. Often increases the amount of students I can meet with.'

'Zoom. I had never really needed to use Zoom before, but now see it as something to use all the time. I mean, why wouldn't we use it? It makes getting together so much easier. Meetings are easier because I don't physically have to drive somewhere to the meeting. Genius!'

'Zoom and Canvas Conference is easy to use and in this rural setting becomes very convenient especially for any type of meeting.'

'Google Meet. It is useful in augmenting other methods in course delivery. I also use it currently to conference one-to-one with students.'

Participants also expressed the benefit of recording lectures. Some of the commonly cited lecture capture technologies that were mentioned included Screencast (Screen-cast-omatic, Screencastify, etc.), Voiceover PPT, Panotpo, and Kaltura.

'kaltura. At times this technology is better than my previous method of delivery'

'PPT voiceover and recording all lectures. I had been wanting to do this for years and had asked about the possibility and then I had to do it'

'I started doing recorded lectures for some of my classes and I have kept those as supplemental and for those that can't come to class due to illness. It's helpful to hear the material more than once in some instances.'

'I will use Panopto to record lectures on days I cannot be in class.'

'Everything!! Collaborate Ultra, Zoom, Screencast...incorporate more video and pictures in my lectures. Multiple webcams to demonstrate positioning from different angles. Ive had to get creative to do what I normally do in the classroom'

Some educators also cited the value in pre-recorded lectures as a way to maximize the face-to-face class time.

'Screencastomatic to prerecord lectures. I will continue to pre record and change the format of some class meetings to be fully lab based and increase the hands in time in the classroom.'

'prerecorded ppt voiceovers to flip my classrooms and allow for in class activities to augment learning rather than typical face to face lectures.'

Another subtheme of educational delivery was the use of learning management systems (LMS) such as Canvas and Blackboard and their associated features.

'Canvas. A long-term goal for the program was to transfer all curriculum to an LMS. COVID -19 pandemic was the perfect time to implement and complete. We will continue to teach via Canvas for ease and convenience of use.'

'In the past I have used Blackboard for quizzes (open book) but since COVID needed to use for unit exams with Lock down browser and Respondus monitor. I will continue to

use these features in Blackboard. So much easier to correct and provide results in a timely manner.'

'Canvas studio has allowed me to integrate interactive quizzes to my students during online lecture'

'Recording and posting videos of my explanations in the learning management system (LMS) that we use, instead of just typing everything out. We also started using video proctoring and lockdown browsers for testing, which will likely continue.'

The final subtheme for educational delivery was the use of interactive quizzes, polls and games. From the current sample, Kahoot, PollEverywhere, and Quizzes were commonly mentioned.

'the students seem to engage alright with these--even the quiet/shy class cohorts that don't like to speak up much during dialogue/discussion would engage well with the quiz questions in class.'

'I started using more quizzes and polls in my classes to see if students were following along. I will continue to do that even if we return face to face. Student feedback was positive'

'Kahoot - The students enjoy it and so do I. They are much more engaged.'

'Kahoot because it allows students to respond to questions and I can get an idea of what content they have mastered and what content still needs some explaining or demonstrating.'

'I started using more interactive/review platforms. Students like being competitive and seeing what they know.'

Radiology-Specific Technologies. The second theme was that of radiology-specific technologies. These are tools and technologies that are specific to radiologic technology education and training, not just educational delivery. The subthemes for radiology-specific included RadTechBootcamp, ASRT Resources, and Virtual Simulation. There were a total of 19 mentions of RadTechBootcamp, with many expressing the positive student feedback and quality of video content.

> *'Bootcamp provides a wonderful set up of videos, notes, and quizzes that my students are still utilizing in the classroom as secondary sources'*
>
> *'RadTechBootCamp was the favorite among students. It was easy to access and understand.'*
>
> *'RadTechBootCamp- great videos and explanations'*

The virtual simulation technologies that were most commonly mentioned included Ziltron, Shaderware, and SIMTICS. Most of the educators expressed they were helpful for clinical concepts. Other simulation technologies that were mentioned were: VR radiology, ScanLabMR, Visible Body Virtual Anatomy Lab, and Varian Simulator VERT.

> *'SimTics provides clinical simulations to my students when they are not allowed in the facilities to complete clinical hours.'*
>
> *'VIRTUAL REALITY SOFTWARE - ALLOWS FOR MORE STUDENTS TO HAVE "HANDS ON" EXPERIENCE DURING LAB HOURS'*
>
> *'Shaderware, to work when we were out of the clinical setting'*
>
> *'Ziltron - valuable as a supplement to positioning/procedures'*

ASRT resources was another radiology-specific subtheme. Participants discussed the value of free student and educator resources that were made available during the pandemic. They noted the quality of the resources in helping transition students into the clinical setting.

'ASRT Webcast ASRT Clinical Refresher courses The students have been very receptive to the addional resources made available by the ASRT'

'ASRT Clinical Core; simple to use, already had member access, accurate'

'The ASRT clinical refreshers. They provide an excellent review of exams without having to be in the lab or clinical setting.'

'the ASRT modules have been a lifesaver.'

None. The final theme was that of 'None'. This theme contained three main reasons as indicated by the comments of participants. The first reason was that the virtual technology would not be used once returning and/or the hands-on nature of the courses would not necessitate the virtual integration.

'Used zoom until school was cleared to have classes live. Teach hands on lab imaging. Zoom classes not possible, had to cover subjects relating to general imaging. Do not plan to use Zoom when COVID is over'

'Microsoft Teams and Google classroom were used temporarily until the students could return to the classroom. We do not intend to continue virtual courses.'

'I do not plan to maintain teaching online lectures, as we are a hands-on healthcare program and require our students to be in the classroom.'

The second reason was because the technologies used by radiologic technology educators during the pandemic were already being used prior to the pandemic. Many of these educators indicated they were already teaching virtually before COVID-19, and therefore it had not been a change for them.

'I have not changed anything. I was already using, Poll Everywhere, Canvas, and Zoom prior to the pandemic.'

'Most of the courses were already fully online so the pandemic did not have a significant impact on how my courses are presented.'

'Since my program is hybrid, I've always incorporated some virtual elements. I haven't added any new technology because of the pandemic.'

Lastly, many educators expressed that they did not desire to use the technologies once it was no longer required or that it was not as effective as traditional methods of teaching.

'None. I have not experienced any virtual technology that has improved learning, retention, or communication. It has all been necessary in this time of the virus, but it is not better. Rarely are things that are easier for us (educators) are equally better for student learning outcomes.'

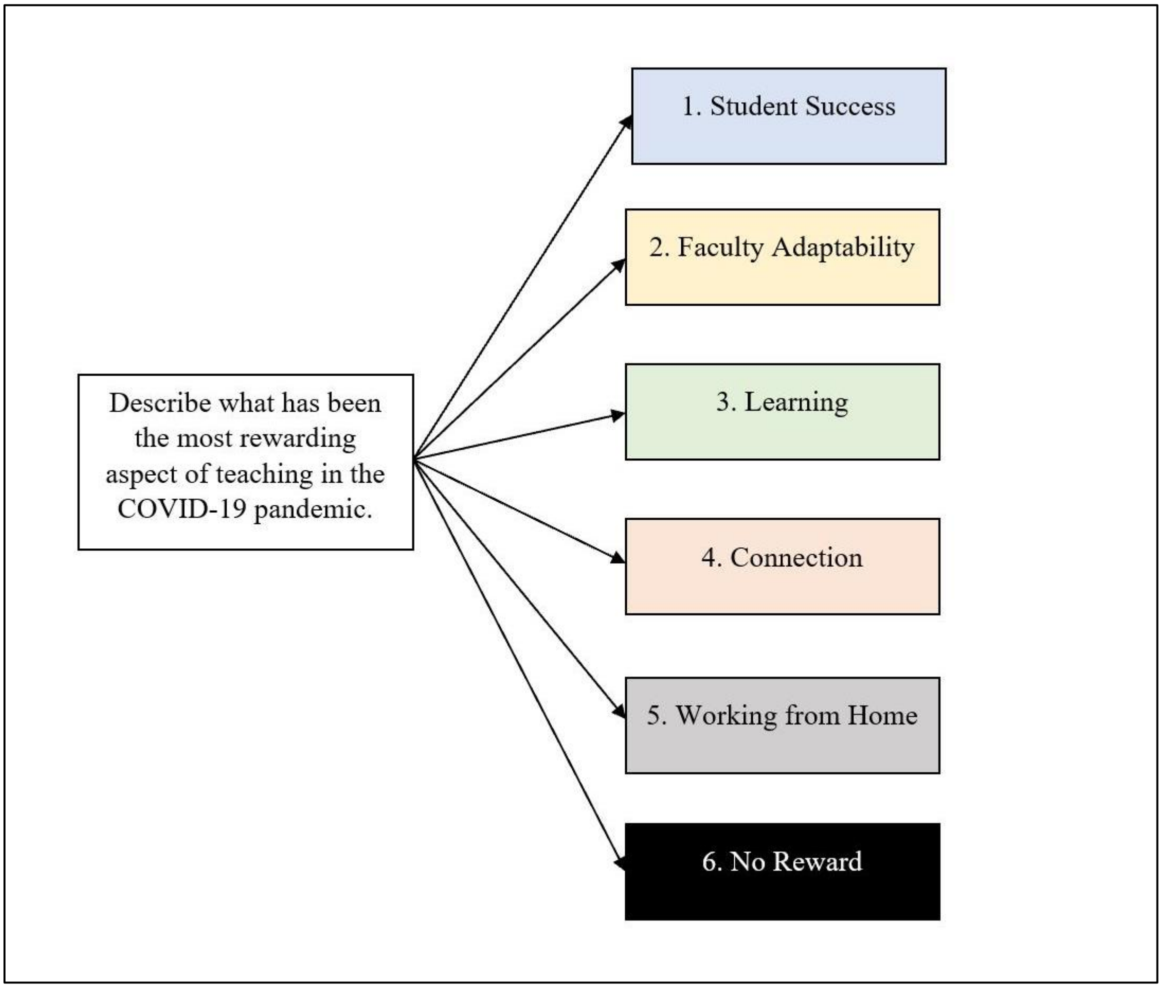
'Utilized SIMTICS radiography simulator for one quarter- poor student feedback- did not continue when we returned to clinical/ campus.'

'Shaderware has been a disappointment.'

Rewards. The third and final open-ended pseudo-qualitative question (Describe what has been the most rewarding aspect of teaching in the COVID-19 pandemic) had a total of 240 comments recorded from participants. The comments were organized and resulted in the emergence of six themes: 1) Student Success, 2) Faculty Adaptability, 3) Learning, 4) Connection, 5) Working from Home, and 6) No Reward (see Figure 8 for summary of Rewards Themes).

Figure 8

Rewards Themes



Student Success. The first theme identified as a rewarding aspect of teaching in the COVID-19 pandemic was that of student success. It was abundantly clear (81 comments) that the radiologic educators cared immensely about the success of their students. The participants' comments indicated they were proud of the students' pushing through a difficult situation, often commenting on their resilience.

'Watching students adapt to a difficult situation (Covid). It reinforces to me the resilience of our students and their dedication to learning the RT profession.'

'Students were very resilient and very patient and that was awesome.'

‘MY STUDENTS RALLIED AND THEY MADE IT!!! THEY WILL GRADUATE NEXT MONTH!!! TAKE THAT, COVID!!!’

‘Working with everyone to get another Radiology class through, ready to pass the ARRT exam and enter the workforce.’

‘Preparation of the future health care professionals.’

‘We had exceptional students that were willing to do whatever was necessary and hurdle whatever obstacles came their way whether it was related to didactic, lab or clinic.”

‘I guess the most rewarding part was just having the opportunity to instill the importance of bravery and resilience in our field when we are needed most.’

‘Observing the determination and mental toughness of our students to overcome many challenges and still be successful.’

‘Our students really want to learn and we have all learned to adapt to whatever is thrown at us.’

‘My students are incredibly resilient, and they persevered strongly - they will graduate on time!’

‘I find the resilience of the students who want this field quite admirable. They have been bounce around, and thrown into non-traditional situations and have persevered with much success! It is quite exciting to see.’

‘I got to see my students complete their program even in the midst of COVID. It was great to see them challenge through and make sure that all their clinical hours were complete. It was a learning experience that they would never forget.’

‘Continuing to produce well prepared Radiologic Sciences students to work during the pandemic is in itself rewarding.’

'The most rewarding part is to see my students prevail through something that has never happened for. There resilience to "go with the flow" and incorporate their creativity as future technologists is something that I commend them for. We made it through a pandemic and succeeded and for that, I could not be happier.'

'Every single one of my students, when they were able to start in the clinical setting, excelled! They have been extremely driven to finish and have shown initiative that previous classes had not.'

'their strength to push through and succeed! Best feeling in the world!'

Faculty Adaptability. The second theme that emerged was that of faculty feeling the reward of adaptability. Many indicated they felt it was rewarding that they simply had the means to continue teaching.

'To be able to continue teaching, because I have a passion for it'

'The fact that I can still teach! We all need to learn more just to keep abreast of the fast changing knowledge in this complex world!!'

'Still being able to teach and interact with students even though not in person. When students applauded that I was going to lecture synchronously because they wanted that immediate access to me while learning.'

'We were grateful that thanks to Zoom we were able to continue the didactic piece as scheduled.'

Participants also stressed the rewarding sense of accomplishment as a result of pushing through the challenges brought on by the pandemic. They expressed their pride in overcoming challenges and getting creative during a difficult time.

'Feeling accomplished in overcoming the challenges of implementing virtual technology instantaneously.'

'We survived'

'I have not lost my creativity in "thinking outside of the box".'

'It has given me strength and feeling that I am contributing to my vocation'

'The chance to put critical thinking into practice to overcome the challenges the COVID-19 pandemic has thrown at us. Critical thinking and innovation are invaluable. To make things work communication is paramount. Not to mention a large dose of grace.'

Learning. The third theme was the reward of learning. As educators, the participants expressed their appreciation for the chance to learn as part of teaching in the COVID-19 pandemic. The forced transition created the opportunity for many educators to learn teaching methods that they may not have otherwise used.

'The personal learning experience since I had to rise to a new challenge after many years as an educator. It is rewarding to realize I am still quite capable to learning new technologies and educational delivery methods.'

'Learning new ways to present information and engage students.'

'Learning additional teaching tools that I did not know before'

'Learning to use Zoom for meetings (advising meetings, committee meetings, etc.) This saves time.'

'Ability to try new things'

'Learning about myself and my students!'

‘I have found new ways to teach. I still don’t believe remote education is the best option for our program. But I will continue to use some of the resources to supplement my lectures when we return to the classroom.’

‘Being able to learn new ways to stay connected which a very important part of our lives.’

‘being able to learn and utilize new technologies in the classroom.’

‘Learning that teaching can be effective even at a distance.’

‘Learning about technologies that deepen student learning.’

‘It has also "forced" the use of alternate teaching methods and had the opportunity to revise and refresh course material.’

‘It has challenged me to be creative and find different ways of engaging and teaching my students.’

‘Opportunity to advance skillset and create new meaningful content and teaching strategies’

‘It has made me be more creative with my teaching methods and to try to reach students on a different level.’

‘Learning new technology and being forced to think outside the box.’

‘It has made all of us re-work our courses so they are not stale. We should do this often.’

Connection. The fourth theme was that of connection. Participants expressed various aspect of connection as a rewarding aspect of teaching during the COVID-19 pandemic. Some expressed it actually gave them the opportunity to connect with students on a different level.

‘learning from my students some of the new ways of communicating. I made an extra effort to develop a relationship with students.’

'More students have reached out for help and have scheduled virtual meetings.'

'I got to know my students on a more personal level. I made sure to touch base with everyone at least every other day, we had chat sessions to see how everyone was feeling, and we saw the home environments of everyone.'

'Breaking the lab groups into smaller groups (more one on one) builds a great rapport. Built stronger supportive relationships between faculty and students.'

'Maybe it was the shared experience of the pandemic, lockdowns etc, with my students and colleagues that strangely gave me a different sense of connection and community.'

'Finding unique ways to communicate with students that REALLY worked and they felt respected and taken care of.'

'My strongest attribute as an educator has been my ability to connect deeply with my students. If I am interpreting course reviews and interpersonal interactions correctly, this ability was not compromised to the extent that I expected.'

Working from Home. Many radiologic technology educators reported that they found working from home to be a rewarding experience. Many highlighted the savings, lack of commute, family time, and personal schedule as perks of working from home.

'as I taught remotely more, I was able to spend more time with my family as I did not have the long commute so that made it nice for me personally.'

'My initial though is the selfish sense of thankfulness I have that I was able to stay home and teach online while essential healthcare workers had to face the pandemic head on.'

'Saves time and $$ by not having to drive to and from campus and allows for more productivity'

'the ability to tutor students after normal working hours in the convenience of my home on my schedule'

'the commute and dress code has been nice while working from home. :)'

'The time I got to spend at home and see what it was like to be a stay at home mom'.

No Reward. The final theme for the rewards question was that of no reward. Many participants described the stress and strain of teaching through the COVID-19 pandemic and that they did not see any rewards as a result.

'Unfortunately, the pandemic has not been rewarding in any way (other than learning how to use Zoom). There was a disconnect between students and faculty as we did not have the on-campus, in person, sessions.'

'Very difficult to answer. Not much has been rewarding watching my students progress without any clinical experience'

'I haven't found it very rewarding. Our students were suspended from clinical and it was an uphill battle to get permission for them to return. They were discouraged and frustrated.'

'Absolutely nothing'

'Still trying to figure it out.'

'nothing - it was mentally draining; Minimal recognition by my employer; considering another job at present.'

'Nothing. The stress and emotional problems students are dealing with have disrupted learning. Financial difficulties have caused several to withdraw and many have said they are depressed.'

‘Frankly, I am exhausted, I am working 3 x harder than before and I didn't think that was even possible!’

‘I cannot say teaching during the pandemic was very rewarding.’

‘Unsure if anything has been rewarding this year. It has been a VERY difficult year to teach.’

V. DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

Discussion

The purpose of the study was to investigate the educational impact of the COVID-19 pandemic on virtual technology use in the radiologic technology classroom by specifically investigating: (a) the pre-COVID-19 versus post-adjustment uses of virtual technology, (b) the pre-COVID versus post-adjustment perceived barriers preventing integration of virtual technology, and (c) the continuance intentions to use virtual technologies post-COVID-19. The rapid shift to the virtual classroom as a result of the COVID-19 pandemic forced teachers to change many aspects of their teaching. Understanding the forced and sudden transition to virtual technology in education due to the COVID-19 pandemic and how it has affected radiologic technology educators and their intentions for continued use is crucial in understanding the educational environment of the future. The information from this study provided valuable insight that may be utilized to improve radiologic technology programs across the country and better anticipate the technology needs for future educators, as was encouraged by the OET (2017). This chapter discusses the findings from the results and analysis as they relate to the literature. It also provides conclusions and recommendations for future research.

Virtual Technology Use

In evaluating virtual technology use, the VTU scores were positively skewed and leptokurtic, with very low mean scores (on a scale of 1-Never to 5-Always). The majority of technologies listed had scores near 1, which indicated that most educators in the present sample never used these technologies pre-COVID or post-adjustment. In the pre-COVID-19 VTU, the highest mean score was 2.78 (Canvas), whereas the highest mean score for post-adjustment was 3.91 (Zoom). Because canvas is a very common LMS platform and is required by many institutions it is not unexpected that it demonstrated higher usage prior to the COVID-19 pandemic. It is understandable that Zoom would exhibit the highest score for post-adjustment use because the platform was being used by educators and non-educators alike. Zoom quickly became a go-to tool for maintaining connection and interaction during the quarantines and lockdowns around the country and the world alike.

The Zoom mean score of 3.91 post-adjustment was the highest mean score recorded, even though the future intentions overall indicated a significant increase across all technologies from the post-adjustment scores. This aligns with the issues discussed in the literature regarding the slow adoption of technology by educators in the classroom (Beyrouti, 2017; Kowalczyk, 2014; Martino & Odle, 2008; Wertz et al., 2014), regardless of the positive intentions and desirability. The significant increases in VTU from pre-COVID-19 to post-adjustment, and then again from post-adjustment to future intentions further support the idea of high desirability. However, a longitudinal design would best evaluate whether the intentions turn into actions when a forced transitional phenomenon (i.e., the COVID-19 pandemic) is not present.

Barriers

Perceived barriers were examined pre-COVID-19 to post-adjustment. The scores for perceived barriers were also positively skewed and leptokurtic, indicating educators only reported a few barriers to virtual technology use. However, the perception of barriers to technology integration decreased from pre-COVID-19 to post-adjustment, indicating that the forced transition to the virtual world allowed many barriers to be overcome. This could be due to institutional assistance and simply the need for educators to ‘find a way’ to keep providing learning experiences for their students. In both pre-COVID-19 and post-adjustment, ‘Cost/Funding’ remained the most common barrier. Due to the COVID-19 pandemic, many institutions were hurting financially, which may have made it difficult to purchase radiology-specific simulation technologies and software. Wood (2021) stated "for higher education institutions, the transition to virtual learning resulted in revenue loss and created more awareness around existing equity gaps" (p. 6). The Coronavirus Aid, Relief, and Economic Security Act (CARES) provided funding that was aimed at assisting with these issues in the educational setting, of which many schools took that opportunity to address. Furthermore, 'Student resistance to use technology' was the least reported barrier in both pre-COVID-19 and post-adjustment aligning with the ideas of the *iGeneration* as described by Rosen (2010) and Wertz et al. (2014) in which younger students coming to college are generally more comfortable and/or receptive to using technology than their older counterparts. The 'Other' category where the participants from the current sample were able to write in their perceived barriers supported findings from the literature and included time (Kopcha, 2012; Stoerger & Krieger, 2016; Wachira & Keengwe, 2010) administrative support/professional development (Ertmer et al., 2012; Kopcha, 2012; Kowalczyk, 2014; Stoerger & Krieger, 2016), 'tech fatigue' and/or effort (Nicol et al., 2018; Stoerger & Krieger, 2016) and access (Ertmer et al., 2012; Inan & Lowther, 2010; Ritzhaupt et al., 2012).

Continuance Intentions

The present study examined the relative contributions of the combination of behavior, perceived behavioral control, attitude, PEU, and PU in explaining CITU in radiologic technology educators. The results indicated that the combined and modified model, which incorporated scales from both the TPB and the TAM, resulted in a statistically significant overall regression equation for explaining CITU in radiologic technology educators. Specifically, the significant predictors of CITU in the current study included Attitude (Ajzen, 1991; Cheng & Chu, 2016;

Cheng et al., 2016; Cheng, 2019; Davis, 1989; Dalvi-Esfahani et al., 2020; Teo, 2011; Wu & Chen, 2017), Behavior (Cheng et al., 2016), and PU (Dalvi-Esfahani et al., 2020; Davis, 1989; Ma et al., 2005; Teo, 2011; Wu & Chen, 2017) which supports the findings in the literature. The findings indicated that radiologic technology educators with better attitudes towards virtual technology use, higher past behavior of technology use, and higher scores for perceived usefulness were more likely to report higher intentions for continued virtual technology use. Measuring past behavior as a predictor, as suggested in the literature (Ajzen, 1991; Cheng & Chu, 2016; Davis, 1989), was found to have significant effects on both attitude and CITU. The multiple regression and path analysis of the present study also found that PEU was significant in predicting PU but was not a significant predictor of CITU, a finding that also supports findings in the literature (Ma et al., 2005; Siegel, 2017; Wu & Chen, 2017).

Unlike the original TPB (Ajzen, 1991), the current study did not find PBC to be a significant predictor of intentions. This was also a divergence from the findings of Dalvi-Esfahani et al. (2020) who utilized a combined model design and found PBC to be a significant predictor of continuance intention. It was also in contrast to many other findings in the literature who found PBC to be an important construct of explaining and/or predicting intentions (Cheng et al., 2016; Cheng & Chu, 2016; Cheng, 2019). This could be due to the mediatory power of attitude that was presented in the findings of the current study and should be investigated more in future research. It could also be due to the forced and rapid nature of the transition that PBC did not play as significant a role in predicting CITU. This phenomenon of the COVID-19 pandemic was unique in the current study compared to prior literature, in that educators were forced into using virtual technologies and remote learning in a very rapid timeframe. This suggests that in situations of massive disruption, PBC may not be as stable a predictor of intentions.

The strongest predictor for CITU was attitude, suggesting that radiologic technology educators with higher scores for attitude (better attitudes towards virtual technology use) were more likely to exhibit intentions for continued use. Mumford and Dikilitaş (2020), Nicol et al. (2018), and Tondeur et al. (2017) all shared the same notion for attitude and technology integration. Alternatively, negative attitudes and/or pedagogical beliefs have the potential to serve as a barrier to technology integration as has been documented in the literature (Chen, 2008; Ertmer et al., 2012; Ertmer et al., 2015; Inan & Lowther, 2010; Kopcha, 2012; Lim and Chai, 2008; Tondeur et al., 2017). The current study found that Behavior, PBC, PEU, and PU all had significant effects on attitude. This aligned with the findings regarding the significant effects of PEU and PU on attitude (Cheng, 2019; Davis, 1989; Siegel, 2017; Teo, 2011) from the TAM but built upon the known relationships between scales of the TPB.

The results derived from this study found that the level of education obtained by radiologic technology educators had a significant effect on CITU but was not significant based on gender, title, geographical region, institution type, or program size. Participants with Associates degrees displayed significantly lower CITU scores than those with Master's and Doctoral/professional degrees, however, there was no significant difference in CITU between participants with Bachelor, Master, and Doctoral/professional degrees. CITU was negatively skewed and leptokurtic, which demonstrated that there was high desirability for future intentions of virtual technology use. This aligns with the thoughts of Beyrouti (2017) who suggested the great potential for technology use but slow response of implementation, Kowalczyk (2014) who highlighted the professional responsibility of educators to integrate current technology and practices in the didactic setting, and Wertz et al. (2014) who described educational technologies as a way to improve educational delivery and learning. Whether the intentions will result in actual behavior would be best evaluated through a longitudinal research design.

Pseudo-Qualitative

The findings from the pseudo-qualitative questions indicated that there were many challenges associated with the fast and forced transition to a virtual environment for radiologic technology educators. As recommended by the NBPTS (2020) the pseudo-qualitative component allowed us to reach out, listen to teachers, and allow for their voices to be heard regarding the challenges encountered as a result of the COVID-19 pandemic. Their perspectives provided additional information to supplement the quantitative findings and can be useful in providing recommendations for future policy.

Challenges. The challenges reported by educators from a pseudo-qualitative perspective demonstrated a variety of challenges encountered. Although the present sample was radiologic technology educators, many of the challenges discussed are likely applicable to educators in other disciplines. These included issues with student engagement, access/IT issues, student issues, time, lack of support, resistance, working from home, and aspects of health. The issues of student engagement, interaction, connection, and access/IT issues has been well documented in the literature in regard to virtual and distance education (De Silva, 2020; Ertmer et al., 2012; Goldstein, 2020; Inan & Lowther, 2010; Mumford & Dikilitaş, 2020; Ritzhaupt et al., 2012). There were numerous comments regarding the lack of engagement and difficulty teaching when students did not have their cameras on.

> *'Teaching large groups via zoom is the most difficult especially when students don't turn on their cameras. It is much harder to know if they are engaged or completely doing something else.'*

The challenges of working from home and/or the classroom and clinic environment were much more specific to the COVID-19 pandemic. With the majority of people working from home, many educators and students alike, who are also parents, found it difficult to work from home due to the distractions and additional need to help their own kids with homeschooling. In the present sample, this was found to be a challenge.

'Balancing work and home life responsibilities! Being a parent of young children in addition to my full time faculty role/responsibilities has been a lot to balance'

Time was another challenge in the present sample. Specifically, the very abrupt nature of the transition and lack of time created by the onset of the COVID-19 pandemic. Although the barrier of 'time' has been documented in the literature (Kopcha, 2012; Stoerger & Krieger, 2016; Wachira & Keengwe, 2011) the unique nature and sudden forced nature of the transition is new to the body of knowledge.

'TIME needed to create and implement it in courses. Converting traditional face to face courses to 100% online was frustrating for both instructors and students. Quality of education suffered as a result.'

'Learning the technology while simultaneously attempting to teach. There was no, and has not been, any time to really learn the technology before having to put courses together and hit the ground running.'

Prior to the COVID-19 pandemic, academic freedom has allowed educators to learn and integrate new technologies at their own pace. The forced transition undoubtedly accelerated the technological integrations in all aspects of educational delivery.

The health aspect was a particularly interesting challenge that was presented in the present sample. Not only were there challenges with getting COVID-19, but there were also mental and emotional issues that emerged. These mental and emotional issues were not exclusive to students, but to radiologic technology educators as well.

> *'Every single aspect of our job is harder for us and students. This issue goes way beyond teaching/classroom. This has been traumatic and want a break from technology.'*
>
> *'Keeping up student morale and being aware of their mental health statuses.'*
>
> *'Health and mental presence due to grief of patient or family members, social aspect of the life'*

These issues resound in recent literature that has emerged since the onset of the pandemic that explores the mental and emotional effects of the COVID-19 pandemic. Parrish (2020) described the 'next pandemic' and the mental health issues emerging as a result of the COVID-19 pandemic. It was stated that "the mental health pandemic that will follow will be far reaching and will last for years to come" (p. 485) and cited issues such as post-traumatic stress disorder, obsessive compulsive disorders, depression, and anxiety. In education specifically, Davis et al. (2021) discussed the implications of parental health and distance learning during the COVID-19 pandemic and suggested "besides improving distance learning via pedagogical interventions, schools and policymakers may also want to consider mental health resources for proxy educators" (p. 62). Furthermore, Lan et al. (2020) evaluated the psychological responses of students to the e-learning environment and the rapid nature of the transition due to the COVID-19 pandemic. The findings indicated that although anxiety was low in e-learning students, the rate of depression and stress was very high. An in-depth evaluation of these mental and emotional effects would be beneficial for future research in both a qualitative and longitudinal design.

Finally, some of the challenges that were presented were more specific to radiologic technology education, particularly the clinical environment and the need for psychomotor learning. As demonstrated by Rizzolo et al. (2010) clinical engagement is more effective in knowledge retention. Due to the clinical requirements as part of a radiologic technology program, a clinical component is necessary for program completion and board eligibility to be achieved. This has been emphasized by Spence (2019) as a necessity for preparing high-quality students who can transition into practice and provide high-quality care to patients in their communities. Due to the hospitals being overwhelmed and the additional liabilities associated with students, many hospitals suspended clinical rotations temporarily. This suspension resulted in many challenges and put many students behind in their clinical progress.

> *'The extended pause on clinical rotations at the onset of the pandemic. This put our 2020 cohort of learners behind in the number of hours of clinical education that they received, and their performance clinically has suffered.'*
>
> *'Finding new ways to continue application of clinical knowledge while students were not allowed in the clinical setting.'*

Future Intentions. The open-ended question for technology learned that will continue to be used in the future found differing perspectives. Some educators found it difficult to adopt certain technologies and did not have the desire to continue use once it was no longer necessary. Some had already been using technology before and/or teaching remotely already and did not experience any changes.

> *'Most of the courses were already fully online so the pandemic did not have a significant impact on how my courses are presented.'*

'None. I have not experienced any virtual technology that has improved learning, retention, or communication. It has all been necessary in this time of the virus, but it is not better. Rarely are things that are easier for us (educators) are equally better for student learning outcomes.'

The idea that the face-to-face classroom just simply cannot be replaced and/or is not as effective is supported by the literature (De Silva, 2020; Goldstein, 2020; Mumford & Dikilitaş, 2020). However, due to the rapidly changing environment and evolving needs of students does suggest that educators embrace new learning environments (Martino & Odle, 2008; Padmo et al., 2019; Wertz et al., 2014).

Alternatively, many found virtual technologies used to have great potential for use moving forward. The use of video conferencing technologies such as Zoom, Google Meet, and Microsoft teams was indicated as a good way to enhance communication, feedback, conduct meetings and restructure teacher time for the better, supporting findings in literature (Camera, 2020; Li et al., 2020; Levin & Schrum, 2013; McKnight et al., 2016).

'Zoom. I had never really needed to use Zoom before, but now see it as something to use all the time. I mean, why wouldn't we use it? It makes getting together so much easier. Meetings are easier because I don't physically have to drive somewhere to the meeting. Genius!'

The fact that so many educators were not already using LMS program such as canvas and blackboard was surprising, but aligns with the notion of educators being generally slow to respond to technologies for educational delivery (Beyrouti, 2017; Kowalczyk, 2014; Martino & Odle, 2008; Wertz et al., 2014).

'Canvas. A long-term goal for the program was to transfer all curriculum to an LMS. COVID -19 pandemic was the perfect time to implement and complete. We will continue to teach via Canvas for ease and convenience of use.'

In response to the challenge presented of student engagement, many educators cited interactive quizzes, polls, and games as helpful for interaction and improving engagement and reported their intentions for continued use of these in the classroom setting.

'I started using more quizzes and polls in my classes to see if students were following along. I will continue to do that even if we return face to face. Student feedback was positive'

The radiology-specific technologies that were reported included Ziltron, Shaderware, SIMTICS, ASRT Resources, and VR simulators. The use of VR simulation specifically has been cited in the literature as a beneficial way to provide education to radiologic technology students by increasing application of knowledge into the clinical setting (Akers, 2019; Gunn et al., 2017; Russell & Spence, 2018; Uppot et al., 2019; Vatansever & Demiryürek, 2019; Vatansever et al., 2019; Ward et al., 2018).

Rewards. The radiologic technology perspectives of the rewarding aspect of teaching during the COVID-19 pandemic was overwhelmingly inspiring. Although there were many who did not see any benefit and/or reward, there were also many who found silver linings in the form of student success, learning, connection, adaptation, and working from home.

The COVID-19 pandemic has impacted everyone in some way. It has been very difficult for many people. This was apparent in the radiologic technology educators who expressed they could not identify any rewarding aspects of the experience. It is important for these voices to be heard and considered in administrative decisions and policies.

‘Frankly, I am exhausted, I am working 3 x harder than before and I didn't think that was even possible!’

‘I cannot say teaching during the pandemic was very rewarding.’

‘Unsure if anything has been rewarding this year. It has been a VERY difficult year to teach.’

Alternatively, many educators were very proud of their students and their adaptability, resilience, and patience. The support these educators have for their students was apparent in the comments.

‘MY STUDENTS RALLIED AND THEY MADE IT!!! THEY WILL GRADUATE NEXT MONTH!!! TAKE THAT, COVID!!!’

‘I guess the most rewarding part was just having the opportunity to instill the importance of bravery and resilience in our field when we are needed most.’

There were many comments stating that their students would be graduating on time and/or that they did not fall behind as a result of the pandemic, which supports the findings of Aggarwal et al. (2017) who suggested that an online format has the potential to result in similar knowledge improvements compared to on-site formats.

A testament to the inquisitory nature of educators was the emerging theme of learning. Many radiologic technology educators in the current sample found it rewarding to learn and use new technologies in their classrooms.

‘It has challenged me to be creative and find different ways of engaging and teaching my students.’

‘Opportunity to advance skillset and create new meaningful content and teaching strategies’

'It has made me be more creative with my teaching methods and to try to reach students on a different level.'

Furthermore, the participants expressed their gratitude that they were able to continue teaching, when many people lost their jobs or where furloughed during the COVID-19 pandemic and/or when physical gathering was not possible (as discussed by Carriero et al., 2012). This was also exhibited in the form of relief that they were able to adapt and got through it.

'Still being able to teach and interact with students even though not in person.'

'We survived'

'Feeling accomplished in overcoming the challenges of implementing virtual technology instantaneously.'

Even though the challenges described lack of engagement and connection, the rewards also noted the different levels of connection that may not have been reached if it were not for the pandemic. This supports the findings of Cook et al. (2010) who suggested that interactivity, online discussion, and audio have the potential to improve satisfaction.

'learning from my students some of the new ways of communicating. I made an extra effort to develop a relationship with students.'

'More students have reached out for help and have scheduled virtual meetings.'

Lastly, the ability to work from home (although previously described as a challenge) was seen by many as a rewarding aspect. Advantages such as dress code, savings, personal schedules, family time, and lack of commute were mentioned.

'as I taught remotely more, I was able to spend more time with my family as I did not have the long commute so that made it nice for me personally.'

'the commute and dress code has been nice while working from home. :)'

'The time I got to spend at home and see what it was like to be a stay at home mom'.

This shifting of the student-teacher role and restructuring of teacher time has been documented in prior literature (McKnight et al., 2016; Levin & Schrum, 2013). However, educators in higher education, and radiologic technology specifically, working from home is a unique situation that was brought on during the COVID-19 pandemic. Further research would benefit from specifically evaluating the working from home environment for radiologic technology educators as it relates to student outcomes and program effectiveness measures such as retention, board examination pass rates, and graduation rates.

Pseudo-Qualitative Summary. The pseudo-qualitative questions demonstrated a large number of challenges and rewards. It also provided insight into the technologies that were learned as a result of the COVID-19 pandemic that educators plan to continue using in the future. It is important to anticipate the future landscape of radiologic technology education, supporting the notions provided by the OET (2017) and Jansen et al. (2019). When looking at the challenges and rewards specifically, it was interesting to note that there were similar phenomena. For example, student engagement and connection were cited as a challenge, but was also described as a reward. This was also the case with working from home. Although many educators described difficulties with distractions (for them and for students) while learning from home, many also described the convenience of working from home for meetings, office hours, advising, etc. and the work-life balance.

The current study aids in understanding the impact of the COVID-19 pandemic on the educational environment in radiologic technology programs as indicated by educator perceptions. This information is valuable in anticipating the future trajectory of the radiologic technology classroom, especially because of the worrisome lack of literature existing for radiologic technology as noted by Linaker (2015).

Conclusion:

Conclusions derived from the present study included:

1. The combination of Attitude, Behavior, PBC, PEU, PU in the regression equation was statistically significant in explaining CITU.
2. Attitude was the strongest predictor of CITU.
3. The mediatory power of Attitude was significantly shown through the relationships between Behavior, PBC, PEU, and PU.
4. The present sample of educators has demonstrated low virtual technology use, increased use because of COVID-19, and demonstrated significantly positive CITU.
5. Level of Education has a significant effect on CITU.
6. Cost/Funding was consistently the highest reported barrier to virtual technology use whereas Student Resistance to use Technology was consistently the lowest reported barrier.
7. Challenges, Rewards, and Future Intentions allowed pseudo-qualitative meaning to be attributed to the quantitative findings.

Recommendations:

Based on the conclusions of the present study, the following recommendations for future research were made:

1. Both the TPB and TAM theoretical models include predictions for actual behavior. Due to the nature of the study, future intentions were measured, which the literature supports as a stable indicator for actual behavior (Ajzen, 1991; Cheng et al., 2016; Cheng, 2019;

Dalvi-Esfahani et al., 2020; Davis, 1989). The first recommendation is that a longitudinal design should be conducted to follow-up with this sample population to compare the CITU measured in the present study and its explanatory power for actual future behavior. Furthermore, Ajzen (1991) suggested that PBC has a direct relationship with predicting actual behavior (mediating intention) and should therefore be investigated in the longitudinal design.

2. Future research should follow up on the population of radiologic technology educators using a longitudinal design to better understand the predictive versus explanatory power of CITU on actual use three to five years past the pandemic.
3. A true qualitative study utilizing focus groups would help to better understand the qualitative element and psychosocial effects of the COVID-19 pandemic on radiologic technology educators.
4. A qualitative study of radiologic technology students would also provide valuable information on the psychosocial effects of the COVID-19 pandemic and add the student perspective.
5. Specific evaluation of mental and emotional health effects of the COVID-19 pandemic on students and educators alike should be conducted.
6. The perceptions of radiologic technology educators should be acknowledged in future administrative decisions and policies.
7. The PCA found that attitude was cross loaded across several components, indicating the potential for other latent variables. Future research would benefit from further evaluation of the psychometric properties of attitude.

References

Aarts, S., Cornelis, F., Zevenboom, Y., Brokken, P., Griend, N., Spoorenberg, M., … Wouters, E. (2017). The opinions of radiographers, nuclear medicine technologists and radiation therapists regarding technology in health care: A qualitative study. *Journal of Medical Radiation Sciences, 64*(1), 3–9.

Aggarwal, R., Gupte, N., Kass, N., Taylor, H., Ali, J., Bhan, A., Aggarwal, A., Sisson, S. D., Kanchanaraksa, S., McKenzie-White, J., McGready, J., Miotti, P., & Bollinger, R. C. (2011). A comparison of online versus on-site training in health research methodology: A randomized study. *BMC Medical Education, 11*, 37. https://doi-org.spot.lib.auburn.edu/10.1186/1472-6920-11-37

Akers, J. (2019). Web 2.0 for the radiology classroom. *Radiologic Technology, 91*(1), 79-82.

American Registry of Radiologic Technologists, ARRT Board of Trustees. (2016, February 26). *Updated Radiography Task Inventory, Clinical Requirements and Content Specifications Effective January 1, 2017* [Press release].

American Society of Radiologic Technologists. (2019). *ASRT Practice Standards for Medical Imaging and Radiation Therapy* (effective June 2019). https://www.asrt.org/docs/default-source/practice-standards/asrt-practice-standards-for-medical-imaging-and-radiation-therapy.pdf?sfvrsn=de532d0_14

American Society of Radiologic Technologists. (2020). *2020 fiscal year annual report: Waves of the future.* https://www.asrt.org/docs/default-source/about/annual-report/asrt-annual-report-2020.pdf?sfvrsn=6d90dd0_8

Applegate, J.S. (2010). The role of mobile electronic devices in radiographer education. *Radiologic Technology, 82*(2), 124–131.

ARRT Find an Educational Program. (n.d.). https://www.arrt.org/about-the-profession/learn-about-the-profession/recognized-educational-programs

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179–211. https://doi-org.spot.lib.auburn.edu/10.1016/0749-5978(91)90020-T

Ajzen, I. (2019). *Theory of planned behavior diagram*. University of Massachusetts Amherst. https://people.umass.edu/aizen/tpb.diag.html#null-link

Arnett, T. (2019). Tech unlocks teachers' capacity: Software is a teaching tool, not a teacher replacement. *Learning Professional, 40*(4), 32–35.

Beyrouti, N. (2017). Digital technology management and educational innovation: The marketability and employability of the higher education degrees. *Journal of Developing Areas, 51*(1), 391–400.

Biasutti, M. (2011). The student experience of a collaborative e-learning university module. *Computers and Education, 57*(3), 1865–1875.

Biden, S., & Ziden, A. (2013). Adoption and application of mobile learning in the education industry. *Procedia – Social and Behavioural Sciences, 90*(inCULT 2012). 720-729

Binder, J., Krautz, C., Engel, K., Grützmann, R., Fellner, F. A., Burger, P. H. M., & Scholz, M. (2019). Leveraging medical imaging for medical education — A cinematic rendering-featured lecture. *Annals of Anatomy, 222*, 159–165. https://doi-org.spot.lib.auburn.edu/10.1016/j.aanat.2018.12.004

Breed, T. (2014). Philosophy of leadership in radiology education. *Radiologic Technology, 86*(2), 217–219.

Brynjolfsson, E., & McAfee, A. (2014). The second machine age: Work, progress, and prosperity in a time of brilliant technologies (1st ed.). W.W. Norton & Company

Callaway, W. J. (2020). *Introduction to radiologic technology* (8th ed.). Elsevier.

Camera, L. (2020). How School Will Change When Kids Return to Classrooms. *U.S. News & World Report - The Report*, C11.

Carriero, A., Bonomo, L., Calliada, F., Campioni, P., Colosimo, C., Cotroneo, A., Cova, M., Ettorre, G. C., Fugazzola, C., Garlaschi, G., Macarini, L., Mascalchi, M., Meloni, G. B., Midiri, M., Mucelli, R. P., Rossi, C., Sironi, S., Torricelli, P., Beomonte, B. Z., … Zuiani, C. (2012). E-learning in radiology: An Italian multicentre experience. *European Journal of Radiology, 81*(12), 3936–3941. https://doi-org.spot.lib.auburn.edu/10.1016/j.ejrad.2012.07.007

Chen, C. H. (2008). Why do teachers not practice what they believe regarding technology integration? *Journal of Educational Research, 102*(1), 65–75.

Cheng, E. W. L. (2019). Choosing between the theory of planned behavior (TPB) and the technology acceptance model (TAM). *Educational Technology Research & Development*, *67*(1), 21–37. https://doi-org.spot.lib.auburn.edu/10.1007/s11423-018-9598-6

Cheng, E. Chu, S. (2016). Students' online collaborative intention for group projects: Evidence from an extended version of the theory of planned behaviour. *International Journal of Psychology, 51*(4), 296–300.

Cheng, E. W. L., Chu, S. K. W., & Ma, C. S. M. (2016). Tertiary students' intention to e-collaborate for group projects: Exploring the missing link from an extended theory of planned behavior model. *British Journal of Educational Technology, 47*(5), 958–969.

Cherry, S. J., & Flora, B. H. (2017). Radiography faculty engaged in online education: Perceptions of effectiveness, satisfaction, and technological self-efficacy. *Radiologic Technology, 88*(3), 249–262.

Chia, H. N., & Wu, B. M. (2015). Recent advances in 3D printing of biomaterials. *Journal of Biological Engineering, 9*(4).

Chockley, K., & Emanuel, E. (2016). The end of radiology? Three threats to the future practice of radiology. *Journal of the American College of Radiology, 13*(12), 1415-1420. doi:10.1016/j.jacr.2016.07.010

Collinsworth, A., & Clark, K. R. (2017). Using 3D printed models in radiologic science education. *Radiologic Science & Education, 22*(1), 23–28.

Cook, D. A., Levinson, A. J., Garside, S., Dupras, D. M., Erwin, P. J., & Montori, V. M. (2010). Instructional design variations in internet-based learning for health professions education: A systematic review and meta-analysis. *Academic Medicine, 85*(5), 909–922. https://doi-org.spot.lib.auburn.edu/10.1097/ACM.0b013e3181d6c319

Corredor, J., & Olarte, F. A. (2019). Effects of school reform factors on students' acceptance of technology. *Journal of Educational Change, 20*(4), 447–468.

Courtois, C., Montrieux, H., De Grove, F., Raes, A., De Marez, L., & Schellens, T. (2014). Student acceptance of tablet devices in secondary education: A three-wave longitudinal cross-lagged case study. *Computers in Human Behavior, 35*, 278–286.

Creswell, J. W., & Guetterman, T. C. (2018). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (6th ed.). Pearson Education.

Dalvi-Esfahani, M., Wai Leong, L., Ibrahim, O., & Nilashi, M. (2020). Explaining students' continuance intention to use mobile web 2.0 learning and their perceived learning: An integrated approach. *Journal of Educational Computing Research, 57*(8), 1956–2005.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319. doi:10.2307/249008

Davis, C. R., Grooms, J., Ortega, A., Rubalcaba, J. A.-A., & Vargas, E. (2021). Distance learning and parental mental health during COVID-19. *Educational Researcher*, *50*(1), 61–64. https://doi-org.spot.lib.auburn.edu/10.3102/0013189X20978806

De Silva, D. V. M. (2020). Developing self-regulated learning skills in university students studying in the open and distance learning environment using the KWL method. *Journal of Learning for Development*, *7*(2), 204–217.

Digital Promise. (2014). *Digital promise: Accelerating innovation in education*. Retrieved from http://www.digitalpromise.org

Dündar, H., & Akçayır, M. (2014). Implementing tablet PCs in schools: Students' attitudes and opinions. *Computers in Human Behavior, 32*, 40–46.

Durán-Guerrero, J. A., Ulloa-Guerrero, L. H., & Salazar-Díaz, L. C. (2019). Blended learning: An effective methodology for teaching radiology to medical students. *Revista Facultad de Medicina de La Universidad Nacional de Colombia*, *67*(2), 273–277. https://doi-org.hal.weber.edu/10.15446/revfacmed.v67n2.69862

Dyment, J., & Downing, J. (2018). "There was nowhere to hide...": The surprising discovery of how weekly web conferences facilitated engagement for online initial teacher education students. *Asia-Pacific Journal of Teacher Education*, *46*(4), 399–418. https://doi-org.spot.lib.auburn.edu/10.1080/1359866X.2018.1444140

Eggers, R.M. & Jones, C.M. (1998). Practical considerations for conducting delphi studies: The oracle enters a new age. *Educational Research Quarterly, 21*(3), 53-66.

Ertmer, P., Ottenbreit-Leftwich, A., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education, 59*(2), 423–435.

Ertmer, P., Ottenbreit-Leftwich, A., & Tondeur, J. (2015). Teacher beliefs and uses of technology to support 21st century teaching and learning. In H. R. Fives & M. Gill (Eds.), International handbook of research on teacher beliefs (pp. 403–418). Routledge, Taylor & Francis.

Estai, M., & Bunt, S. (2016). Best teaching practices in anatomy education: A critical review. *Annals of Anatomy*, 208, 151–157. https://doi-org.spot.lib.auburn.edu/10.1016/j.aanat.2016.02.010

Fishbein M, & Ajzen I. (2005). Theory-based behavior change interventions: comments on Hobbis and Sutton. *Journal of Health Psychology, 10*(1), 27–31. https://doi-org.spot.lib.auburn.edu/10.1177/1359105305048552

Fisher, K., & Koren, A. (2007). Palm perspectives: The use of personal digital assistances in nursing clinical education: A qualitative study. *Online Journal of Nursing Informatics 11*(2).

Forbes, D., & Khoo, E. (2015). Voice over distance: A case of podcasting for learning in online teacher education. *Distance Education, 36*(3), 335–350. https://doi-org.spot.lib.auburn.edu/10.1080/01587919.2015.1084074

George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference. 11.0 update* (4th ed.). Allyn & Bacon.

Gillan, C., Wiljer, D., Harnett, N., Briggs, K., & Catton, P. (2010). Changing stress while stressing change: The role of interprofessional education in mediating stress in the introduction of a transformative technology. *Journal of Interprofessional Care, 24*(6), 710-721.

Goldstein, D. (2020, June 5). Research shows students falling months behind during virus disruptions. *The New York Times*. https://www.nytimes.com/2020/06/05/us/coronavirus-education-lost-learning.html

Gordon, H. (2014). *The history and growth of career and technical education in America* (4th ed.). Waveland Press.

Gunn, T., Jones, L., Bridge, P., Rowntree, P., & Nissen, L. (2017). The use of virtual reality simulation to improve technical skill in the undergraduate medical imaging student. *Interactive Learning Environments, 26*(5), 613-620.

Gurley, L. T., & Callaway, W. J. (2011). *Introduction to radiologic technology* (7th ed.). Elsevier/Mosby.

Heptonstall, N. B., Ali, T., & Mankad, K. (2016). Integrating radiology and anatomy teaching in medical education in the UK—The evidence, current trends, and future scope. *Academic Radiology, 23*(4), 521–526. https://doi-org.spot.lib.auburn.edu/10.1016/j.acra.2015.12.010

Hyde, E., & Strudwick, R. (2017). How prepared are students for the workplace? *Synergy: Imaging & Therapy Practice*, 5–11. Retrieved from https://hal.weber.edu/login?url=https://search-ebscohost-com.hal.weber.edu/login.aspx?direct=true&db=ccm&AN=125444229&site=ehost-live

Inan, F., & Lowther, D. (2010). Factors affecting technology integration in K-12 classrooms: a path model. *Educational Technology Research and Development*, *58*(2), 137.

International Society for Technology in Education. (2019). ISTE Standards. Retrieved from https://www.iste.org/standards

Jansen, A. J., White, L. A., Dhuey, E., Foster, D., & Perlman, M. (2019). Training and skills development policy options for the changing world of work. *Canadian Public Policy, 45*(4), 460–482.

Kopcha, T. J. (2012). Teachers' perceptions of the barriers to technology integration and practices with technology under situated professional development. *Computers & Education*, *59*(4), 1109–1121.

Kowalczyk, N. K. (2014). Perceived barriers to online education by radiologic science educators. *Radiologic Technology, 85*(5), 486–493.

Lan, H. T. Q., Long, N. T., & Hanh, N. V. (2020). Validation of depression, anxiety and stress scales (DASS-21): Immediate psychological responses of students in the e-learning environment. *International Journal of Higher Education, 9*(5), 125–133.

Leading Education by Advancing Digital Commission (LEAD). (2013). *Paving a path forward for digital learning in the United States.* Retrieved from: http://www.leadcommission.org

Levin, B., & Schrum, L. (2013). Using systems thinking to leverage technology for school improvement: Lessons learned from award-winning secondary schools/districts. *Journal of Research on Technology in Education*, *46*(1), 29–51. https://doi-org.spot.lib.auburn.edu/10.1080/15391523.2013.10782612

Li, C. H., Rajamohan, A. G., Acharya, P. T., Liu, C.-S. J., Patel, V., Go, J. L., Kim, P. E., & Acharya, J. (2020). Virtual Read-Out: Radiology education for the 21st century during the COVID-19 pandemic. *Academic Radiology, 27*(6), 872–881. https://doi-org.spot.lib.auburn.edu/10.1016/j.acra.2020.04.028

Lim, C. P., & Chai, C. S. (2008). Teachers' pedagogical beliefs and their planning and conduct of computer mediated classroom lesson. *British Journal of Educational Technology, 39*(5), 807–828.

Linaker, K. L. (2015). Pedagogical approaches to diagnostic imaging education: A narrative review of the literature. *Journal of Chiropractic Humanities, 22*(1), 9–16. https://doi-org.spot.lib.auburn.edu/10.1016/j.echu.2015.09.005

Louhab, F. E., Bahnasse, A., & Talea, M. (2018). Considering mobile device constraints and context-awareness in adaptive mobile learning for flipped classroom. *Education and Information Technologies, 23*(6), 2607–2632.

Lowther, D., Inan, F., Daniel Strahl, J., & Ross, S. (2008). Does technology integration "work" when key barriers are removed? *Educational Media International, 45*(3), 195–213. https://doi-org.spot.lib.auburn.edu/10.1080/09523980802284317

Ma, W., Andersson, R., Streith, K. (2005). Examining user acceptance of computer technology: An empirical study of student teachers. *Journal of Computer Assisted Learning 21*, 387-395.

Macko, M., Szczepanski, Z., Mikolajewska, E., Nowak, J., & Mikolajewski, D. (2017). Repository of 3D images for education and everyday clinical practice purposes. *Bio-Algorithms & Med-Systems, 13*(2), 111.

Martino S, & Odle T. (2008). New instructional technology in radiologic science education. *Radiation Therapist, 17*(2), 128–135.

McKnight, K., O'Malley, K., Ruzic, R., Horsley, M. K., Franey, J. J., & Bassett, K. (2016). Teaching in a digital age: How educators use technology to improve student learning. *Journal of Research on Technology in Education, 48*(3), 194–211. doi:10.1080/15391523.2016.1175856

McNulty, J. A., Sonntag, B., & Sinacore, J. M. (2009). Evaluation of computer-aided instruction in a gross anatomy course: A six-year study. *Anatomical Sciences Education*, *2*(1), 2–8.

Metcalf, K. L., & Haugen, K. (2018). Engaging students online. *Radiologic Technology, 90*(2), 192–195.

Moran, M., Hawkes, M., & Gayar, O. E. (2010). Tablet personal computer integration in higher education: Applying the unified theory of acceptance and use technology model to understand supporting factors. *Journal of Educational Computing Research*, *42*(1), 79–101.

Mumford, S., & Dikilitaş, K. (2020). Pre-service language teachers reflection development through online interaction in a hybrid learning course. *Computers & Education, 144*. https://doi-org.spot.lib.auburn.edu/10.1016/j.compedu.2019.103706

National Board for Professional Teaching Standards. (2014). *Career and Technical Education Standards* [Policy Brief]. http://www.nbpts.org/wp-content/uploads/EAYA-CTE.pdf.

National Board for Professional Teaching Standards. (2020). *Teacher leadership in uncertain times: Recommendations from board-certified teachers for school, district and state leaders* [Issue Brief]. https://www.nbpts.org/wp-content/uploads/NBPTS-Report-Covid_mastercopy_Final-High-Quality.pdf

Nicol, A. A. M., Owens, S. M., Le Coze, S. S. C. L., MacIntyre, A., & Eastwood, C. (2018). Comparison of high-technology active learning and low-technology active learning classrooms. *Active Learning in Higher Education, 19*(3), 253–265. https://doi.org/10.1177/1469787417731176

Office of Educational Technology - US Department of Education. (2017). *Reimagining the role of technology in education. 2017 National Education Technology Plan.* Retrieved from https://tech.ed.gov/files/2017/01/Higher-Ed-NETP.pdf

Ogura, A., Hayashi, N., Negishi, T., & Watanabe, H. (2018). Effectiveness of an e-learning platform for image interpretation education of medical staff and students. *Journal of Digital Imaging, 31*(5), 622–627. https://doi-org.hal.weber.edu/10.1007/s10278-018-0095-6

Padmo, D., Idrus, O., & Ardiasih, L. S. (2019). The utilization of mobile devices for improving access to online learning for distance education's students. *Turkish Online Journal of Distance Education, 20*(2), 147–161.

Parrish, E. (2020). The next pandemic: COVID-19 mental health pandemic. *Perspectives in Psychiatric Care, 56*(3), 485. https://doi-org.spot.lib.auburn.edu/10.1111/ppc.12571

Privitera, G. J., & Ahlgrim-Delzell, L. (2019). *Research methods for education*. SAGE Publications, Inc.

Pyörälä, E., Mäenpää, S., Heinonen, L., Folger, D., Masalin, T., & Hervonen, H. (2019). The art of note taking with mobile devices in medical education. *BMC Medical Education, 19*(1), 96.

Quan-Baffour, K. P., & Arko-Achemfuor, A. (2018). Quality assurance through experiential learning in a distance education context: The views of major stakeholders. *Turkish Online Journal of Distance Education, 19*(3), 15–23.

Riedel, C. (2014). 10 Major Technology Trends in Education. Retrieved from https://thejournal.com/articles/2014/02/03/10-major-technology-trends-in-education.aspx.

Ritzhaupt, A. D., Dawson, K., & Cavanaugh, C. (2012). An investigation of factors influencing student use of technology in K-12 classrooms using path analysis. *Journal of Educational Computing Research, 46*(3), 229–254.

Rizzolo, L. J., Rando, W. C., O'Brien, M. K., Haims, A. H., Abrahams, J. J., & Stewart, W. B. (2010). Design, implementation, and evaluation of an innovative anatomy course. *Anatomical Sciences Education, 3*(3), 109–120.

Romans, L. E. (2019). *Computed tomography for technologists: A comprehensive text*. (2nd ed.) Wollters Kluwer Health/Lippincott Williams & Wilkins.

Rosen, L. D., Carrier, L. M., & Cheever, N. A. (2010). *Rewired: Understanding the iGeneration and the way they learn*. Palgrave Macmillan.

Rural Development. (n.d.) *Distance learning & telemedicine grants.* U.S. Department of Agriculture. https://www.rd.usda.gov/programs-services/distance-learning-telemedicine-grants

Russell, A., & Spence, B. (2018). Virtual simulation in radiologic science education. *Radiologic Technology, 90*(2), 169–171.

Seeram, E. (2019). *Digital radiography: Physical principles and quality control* (2nd ed.). Springer Nature Singapore Pte Ltd.

Siegel, D., Acharya, P., & Sivo, S. (2017). Extending the technology acceptance model to improve usage & decrease resistance toward a new technology by faculty in higher education. *Journal of Technology Studies, 43*(2), 58–69.

Spence, B. (2019). Practical applications in radiography education. *Radiologic Technology, 90*(4), 369–386.

Stoerger, S., & Krieger, D. (2016). Transforming a large-lecture course into an active, engaging, and collaborative learning environment. *Education for Information, 32*(1), 11–26. https://doi-org.spot.lib.auburn.edu/10.3233/EFI-150967

Tam, M. D. B. S., Hart, A. R., Williams, S. M., Holland, R., Heylings, D., & Leinster, S. (2010). Evaluation of a computer program ('disect') to consolidate anatomy knowledge: A randomised-controlled trial. *Medical Teacher*, *32*(3), e138–e142. https://doi-org.spot.lib.auburn.edu/10.3109/01421590903144110

Teo, T. (2011). Factors influencing teachers' intention to use technology: Model development and test. *Computers & Education, 57*(4), 2432-2440.

Tondeur, J., Braak, J., Ertmer, P., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review of qualitative evidence. *Educational Technology Research and Development, 65*(3), 555–575. doi:10.1007/s11423-016-9481-2

Tyree, E. (2020, March 13). AT&T, Verizon waiving fees, Comcast offering free internet amid coronavirus outbreak. *WSET ABC 13 News*. https://wset.com/news/coronavirus/att-verizon-waiving-fees-comcast-offering-free-internet-amid-coronavirus-outbreak

Uppot, R. N., Laguna, B., McCarthy, C. J., De Novi, G., Phelps, A., Siegel, E., & Courtier, J. (2019). Implementing virtual and augmented reality tools for radiology education and training, communication, and clinical care. *Radiology, 291*(3), 570–580. https://doi-org.spot.lib.auburn.edu/10.1148/radiol.2019182210

U.S. Department of Education (USDOE). (2010). *Office of Planning, Evaluation and Policy Development, ESEA Blueprint for Reform*, Washington, DC.

Vaccarezza, M., & Papa, V. (2015). 3D printing: a valuable resource in human anatomy education. *Anatomical Science International, 90*(1), 64–65. https://doi.org/10.1007/s12565-014-0257-7

Valler-Jones, T., Meechan, R., & Jones, H. (2011). Simulated practice--a panacea for health education? *British Journal of Nursing (Mark Allen Publishing), 20*(10), 628–631.

Van Wyk, M. M. (2019). Flipping the economics class in a teacher education course. *Technology, Knowledge and Learning*, *24*(3), 373–399.

Vatansever, A., & Demiryürek, D. (2019). Teaching pelvis anatomy using hologramic images and three-dimensional printed model. *Anatomy: International Journal of Experimental & Clinical Anatomy, 13*(Supplement2), S124.

Vatansever, D., Demiryürek, D., & Özcan, E. (2019). Teaching brain anatomy using hologramic images. *Anatomy: International Journal of Experimental & Clinical Anatomy, 13*(Supplement2), S162–S163.

Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. *MIS Quarterly, 36*, 157–178.

Ventola, C. L. (2014). Medical applications for 3D printing: Current and projected uses. *Pharmacy and Therapeutics, 39*(10), 704-711.

Wachira, P., & Keengwe, J. (2011). Technology integration barriers: Urban school mathematics teachers perspectives. *Journal of Science Education & Technology, 20*(1), 17–25. https://doi-org.spot.lib.auburn.edu/10.1007/s10956-010-9230-y

Ward, T. M., Wertz, C. I., & Mickelsen, W. (2018). Anatomage table enhances radiologic technology education. *Radiologic Technology, 89*(3), 304–306.

Wallace, S., Clark, M., White, J. (2012). ‘It’s on my iPhone’: Attitudes to the use of mobile computing devices in medical education: A mixed-methods study. *BMJ Open 2*(4).

Wertz, C. I., Hobbs, D. L., & Mickelsen, W. (2014). Integrating technology into radiologic science education. *Radiologic Technology, 86*(1), 23–31.

Wood, S. (2021). How did institutions spend COVID-19 relief funding? *Diverse: Issues in Higher Education, 38*(4), 6.

Wu, B., & Chen, X. (2017). Continuance intention to use MOOCs: Integrating the technology acceptance model (TAM) and task technology fit (TTF) model. *Computers in Human Behavior, 67*, 221–232. https://doi-org.spot.lib.auburn.edu/10.1016/j.chb.2016.10.028

Yildiz, M., & Erdem, M. (2018). An investigation on instructors’ knowledge, belief and practices towards distance education. *Malaysian Online Journal of Educational Technology, 6*(2), 1–20.

APPENDIX

Appendix A – Permission to use TAM model

Appendix B – ACERT and ASRT Permission

Appendix C – Survey Instrument: Educational Virtual Technology Use in the COVID-19 Pandemic

Appendix D – IRB Application Approval

Appendix E – Information Letter

Appendix F – Email Recruitment Letter

APPENDIX A

Permission to use TAM model

RE: TAM Figure Permission

Davis, Fred <Fred.Davis@ttu.edu>
Fri 10/23/2020 3:00 PM
To: Taylor Ward <tcw0022@auburn.edu>

You have my permission to use the TAM diagram as a figure in your dissertation.
Best wishes
Fred Davis

From: Taylor Ward <tcw0022@auburn.edu>
Sent: Thursday, October 22, 2020 10:42 PM
To: Davis, Fred <Fred.Davis@ttu.edu>
Subject: TAM Figure Permission

Dr. Davis,

Hello! My name is Taylor Ward, and I am a doctoral student at Auburn University. I am currently in the writing state of my dissertation and the TAM theoretical framework fits well with my topic: Virtual Technology use in Radiologic Technology Classrooms: The Educational Impact of the COVID-19 Pandemic.

I would like to use the TAM diagram as a figure in my dissertation. I am writing you to ask permission to include the diagram in my dissertation. Please let me know if you grant or deny permission.

Thank you for your consideration and I look forward to hearing from you!

Taylor

APPENDIX B

ACERT and ASRT Permission

ACERT

I did check with the ACERT board and we can distribute your survey link to the institutional members. We have 60 institutional members and could request they forward the survey if you need us to.
IDo you have a site authorization form or should I write a letter? Let me know if you want to follow this through.

I am in about the same spot as you for dissertation. I am working on proposal approval and hoping to start my surveys in January (optimistically).
Good luck!
Mary
...
--
Mary C. Doucette, M.S., R.R.A, R.T.(R)(M)(MR)(CT)(QM)
Great Basin College
Dean of Arts and Sciences

ASRT

Michael Jennings <MJennings@asrt.org> Tue, Oct 20, 1:11 PM
to me, John

Hi Taylor,

We will need to see a copy of the survey, the IRB approval letter (if applicable), and the email cover letter with the actual link to the online survey. From there, we will review all of these items to make sure that it adheres to the ASRT's basic guidelines for sending out emails to our membership. If approved, we will draw a random sample of our members and email your cover letter with the survey link to the sample. I'm not sure exactly how many educators we have in our database, right off hand, but we could communicate about the sample once the rest of the pieces are in place.

We also ask for all researchers to view this short PowerPoint located on our website that covers the basic requirements and guidelines:

http://media.mycrowdwisdom.com.s3.amazonaws.com/asrt/RSH_SurveyRequest_Guidelines.mp4

Thanks,

Michael Jennings
Senior Research Analyst
800-444-2778, Ext. 1295
505-298-4500, Ext. 1295

APPENDIX C

Survey Instrument: Educational Virtual Technology Use in the COVID-19 Pandemic

<u>Educational Virtual Technology Use in the COVID-19 Pandemic Survey</u>

Demographic Questions

The following questions are in regard to your academic teaching experience and the demographic information about your program/institution.

1. **What is your age?**
   ____
2. **What is your gender?**
   □ Male
   □ Female
   □ Other. Please specify: ________
   □ Prefer not to answer
3. **How many years of experience do you have as an educator in your current field?**
   ____
4. **How many years where you in clinical practice (prior to being an educator)? If not applicable, please put N/A**
   ____
5. **What is your title?**
   □ Adjunct
   □ Instructor
   □ Instructor
   □ Assistant Professor
   □ Associate Professor
   □ Professor
   □ Other: Please Specify: __________
6. **What is your highest level of education?**
   □ Certificate
   □ Associate degree
   □ Bachelor's Degree
   □ Master's Degree
   □ Doctoral/Professional Degree (Ph.D., Ed.D., M.D.)
   □ Specialist
7. **In what region of the United States is your school located?**
   □ Northwest
   □ Southwest
   □ Midwest
   □ Northeast
   □ Southeast
8. **What is the type of institution at which you teach?**
   □ Community/Junior College
   □ Vocational/Technical School
   □ 4-year University
   □ Military School
   □ Other. Please Specify: __________
9. **For your current program, what is the level of degree earned upon completion of the program? (check all that apply)**
   □ Certificate
   □ Associate of Applied Science
   □ Associates
   □ Baccalaureate
   □ Masters
   □ Doctorate
   □ Other. Specify: ___

Continue to next page

10. **What is the approximate size of your educational program?**

- □ 50 or less students
- □ 50-100 students
- □ 100-200 students
- □ 200+ students

11. **In which modalities are you certified? (check all that apply)**

- □ Bone Densitometry (BD)
- □ Breast Sonography (BS)
- □ Cardiac Interventional (CI)
- □ Cardiovascular Interventional (CV)
- □ Computed Tomography (CT)
- □ Magnetic Resonance (MR)
- □ Mammography (M)
- □ Nuclear Medicine (N)
- □ Quality Management (QM)
- □ Radiation Therapy (T)
- □ Radiography (R)
- □ Radiologist Assistant (R.R.A)
- □ Sonography (S) or SDMS
- □ Vascular Interventional (VI)
- □ Vascular Sonography (VS)
- □ Other. Please Specify: __________

Continue to next page

Pre-COVID-19 Virtual Technology Use

The following questions are in regard to your virtual technology use PRIOR to the COVID-19 Pandemic.

Please respond to your degree of use for the following virtual technologies used in one or more of your courses PRIOR to the COVID-19 Pandemic

Virtual Technology	**Degree of Use**				
	Never	**Rarely**	**Sometimes**	**Often**	**Always**
12. Zoom	☐	☐	☐	☐	☐
13. Google Hangout	☐	☐	☐	☐	☐
14. Kaltura	☐	☐	☐	☐	☐
15. Voiceover PPT	☐	☐	☐	☐	☐
16. Prezi	☐	☐	☐	☐	☐
17. Canvas	☐	☐	☐	☐	☐
18. Anatomage Table	☐	☐	☐	☐	☐
19. Shaderware	☐	☐	☐	☐	☐
20. Screencast-o-matic	☐	☐	☐	☐	☐
21. PB works	☐	☐	☐	☐	☐
22. Diigo	☐	☐	☐	☐	☐
23. Mindomo	☐	☐	☐	☐	☐
24. Quizziz	☐	☐	☐	☐	☐
25. Meducoach	☐	☐	☐	☐	☐
26. ASRT Clinical Refresher Modules	☐	☐	☐	☐	☐
27. YuJa Videos	☐	☐	☐	☐	☐
28. Evernote	☐	☐	☐	☐	☐
29. Panopto	☐	☐	☐	☐	☐
30. Big Blue Button	☐	☐	☐	☐	☐
31. RadTechBootcamp	☐	☐	☐	☐	☐
32. ASRT Ziltron Simulators	☐	☐	☐	☐	☐
33. ASRT Roadmaps	☐	☐	☐	☐	☐
34. Augmented Reality (AR)	☐	☐	☐	☐	☐
35. Virtual Reality (VR)	☐	☐	☐	☐	☐
36. Kahoot	☐	☐	☐	☐	☐
37. VoiceThread	☐	☐	☐	☐	☐
38. Piktochart	☐	☐	☐	☐	☐
39. Poll Everywhere	☐	☐	☐	☐	☐
40. Other Lecture Capture Technology. Please specify:___	☐	☐	☐	☐	☐
41. Other Virtual Simulation Software: Please Specify: ____	☐	☐	☐	☐	☐
42. Other: Please specify: _______	☐	☐	☐	☐	☐

Continue to next page

43. What barriers do you think may be preventing you or your program from integrating virtual technology in the classroom? (Check All That Apply)

□ Cost/Funding
□ Availability of space
□ Lack of professional development opportunities
□ Hard to keep up with the rapid technological advancements
□ Faculty are resisting the use of new equipment or are not using what you currently have
□ Student resistance to use technology
□ Other: please specify: ________________
□ N/A

Continue to next page

Post-Adjustment Virtual Technology Use

The following questions are in regard to your virtual technology use AFTER to the COVID-19 Pandemic began.

For the following questions, please mark the option that most accurately relates to you CURRENTLY.

Please respond to the degree of use for the following virtual technologies you are CURRENTLY using in one or more of your courses.

Virtual Technology	**Degree of Use** **Never**	**Rarely**	**Sometimes**	**Often**	**Always**
44. Zoom	☐	☐	☐	☐	☐
45. Google Hangout	☐	☐	☐	☐	☐
46. Kaltura	☐	☐	☐	☐	☐
47. Voiceover PPT	☐	☐	☐	☐	☐
48. Prezi	☐	☐	☐	☐	☐
49. Canvas	☐	☐	☐	☐	☐
50. Anatomage Table	☐	☐	☐	☐	☐
51. Shaderware	☐	☐	☐	☐	☐
52. Screencast-o-matic	☐	☐	☐	☐	☐
53. PB works	☐	☐	☐	☐	☐
54. Diigo	☐	☐	☐	☐	☐
55. Mindomo	☐	☐	☐	☐	☐
56. Quizziz	☐	☐	☐	☐	☐
57. Meducoach	☐	☐	☐	☐	☐
58. ASRT Clinical Refresher Modules	☐	☐	☐	☐	☐
59. YuJa Videos	☐	☐	☐	☐	☐
60. Evernote	☐	☐	☐	☐	☐
61. Panopto	☐	☐	☐	☐	☐
62. Big Blue Button	☐	☐	☐	☐	☐
63. RadTechBootcamp	☐	☐	☐	☐	☐
64. ASRT Ziltron Simulators	☐	☐	☐	☐	☐
65. ASRT Roadmaps	☐	☐	☐	☐	☐
66. Augmented Reality (AR)	☐	☐	☐	☐	☐
67. Virtual Reality (VR)	☐	☐	☐	☐	☐
68. Kahoot	☐	☐	☐	☐	☐
69. VoiceThread	☐	☐	☐	☐	☐
70. Piktochart	☐	☐	☐	☐	☐
71. Poll Everywhere	☐	☐	☐	☐	☐
72. Other Lecture Capture Technology. Please specify:___	☐	☐	☐	☐	☐
73. Other Virtual Simulation Software: Please Specify: ____	☐	☐	☐	☐	☐
74. Other: Please specify: _______	☐	☐	☐	☐	☐

Continue to next page

75. What barriers do you think may be preventing you or your program from integrating virtual technology in the classroom? (Check All That Apply)

□ Cost/Funding
□ Availability of space
□ Lack of professional development opportunities
□ Hard to keep up with the rapid technological advancements
□ Faculty are resisting the use of new equipment or are not using what you currently have
□ Student resistance to use technology
□ Other: please specify: ________________
□ N/A

For the following questions, please mark the option that most accurately relates to you CURRENTLY.

Behavior

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
76. I use virtual technology in the courses I teach.	☐	☐	☐	☐	☐
77. I use virtual technology to collaborate with colleagues.	☐	☐	☐	☐	☐
78. I use virtual technology to collaborate with students.	☐	☐	☐	☐	☐

Perceived Behavioral Control (PBC)

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
79. I am confident using virtual technology to teach my course(s).	☐	☐	☐	☐	☐
80. I believe that I am able to work with colleagues using virtual technology.	☐	☐	☐	☐	☐
81. If I want to, it is easy for me to find virtual technologies to integrate into my classroom.	☐	☐	☐	☐	☐
82. I am confident learning new technologies in the classroom.	☐	☐	☐	☐	☐
83. I am NOT confident using virtual technology in the classroom.	☐	☐	☐	☐	☐
84. I am NOT confident in my ability to find virtual technologies that best fit the needs of my course(s).	☐	☐	☐	☐	☐

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Perceived Ease of Use (PEU)

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
85. I seldom become confused when integrating technology in the course(s) I teach.	☐	☐	☐	☐	☐
86. I find it difficult to implement new technologies in the course(s) I teach.	☐	☐	☐	☐	☐
87. I do NOT make frequent errors when using virtual technology in my course(s)	☐	☐	☐	☐	☐
88. I think it is easy to use virtual technology in the course(s) I teach.	☐	☐	☐	☐	☐
89. Learning new virtual technologies is easy for me.	☐	☐	☐	☐	☐
90. I find it cumbersome to use virtual technology in my course(s).	☐	☐	☐	☐	☐

Perceived Usefulness (PU) (91-96)

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
91. Using virtual technology improves the quality of student learning experiences	☐	☐	☐	☐	☐
92. The technology currently used in my program/classroom provides students with the most current practices.	☐	☐	☐	☐	☐
93. The technology currently used prepares students for future applications and upcoming advancements in clinical practice.	☐	☐	☐	☐	☐
94. The virtual technology I currently use prevents students from getting behind on their academic progress.	☐	☐	☐	☐	☐
95. Using virtual technology hinders students' academic progress.	☐	☐	☐	☐	☐
96. The use of virtual technology increases students' likelihood of passing board examinations.	☐	☐	☐	☐	☐

Continue to next page

Attitude

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
97. I enjoy learning new technologies for educational purposes.	☐	☐	☐	☐	☐
98. I do not like using virtual technologies in the course(s) I teach.	☐	☐	☐	☐	☐
99. In general, my attitude towards the use of virtual technology is positive:	☐	☐	☐	☐	☐
100. I feel that collaboration using virtual technology is helpful:	☐	☐	☐	☐	☐
101. I feel that the integration of virtual technology in my course(s) is helpful:	☐	☐	☐	☐	☐

Continuance Intention of Virtual Technology Use

The following questions are in regard to your intention to continue use of virtual technology in your courses in the future past the pandemic (i.e. when all methods of teaching such as face-to-face, hybrid, and online/distance are available without restrictions).

For the following questions, please mark the option that most accurately relates to you.

Continuance Intention to Use (CITU)

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
102. I will try to use virtual technology in future semesters past the pandemic.	☐	☐	☐	☐	☐
103. I will make an effort to incorporate virtual technology in professional/educational interactions	☐	☐	☐	☐	☐
104. I intend to use virtual technology in future courses past the pandemic.	☐	☐	☐	☐	☐
105. I will NOT be using virtual technology after the COVID-19 pandemic is over.	☐	☐	☐	☐	☐
106. I will NOT make an effort to incorporate virtual technology in my professional/educational interactions after the pandemic.	☐	☐	☐	☐	☐

Continue to next page

To what extent do you intend to use the following virtual technologies in one or more your courses in the future, past the COVID-19 Pandemic (i.e. when all methods of teaching such as face-to-face, hybrid, and online/distance are available without restrictions)?

Virtual Technology	**Degree of Use** **Never**	**Rarely**	**Sometimes**	**Often**	**Always**
107. Zoom	☐	☐	☐	☐	☐
108. Google Hangout	☐	☐	☐	☐	☐
109. Kaltura	☐	☐	☐	☐	☐
110. Voiceover PPT	☐	☐	☐	☐	☐
111. Prezi	☐	☐	☐	☐	☐
112. Canvas	☐	☐	☐	☐	☐
113. Anatomage Table	☐	☐	☐	☐	☐
114. Shaderware	☐	☐	☐	☐	☐
115. Screencast-o-matic	☐	☐	☐	☐	☐
116. PB works	☐	☐	☐	☐	☐
117. Diigo	☐	☐	☐	☐	☐
118. Mindomo	☐	☐	☐	☐	☐
119. Quizziz	☐	☐	☐	☐	☐
120. Meducoach	☐	☐	☐	☐	☐
121. ASRT Clinical Refresher Modules	☐	☐	☐	☐	☐
122. YuJa Videos	☐	☐	☐	☐	☐
123. Evernote	☐	☐	☐	☐	☐
124. Panopto	☐	☐	☐	☐	☐
125. Big Blue Button	☐	☐	☐	☐	☐
126. RadTechBootcamp	☐	☐	☐	☐	☐
127. ASRT Ziltron Simulators	☐	☐	☐	☐	☐
128. ASRT Roadmaps	☐	☐	☐	☐	☐
129. Augmented Reality (AR)	☐	☐	☐	☐	☐
130. Virtual Reality (VR)	☐	☐	☐	☐	☐
131. Kahoot	☐	☐	☐	☐	☐
132. VoiceThread	☐	☐	☐	☐	☐
133. Piktochart	☐	☐	☐	☐	☐
134. Poll Everywhere	☐	☐	☐	☐	☐
135. Other Lecture Capture Technology. Please specify:___	☐	☐	☐	☐	☐
136. Other Virtual Simulation Software: Please Specify: ____	☐	☐	☐	☐	☐
137. Other: Please specify: _______	☐	☐	☐	☐	☐

Continue to next page

Open-Ended Pseudo-Qualitative Questions:

138. Describe what has been the most challenging aspect of teaching in the COVID-19 pandemic and why.

139. Describe what virtual technology you started using as a result of the COVID-19 pandemic that you plan to continue using and why.

140. Describe what has been the most rewarding aspect of teaching in the COVID-19 pandemic and why.

Thank you for participating in this survey!

Complete!

APPENDIX D

IRB Application Approval

Ward Approval Exempt Protocol #21-095 EX 2102 "Virtual Technology in Radiologic Technology Classrooms: the Educational Impact of the COVID-19 Pandemic"

IRB Administration <irbadmin@auburn.edu>

Thu 3/25/2021 6:18 AM

To: Taylor Ward <tcw0022@auburn.edu>
Cc: Leane Skinner <skinnal@auburn.edu>; Marilyn Strutchen <strutme@auburn.edu>

2 attachments (14 MB)

Investigators Responsibilities rev 1-2011.docx; Ward 21-095 EX 2102 revisions 3.pdf;

Use IRBsubmit@auburn.edu for protocol-related submissions and IRBadmin@auburn.edu for questions and information.
The IRB only accepts forms posted at https://cws.auburn.edu/vpr/compliance/humansubjects/?Forms and submitted electronically.

Dear Ms. Ward,

Your protocol entitled "Virtual Technology in Radiologic Technology Classrooms: the Educational Impact of the COVID-19 Pandemic" has been approved by the IRB as "Exempt" under federal regulation 45 CFR 46.101(b)(2). Attached is a copy of your approved request.

Official notice:
This e-mail serves as official notice that your protocol has been approved. By accepting this approval, you also accept your responsibilities associated with this approval. Details of your responsibilities are attached. Please print and retain.

Expiration:
Continuing review of this Exempt protocol is not required; however, all modification/revisions to the approved protocol must be reviewed and approved by the IRB.

When you have completed all research activities, have no plans to collect additional data and have destroyed all identifiable information as approved by the IRB, please notify this office via e-mail. A final report is no longer required for Exempt protocols.

Best wishes for success with your research!

IRB Admin
Office of Research Compliance
Auburn University
540 Devall Drive
Auburn, AL 36832

APPENDIX E

Information Letter

AUBURN
UNIVERSITY

COLLEGE OF EDUCATION

CURRICULUM & TEACHING

(NOTE: DO NOT AGREE TO PARTICIPATE UNLESS IRB APPROVAL INFORMATION WITH CURRENT DATES HAS BEEN ADDED TO THIS DOCUMENT.)

INFORMATION LETTER

for a Research Study entitled

"Virtual Technology in Radiologic Technology Classrooms: The Educational Impact of the COVID-19 Pandemic"

You are invited to participate in a research study to aid in identifying the impact on virtual technology use as a result of the COVID-19 pandemic and to understand the current and potential future impact on educational delivery. The study is being conducted by Taylor Ward, student, under the direction of Dr. Leane Skinner, Professor and Program Coordinator of Business/Marketing Education in the Auburn University Department of Curriculum and Teaching. You are invited to participate because you are an educator of Radiologic Sciences and are age 18 or older.

What will be involved if you participate? Your participation is completely voluntary. If you decide to participate in this research study, you will be asked to click the link to the survey which will be administered via an online program called "Qualtrics". Your total time commitment will be approximately 10-15 minutes.

Are there any risks or discomforts? There are no more than minimal risks associated with participating in this study.

Are there any benefits to yourself or others? There are no direct benefits from participating in this study. If you participate in this study, you may assist in providing information that will aid in identifying trends that could improve radiologic technology programs and student outcomes throughout the U.S.

Will you receive compensation for participating? No. There will be no compensation for participation in this study.

Are there any costs? No. There are no costs for participation in this study.

If you change your mind about participating, you can withdraw at any time by exiting the survey without submitting, or by closing the internet browser. Once you have submitted anonymous data, it cannot be withdrawn since it will be unidentifiable. There will be no repercussions for choosing to withdraw from the study. Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with Auburn University, the Department of Curriculum and Teaching, or the Career and Technical Education program.

Any data obtained in connection with this study will remain anonymous. We will protect your privacy and the data you provide by not collecting emails or IP addresses. Data will only be accessed by the researchers. The data you provide will be protected by storing and maintaining data on password protected computers Information collected through your participation may be published as part of a dissertation to fulfill an educational requirement, published professional journal and/or presented at a professional meeting.

If you have questions about this study, please contact Taylor Ward at tcw0022@auburn.edu or 801-626-6617 or Dr. Leane Skinner at skinnal@auburn.edu.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334) 844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION ABOVE, YOU MUST DECIDE IF YOU WANT TO PARTICIPATE IN THIS RESEARCH PROJECT. IF YOU DECIDE TO PARTICIPATE, PLEASE CLICK ON THE LINK BELOW. YOU MAY PRINT A COPY OF THIS LETTER TO KEEP.

__Taylor Ward________2-22-21___
Investigator Date

__Dr. Leane Skinner____2-22-21___
Co-Investigator Date

The Auburn University Institutional Review Board has approved this Document for use from 02/22/2021 to -------------- Protocol # 21-095 EX 2102

The Auburn University Institutional Review Board has approved this document for use from_______ to________. Protocol # _________

LINK TO SURVEY

5040 HALEY CENTER
AUBURN, AL 36849-5212
TELEPHONE:
334-844-4434
FAX:
334-844-6789
www.auburn.edu

APPENDIX F

Email Recruitment Letter

Email Recruitment Letter

Dear Educator,

You are invited to participate in this research project titled: "Virtual Technology in Radiologic Technology Classrooms: The Educational Impact of the COVID-19 Pandemic". This study aims to identify the impact on virtual technology use as a result of the COVID-19 pandemic and to understand the current and potential future impact on educational delivery. This study is being conducted by Taylor Ward, in partial fulfillment of the Doctor of Philosophy degree at Auburn University under supervision of Dr. Leane Skinner. You were selected as a potential participant because you are an educator of Radiologic Sciences employed at a postsecondary institution, are age 18 or older, and teach at least one didactic course for radiologic sciences.

Participation in this study is completely voluntary. There are no more than minimal risks associated with participation in this study. All data collected will be completely anonymous. If you choose to participate in this study, you will be asked to click the link or use the QR code (below) to the survey. The survey should take about 10-15 minutes of your time.

Survey Link or QR Code:

This second link will take you to a detailed information letter about the survey.

Electronic Information Letter

Your full participation is encouraged, as the data gathered can be valuable in identifying trends that could improve radiologic technology programs and student outcomes throughout the U.S. Your input is vital for the success of this research study. Because this research is completely voluntary, you may choose to withdraw from the survey at any time by exiting the survey without submitting, or by closing the internet browser. There will be no repercussions for choosing to withdraw from the study and will not jeopardize your future relations with Auburn University, the Department of Curriculum and Teaching, or the Career and Technical Education Business/Marketing Education program. Once the data is submitted, the data cannot be withdrawn as it will be unidentifiable. Data obtained through your participation may be used in the publication of a dissertation for an educational requirement, published in a professional journal, and/or presented at a professional conference.

If you have any questions or concerns regarding this study, please contact Taylor Ward (801) 626-6617 (tcw0022@auburn.edu).

The Auburn University Institutional Review Board has approved this document for use on __________ Protocol # ____________________.

Thank you in advance for your time and participation!

Taylor Ward R.T. (R)(CT)(MR)(ARRT)
Auburn University Ph.D. Student, Career and Technical Education

The Auburn University Institutional Review Board has approved this Document for use from 02/22/2021 to -------------- Protocol # 21-095 EX 2102