Relationships Between Student Selection Criteria and Student Success Among Radiologic Technology Graduates at Two-Year Technical Colleges in the Southeastern United States

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Abstract

Having enough allied health professionals to accommodate the needs of facilities that care for the growing aging population is a concern for allied health educators. To address the high workforce demands for health science careers, schools offering medical imaging programs seek competitive selection models that predict success. To improve the chances of students completing and succeeding in health science programs, health science education programs require a competitive selection process. This process seeks to identify students who possess the academic ability to succeed. Using the input-environment-output model, the purpose of this retrospective correlational study was to determine the predictive validity among selective math grade point average (GPA), science GPA, and standardized test scores from the Psychological Service Bureau (PSB) Health Occupations Aptitude Exam, Test of Essential Academic Skills (TEAS), and RADT 1085 Radiographic Equipment Final GPA and outcome of interest, passing the American Registry of Radiologic Technologist (ARRT) radiography credentialing exam. Using logistic regression, two independent variables—PSB-HOAE/TEAS Score and BIOL 2114L Anatomy and Physiology II Lab—were found to be significant predictors of passing the ARRT radiography credentialing exam on the first attempt. Proportions tests for the PSB-HOAE and TEAS found no significant difference between the proportion of students who passed on the first attempt.

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Dedication

This work is dedicated to my family. Thank you for believing in me, inspiring me, and loving me throughout this process. Thank you all for the joy each of you brings to my life. I love you.

Chapter 1

Introduction

The number of Americans seeking health care for diagnosis and treatment of disease is on the rise. The Patient Protection and Affordable Care Act was enacted with the intent to provide affordable health insurance to more people, expand the Medicaid program by covering adults with income below the federal poverty level, and support innovative health care delivery methods that decrease the costs of health care (Patient Protection and Affordable Care Act, 2010). With the influx of newly insured people in the United States, the demand for more qualified allied health professionals continues to rise (Barrett, 2016; Demo et al., 2015; Frogner & Skillman, 2016; Mollura et al., 2019).

The need for allied health professionals is not only a concern for the United States but for other countries worldwide. The World Health Organization (2015) reported that regardless of the socioeconomic status of a country the need for health care professionals continues to increase and estimated a "gap of 7.2 million professional health workers was set to rise to 12.9 million over the next decades" (p. 4).

Even though allied health is a popular major among college-level students, the projected shortages of qualified health care workers continue to grow. The U.S. Bureau of Labor Statistics (2017) reported employment among allied health related occupations is expected to have the largest and fastest growth between 2016 and 2026. The American Medical Association (2012) indicated there were 8,900 accredited health care programs, a 176.56% increase when compared to the 3,218 health care programs reported by Jensen (1989). Although the U.S. Department of Education's National Center for Education Statistics (2018c) reported a 37% increase in health

science awards from 2003 to 2015, challenges with selecting, educating, and graduating enough students to meet the demands exist. While the number of health care educational programs has significantly increased, the American Society of Radiologic Technologists (ASRT, 2019d) reported increasing vacancy rates for radiographers from 1.7% in 2013 to 8.5% in 2019.

The Public Health Service Act of 1944 and the 2010 Patient Protection and Affordable Care Act defined allied health professionals as individuals who have successfully earned a degree or certificate in an allied health profession from an institution of higher learning. Allied health professionals may work in a variety of health care service areas (Patient Protection and Affordable Care Act, 2010). The Association of Schools Advancing Health Professions (ASAHP, 2020) suggested, allied health occupations are separate from medicine and nursing and serve in the diagnosis, treatment and prevention of disease and include dental hygienists, diagnostic medical sonographers, dieticians, occupational therapists, physical therapists, and respiratory therapists. Radiologic technologists are allied health professionals (ASAHP, 2020; Hamburg, 2015). Radiology careers encompasses a wide variety of specialty areas, including computed tomography, diagnostic radiology, interventional radiology, magnetic resonance imaging, mammography, and ultrasound (ASRT, 2019c).

Radiologic technology (RT) programs need to determine which students will be most successful in their programs. Capturing the most qualified students to maximize the limited number of clinical spots makes a competitive selection process imperative (Ingrassia, 2016; Oranye, 2016; Prideaux et al., 2011). Programs accredited under Joint Review Committee on Education in Radiologic Technology, must abide by standards, including each student be under the direct supervision of a registered RT (JRCERT, 2019a). The field of RT is relatively young when compared to other areas related to health care (Young & McElveny, 1996; Zhang, 2018). RT requires a multifaceted approach to learning. Students interested in becoming radiologic

technologists should have strong foundations in mathematics and the sciences, predominantly physics and human anatomy and physiology (Zhang, 2018).

Many RT programs in Georgia's 2-year technical colleges use standardized test scores and selective grades for math and science courses to determine which students have the best chance for success. However, there is currently no research literature to guide schools in selection criteria may be predictive of success in RT programs for students in 2-year public technical colleges. Multiple studies related to nursing programs have been conducted to predict admission variables leading to higher pass rates on the National Council Licensure Exam for Registered Nurses (NCLEX-RN). However, the literature is lacking in RT in predicting variables leading to passing the ARRT radiography credentialing Exam on the first attempt (Schmuck & Cook, 2018; Tay et al., 2008).

Statement of the Problem

There is currently no research-based, or data-driven competitive selection model for selecting associate degree-level students who will likely pass the ARRT radiography credentialing exam on the first attempt (Ingrassia, 2016; Menser & Hughey, 2016; Schmuck & Cook, 2018). The search for successful models of competitive admission in allied health education, specifically RT, leading to passing the ARRT radiography credentialing exam on the first attempt was inconclusive. Tay et al. (2008) stated, "Evidence-based radiology education and radiology education research are glaringly lacking" (p. 195).

Purpose of the Study

The purpose of this study was to determine the predictive validity among selective math grade point average (GPA), science GPA, and standardized test scores from the Psychological Service Bureau-Health Occupations Aptitude Exam, Test of Essential Academic Skills (PSB-HOAE, TEAS), and RADT 1085 Radiographic Equipment Final GPA and outcome of interest,

passing the ARRT radiography credentialing exam. The dataset came from RT graduates of four Joint Review Committee on Education in Radiologic Technology (JRCERT) accredited programs in, 2-year public technical colleges in Georgia from 2017 to 2019. Relationships between these factors and first-time pass rates on the ARRT radiography credentialing exam were evaluated. The total number of graduates from the four JRCERT accredited, 2-year public technical colleges in Georgia from 2017 to 2019 was 228.

Research Questions

Creswell (2014) explained that quantitative research questions are used to "shape and specifically focus the purpose of the study" (p. 143). Relating one or more independent variables to see how it impacts a dependable variable, is an important aspect of writing good quantitative research questions (Creswell, 2014).

RQ1. What is the relationship between selection criteria (selective math GPA, selective science GPA, standardized test scores), RADT 1085 Radiographic Equipment final GPA, and passing scores on the ARRT radiography credentialing exam among graduates from 2-year technical colleges in the southeastern United States?

RQ2. Which standardized test (PSB-HOAE, TEAS) is a better predictor of success as measured by a score of 75 or above on the ARRT radiography credentialing exam?

Significance of the Problem

Having enough allied health professionals to accommodate the needs of facilities caring for the growing aging population is a concern for allied health educators. To address the high workforce demands for health science careers, schools offering medical imaging programs seek competitive selection models that predict success. To improve the chances of students completing and succeeding in health science programs, health science education programs

require a competitive selection process. The competitive selection process seeks to identify students who possess the academic ability to succeed.

The RT program for Technical College A, Campus 1 turns away many as 75% of its applicant pool. Over 100 students participate in the selection process, and only 20 are selected. The limited number of clinical spots is due to guidelines and standards associated with programmatic accreditation. RT students must be under the direct supervision of a registered RT (JRCERT, 2019b). Although the competitive selection process is in place to select students who should complete the program and pass the ARRT radiography credentialing exam on their first attempt, not all students do. Technical College A, Campus 1 RT program reported a decrease in completion rates from 90% in 2015, 2016 and 2017, to 83% in 2018 and 80% for 2019 (Appendix A). These data indicate a downward trend in completion due to students failing out of the program or leaving for personal reasons.

Figure 1

College A Campus 1 RADT Completion Rates 2015–2019

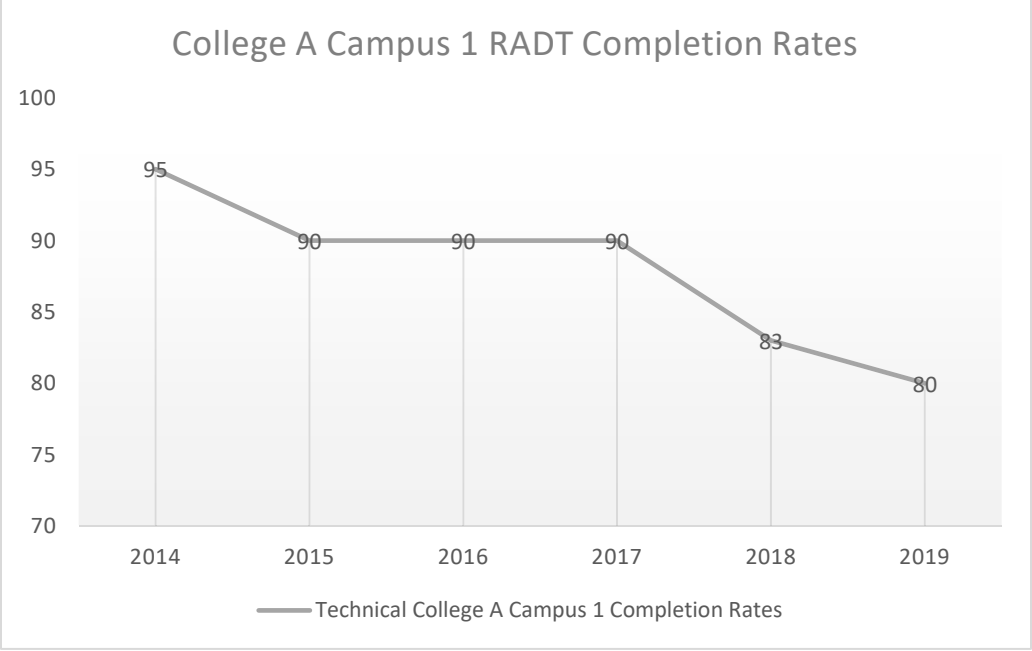


Figure 1 indicates the steady decrease in completion rates from 2015–2019. No investigation or statistical research has been conducted on Technical College A's competitive selection criteria. Those responsible for determining what to use for selection criteria should be concerned with the subsequent decrease in completion rate from 2015 to 2019 and call attention to the issue. Although completion rates are not the focus of the study, statistical analysis needs to be conducted on academic student information which may also lead to predicting successful student program completion.

Figure 2

College A Campus 1 and National ARRT Radiography Credentialing Exam Data 2015–2019

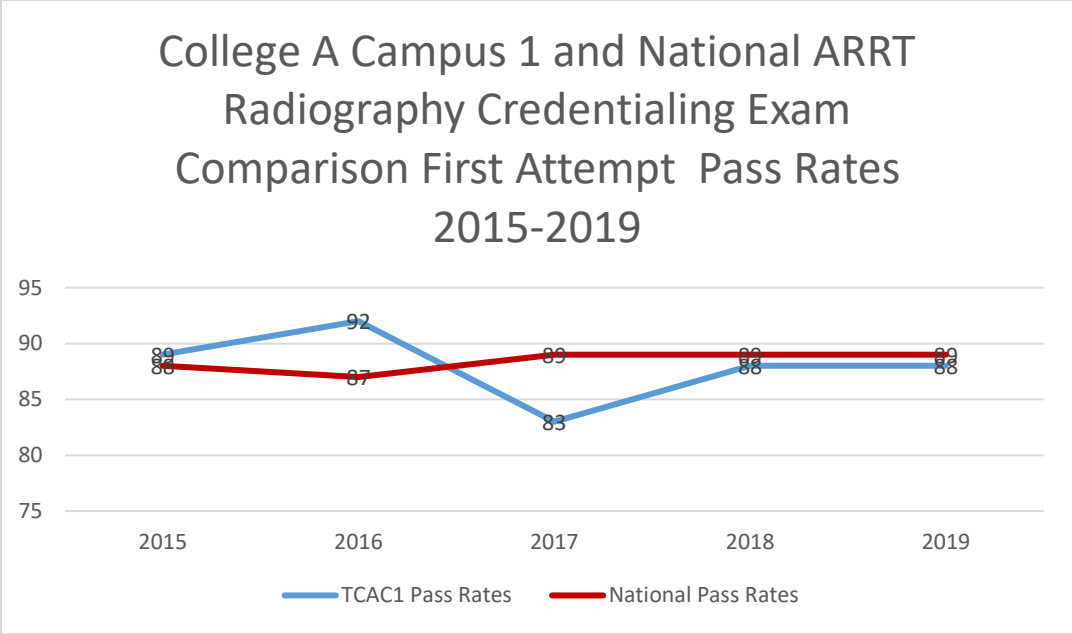


Figure 2 indicates an overall upward trend in ARRT radiography credentialing exam pass rates from 2015 to 2019, but with drastic swings along the way. In 2017, Governor Deal required programs to reduce program lengths to address the high demand for trade and industry workers. As a result, Technical College System of Georgia (TCSG) RT associate degree level programs were reduced from 93 semester hours to 77 semester hours. Prior to the curriculum reduction, some programs were 6 semesters long whereas others were 5 semesters long. Having students

complete their programmatic courses in 4 semesters was the overarching goal for the curriculum reduction, getting graduates to work sooner. Around the same time, the ARRT revised the content specification for the ARRT radiography credentialing exam and the format. Technical College A Campus 1's (TCAC1) first-time pass rate remains below the national average for first-time pass rates.

Theoretical Framework

The theoretical framework for the study is the input-environment-output (I-E-O) assessment model for higher education. The I-E-O model emphasizes input, output, and environmental factors are necessary variables must be considered when assessing any project in education (Astin, 1991). Astin and Antonio (2012) described input as a student's personal qualities and talents developed before entering an educational program. Outcomes were identified as the overarching goal an educational program is seeking to develop regarding a student's abilities and environmental factors refer to what a student may have experienced during the educational program. Astin's first educational research investigated the productivity of Ph.D. (Astin, 1991). students and sought ways to encourage more interest in graduate work in the sciences. Astin reported the largest contributing factor to successful program outcomes was the preexisting skill set of the student (Astin, 1991). Chevan et al. (2017) conducted a study using the I-E-O assessment model to determine advantages of using this framework as an early assurance model for a physical therapy education program. They found the model to support students who are successful in physical therapy education programs and suggested a longitudinal study in the physical therapy education field.

For the study, the input were selective math GPA, selective science GPA, and standardized test scores (PSB-HOAE, TEAS). A Competitive Selection Criteria Data form, containing the input data, was completed, and submitted by RT program directors for

compilation. The environmental factor was a RT program, specifically the final GPA from a single course, RADT 1085 Radiographic Equipment of graduates from 2-year public technical colleges located in the southeastern United States. The outcome variable was dichotomous (pass/fail) and based on the ARRT radiography credentialing exam results. A Program Director Questionnaire, survey instrument (Appendix B) was used to collect descriptive data from all programs considered in the study. Astin suggested both the input and environment affect the outcome. The study aims to determine whether standardized test scores (PSB-HOAE, TEAS) and selective math and science GPAs (inputs) and RADT 1085 Radiographic Equipment Final GPA (environment) have any relationship to the outcome measure of passing the ARRT radiography credentialing exam on the first attempt.

Methodology

The methodology for the study is correlational quantitative, ex post facto/nonexperimental, retroactive design using linear regression. Typical procedures in correlational research include selecting a problem, identifying the population of interest, and selecting a sample from that population. The next step is to identify a dependent variable and one or more independent variables to which it is related and then selecting or developing the instrument, determining the appropriate procedure, collecting, and analyzing the data, and then finally interpreting the results (Ary et al., 2013; Field, 2017).

As mentioned earlier, the problem in the study is the lack of research-based or data-driven, competitive selection model for selecting students who will pass the credentialing exam on the first attempt. The population consisted of RT students who have successfully completed JRCERT accredited RT programs at three associate degree programs in the southeastern United States. Three technical colleges were included in the study. They are identified as Technical College A, Technical College B, and Technical College C. Technical College A has two distinct

RT programs, Campus 1 and Campus 2. The four RT programs combined produced approximately 60 graduates per year and the number of graduates is dependent on retention. The study focused on the past 3 years of graduates; the total population was 169 students (n = 169). A nonrandom convenience sampling was used for the study. Convenience sampling is economical and less time consuming (Ary et al., 2013). The study required a specific population (associate degree RT students) with specific variables, requiring a purposive sample to be used.

The independent variables identified in the study were math GPA, science GPA, standardized test scores (PSB-HOAE, TEAS), and the final grade from RADT 1085. The dependent variable was success or lack of success (pass/fail) on the graduate's first attempt on the ARRT radiography credentialing exam attempt. Published and unpublished data were included in the study. The published data consisted of each college's JRCERT Program Effectiveness Data and competitive selection process. The unpublished data consisted of selection criteria outcomes. Electronic surveys were used to collect nonpublished data and to confirm the accuracy of published data. The instrument used was developed for a dental hygiene study several years ago and modified to meet the needs of the study. In addition, I developed a data collection form and used it to collect the independent variables from each individual program.

Data collection included a letter requesting permission to access the archival data from each institution. An electronic survey was emailed to each college's program director/program faculty. One of the questions in the survey asked the program director/program faculty if they were willing to share cohort selection data from 2017–2019. Each program director/program faculty agreeing to participate was provided a Competitive Selection Criteria Data Form specifically designed for the study via email. College demographic as well as other identifying data were coded numerically. Numeric coding of information helped protect student

confidentiality. An encrypted flash drive was used for storing the data. The flash drive was placed in a secured office cabinet located in the health sciences department and will be deleted after 3 years.

Logistic regression was the statistical method used to analyze the dataset. Due to the dichotomous outcome variable (pass/fail), logistic regression was the most appropriate approach (Agresti, 2013; Astin & Antonio, 2012; Creswell, 2014; Field, 2017). Logistic regression is an effective technique for The I-E-O model because the statistical procedure allows for control of the input or predictor variables (Astin & Antonio, 2012). Table 1 shows the data collection methods I used to address each research question and the quantitative techniques to be used for analyzing projected data.

Table 1

Research Questions, Data Collection Method, and Analysis

Research Question (RQ)	Data Collection Method	Analysis
1. What is the relationship between selection criteria (selective math GPA, selective science GPA), standardized test scores (PSB or TEAS), RADT 1085 GPA Radiographic Equipment Final GPA, and passing scores on the ARRT radiography credentialing exam among graduates from 2-year public technical colleges in the southeastern United States?	• Competitive Selection Survey • Competitive Selection Criteria Data Form	• Descriptive statistics • Binary logistic regression
2. Which standardized test (PSB-HOAE or TEAS) is a better predictor as measured by a score of 75 or above on the ARRT radiography credentialing exam?	• Competitive Selection Survey • Competitive Selection Criteria Data Form	• Inferential statistics • Proportions testing

Assumptions, Limitations, and Delimitations

Researchers make assumptions, which they believe to be true. One assumption for the study was all students selected for their programs met the selection criteria. The rationale for this assumption is RT program administration and faculty would have adhered to the guidelines as required by program admission. Another assumption was each student performed their best on the required standardized test (PSB-HOAE or TEAS). Assumptions for the study also included all ex post facto secondary data were valid. This assumption is important because the PSB-HOAE and TEAS scores were assessed for any relationship to student success with passing the ARRT radiography credentialing exam on the first attempt. Additionally, assumptions regarding the publicized selection criteria were made; however, the Program Director Survey was created to validate accuracy of the information. I describe the discrepancies I found among publicized selection criteria in Chapters 3 and 4.

Other assumptions associated with the method of logistic regression were also considered. Assumptions for logistic regression include (a) dichotomous dependent variable, (b) more than one independent variable, which can be continuous or categorical, (c) dependent variable logistic regression requires a dichotomous dependent variable (Field, 2017). This assumption was met since the dependent variable, pass or fail on the ARRT radiography credentialing exam was dichotomous and could be either yes or no. The dichotomous dependent variable was labeled “1” for yes and “0” for no. In addition, an analysis of residuals was conducted to test for linearity, normality, and homogeneity of variance, discussed more in Chapter 4.

Limitations for the study included the select number of academic factors that predict student success. Other variables, including attendance, life events, number of hours spent

studying, number of hours a student works while attending school, role strain, and student support system were not considered in the study.

Delimitations included the focus on only four technical colleges (five programs) in the southeastern United States. Other delimitations included the small number of TEAS scores when compared to PSB scores in the dataset. Three of the five schools publicized the use of TEAS scores for the selection process; however, Technical College E only used them when the selection process did not fill the available number of cohort spots. Technical College C just started using the TEAS for selection in 2019 and data for their first TEAS cohort will not be available until after December 2021. Originally, Technical College F was identified as a school of interest, but the program director did not complete the survey. I contacted TCSG and got the approval to include Technical College B, making it the only school to provide TEAS scores for the study, which is also a delimitation.

Definition of Terms

American Registry of Radiologic Technologists. The credentialing agency for professionals in medical imaging, interventional procedures, and radiation therapy. After qualified candidates successfully pass the credentialing exam they receive their credentials. This agency is also responsible for overseeing and administration education, ethics, and exam requirements for these professions (ARRT, 2019).

Assessment Technologies Institute (ATI). The producers of the Test of Essential Academic Skills or TEAS. (ATI, 2020).

BIOL 2113 Anatomy and Physiology I. A course offered in TCSG that introduces the anatomy and physiology of the human body with an emphasis on the development of a systemic perspective of anatomical structures and physiological processes. Topics include body organization, cell structure and functions, tissue classifications, integumentary system, skeletal

system, muscular system, and nervous and sensory systems (Central Georgia Technical College [CGTC], 2020).

BIOL 2113L Anatomy and Physiology I Lab. A course offered with in TCSG with laboratory exercises in body organization, cell structure and functions, tissue classifications, integumentary system, skeletal system, muscular system, and nervous and sensory systems (CGTC, 2020).

BIOL 2114 Anatomy and Physiology II. An anatomy and physiology course offered with in TCSG where topics include the endocrine system, cardiovascular system, blood and lymphatic system, immune system, respiratory system, digestive system, urinary system, and reproductive system (CGTC, 2020).

BIOL 2114L Anatomy and Physiology II Lab. A course offered with in TCSG with laboratory exercises in the endocrine system, cardiovascular system, blood and lymphatic system, immune system, respiratory system, digestive system, urinary system, and reproductive system (CGTC, 2020).

Criteria. Standardized tests, GPA, or other criteria that measure cognitive ability or the ability to reason, problem solve and think critically.

Competitive admission. The Columbus Community College office defines competitive admission as a competitive process used for programs who have limited number of spaces and includes additional requirements beyond general admission to the college. Additional requirements could include GPA, academic standing, essay submission or other criteria. (Columbus State Community College, 2019). Also known as competitive selection.

Large suburb college setting. A campus setting inside an urbanized area with a population of 250,000 or more (National Center for Education Statistics, Locale Classifications and Criteria, 2020).

MATH 1101 Mathematic Modeling. A course offered by TCSG that emphasizes functions using real-world applications as models. Topics include fundamental concepts of algebra; functions and graphs; linear, quadratic, polynomial, exponential, and logarithmic functions, and models; systems of equations; and optional topics in algebra (CGTC, 2020).

MATH 1103 Quantitative Skills and Reasoning. A course offered by TCSG focusing on quantitative skills and reasoning in the context of experiences students will be likely to encounter. The course emphasizes processing information in context from a variety of representations, understanding of both the information and the processing, and understanding which conclusions can be reasonably determined. Students will use appropriate technology to enhance mathematical thinking and understanding. Topics covered in the course include sets and set operations, logic, basic probability, data analysis, linear models, quadratic models, exponential and logarithmic models, geometry, and financial management (CGTC, 2020).

MATH 1111 College Algebra. A course offered by TCSG that emphasizes techniques of problem solving using algebraic concepts. Topics include fundamental concepts of algebra, equations and inequalities, functions and graphs, and systems of equations; optional topics include sequences, series, and probability or analytic geometry (CGTC, 2020).

MATH 1113 Pre-Calculus. A course that prepares students for calculus. The topics discussed include an intensive study of polynomial, rational, exponential, logarithmic, and trigonometric functions, and their graphs. Applications include simple maximum and minimum problems, exponential growth, and decay (CGTC, 2020).

National Council Licensure Exam for Registered Nurses. National exam every graduate nurse must take and pass before they can practice as a registered nurse (National Council of State Boards of Nursing, 2019).

Noncognitive criteria. Factors related to interpersonal skills, learning styles and personality traits. Commonly assessed through interviews, essays, and letters of recommendation.

Program success. Successful completion of courses work, both clinical and didactic and passing the ARRT registry on the first attempt.

Psychological Service Bureau-Health Occupations Aptitude Exam. A test used by allied health programs as a tool in the competitive selection process. The PSB-HOAE exam evaluates the areas of academic aptitude, spelling, reading comprehension, natural sciences, and vocational aptitude (PSB, 2019).

Radiologic science program. Educational programs that teach curriculum specific to radiography, radiation therapy, or nuclear medicine.

Rural fringe campus setting. A campus setting less than or equal to 5 miles from an urbanized area, as well as rural territory less than or equal to 2.5 miles from an urban center. (U.S. Department of Education, National Center for Education Statistics, Locale Classifications and Criteria, 2020).

Selective GPA. The GPA of the courses used as specific selection criteria for competitive admission into an allied health program.

Selective math GPA. The GPA of all attempted undergraduate college-level math courses used in the programmatic competitive selection process.

Selective science GPA. The GPA of Anatomy and Physiology courses used in the programmatic competitive selection process.

Small city campus setting. A campus setting with a population less than 100,000, in an urban area and inside a principal city (U.S. Department of Education, National Center for Education Statistics, Locale Classifications and Criteria, 2020).

Standardized tests. Tests used as specific selection criteria for competitive admission into an allied health program. The PSB-HOAE and TEAS predominate the study.

Test of Essential Academic Skills. The TEAS is used by nursing and allied health programs as a tool in the competitive selection process. Areas on the TEAS include reading, math, science, and English language usage (ATI, 2017).

Summary

Health care needs in the United States continue to rise. Radiologic technologists serve to diagnose and aid in treatment of those seeking health care. Associate degree level RT programs in the TCSG attempt to better predict which students will successfully complete the RT program and in passing the ARRT radiography credentialing exam on the first attempt. Improving the number of RT professionals entering the profession will aid in the current vacancies in the US. The study aimed to determine what valid relationships exist among competitive selection criteria used for associate degree level RT programs at technical colleges in the Southeastern United States.

Chapter 2 provides a brief history of RT education and programmatic accreditation from JRCERT; describes 2-year colleges, the competitive selection process used for allied health programs and the five participating colleges; reviews the literature on selective GPAs (math and science) and standardized tests (PSB-HOAE, TEAS) as predictors of success in nursing and allied health programs; and defines completion and success for RT students enrolled in 2-year technical colleges in the state of Georgia.

Chapter 2

Literature Review

RT programs need to determine which students will be most successful in their programs. Capturing the most qualified students to maximize the limited number of clinical spots makes a competitive selection process imperative (Ingrassia, 2016; Oranye, 2016; Prideaux et al., 2011). Programs accredited under Joint Review Committee on Education in Radiologic Technology, must abide by standards, including each student be under the direct supervision of a registered RT (JRCERT, 2019b). The field of RT is relatively young when compared to areas related to health care (Young & McElveny, 1996; Zhang, 2018). RT requires a multifaceted approach to learning. Students interested in becoming RT s should have strong foundations in mathematics and the sciences, predominately physics and human anatomy (Zhang, 2018).

In review of the literature available from 1976 to 2013, Ingrassi (2016) reported most of the literature available regarding RT admission criteria, was focused on improving attrition rates due to the significant shortage of radiologic technologists. Overall, the search for information on theoretical framework specific to the competitive admission process and its relationship to student success as measured by first-time pass rates of the ARRT radiography credentialing exam was significantly lacking. The literature does consist of models for the success of students from associate degree level programs discussed later in Chapter 2.

Many RT programs in Georgia's 2-year technical colleges use standardized test scores and the selective grades for math and science courses to determine which students have the best chance for success; however, there is currently no research literature to guide schools in selection criteria which may be predictive of success in associate degree level RT programs. Multiple

studies related to nursing programs have been conducted to predict admission variables which may lead to higher pass rates on the National Council Licensure Exam for Registered Nurses (NCLEX-RN). However, the literature is lacking in RT in predicting variables leading to passing the American Society of Radiologic Technologists (ARRT) radiography credentialing exam on the first attempt (Schmuck & Cook, 2018; Tay et al., 2008).

Literature Review Process

The database used for the review came from the Cumulative Index to Nursing and Allied Health in addition to ProQuest Nursing, and Allied Health, available on Valdosta State University library website. Literature on competitive admission among allied health education "is not strongly theoretical or conceptual" (Prideaux et al., 2011, p. 215). Ample literature on predictors of success in nursing programs on passing the NCLEX exists (Blozen, 2017; Carrick, 2011; Cherkis & Rosciano, 2015; Reinhardt et al., 2019). However, there is a gap in the literature as studies investigating predictors of success among associate degree level allied health programs, specifically RT students (Ingrassia, 2016; Menser & Hughey, 2016). The sparse literature available on 2-year RT programs warranted the use of studies from nursing and other allied health programs, including physical therapy, that have been included in the research parameters. Searching for keywords and phrases such as *competitive admission criteria in allied health education, admission criteria* and *student success, predictors of student success in allied health, admission criteria in RT, and admission criteria in radiation science education* during the review produced several articles related to students of undergraduate and graduate medicine, nursing, and various allied health programs.

Historical Perspective of Radiologic Technology Education

RT education has evolved over the years due in part to the efforts of some influential organizations and the work of dedicated individuals (ASRT, 2019b). The foundation of RT

education can be traced back to Eddy C. Jerman, “Radiologic Technology’s first teacher” (ASRT, 2019b; Hamburg, 2015; Young & McElveny, 1996). Together the ASRT and the ARRT have used their concerted efforts to establish a voice for those in the field.

After Wilhelm Roentgen’s scientific discovery of X-rays in 1895, it was not long before the new discovery was used for commercial purposes (Babic et al., 2017; Carlton et al., 2020). Using x-radiation to take pictures of bones had proven to be a source of entertainment in Europe as well as the United States, and most operators of x-ray equipment were photographers rather than being trained in health care (Babic et al., 2017; Carlton et al., 2020). Shoe-fitting fluoroscopic machines developed in the 1920s were used to ensure properly fit shoes and although concerns for radiation safety related to these machines became a concern in the 1950s, some states allowed their use until the 1970s (Taylor, 2015).

Early on, physicians purchased their own equipment and even performed most x-rays. However, many doctors found keeping up with the technological advancements in this new field were time consuming, leaving them little time to treat and care for patients. In response, many physicians employed nonmedical personnel to care out the arduous task. Young and McElveny (1996) reported early radiographic procedures were often conducted by individuals with limited knowledge of human anatomy, pathology, and radiation safety. They further reported nurses were often expected to take radiographic images as well as maintain the equipment, in addition to their nursing responsibilities.

In the early 1920s, Jerman and a small number of his associates set out to establish guidelines and standards would “afford technicians an opportunity for the interchange of thoughts and ideas concerned with radiologic technique” (ASRT, 2019b). Their efforts lead to the birth of what is now known as the ASRT (Young & McElveny, 1996). Formal education

standards were not developed until the early 1950s, and until 2015 successful completion of a RT certificate program was the only education requirement.

The education requirements for radiographers have changed since the original curriculum and standards were established. Initially, technologists were required to work directly with a radiologist for a 2-year minimum; however, there were times when a high school diploma and one year of formal x-ray training were deemed acceptable (ASRT, 2019b). Since January 1, 2015, eligibility requirements to sit for the ARRT (2019b) exam include successful completion of an associate degree level program. Once students have successfully passed the initial registry, other secondary pathways are available in magnetic resonance imaging, mammography, nuclear medicine, or ultrasound are also available as secondary pathways (ARRT, 2019).

Programmatic Accreditation

Working together, the ASRT and ARRT established guidelines and standards many RT programs strive to obtain in the accreditation process. Before the organizations stepped in, many technicians (now referred to as technologists) were trained by physicians with little or no guidelines on technical factors or positioning (Young & McElveny, 1996). The Consumer-Patient Radiation Health and Safety Act of 1981 was an influential piece of legislation leading to developing guidelines and standards for educating RTs. The act paved the way for quality to be a foundation in RT education and accreditation standards. The act further opened the door for states to require licensure, although voluntary.

Today, accreditation by the JRCERT is an important factor. Programs accredited by the JRCERT adhere to high standards and commitment by "assuring and improving" the quality of radiology programs in the United States (JRCERT, 2019b). Although not required for the registry, students graduating from JRCERT accredited programs are eligible for federal and state grants and loans (JRCERT, 2019b). Graduates of JRCERT accredited programs may also work

in a government-affiliated RT position, whereas those who do not graduate from a JRCERT accredited program, do not have that opportunity.

ARRT Radiography Credentialing Exam

While Jerman worked towards establishing a curriculum and standards for teaching x-ray operators, others were working towards a means of certifying them. Once technicians started purchasing their own equipment, physicians became concerned the group would unionize and begin offering services separate from their diagnosis and treatment efforts. Out of these concerns, the Radiological Society of North America and the American Roentgen Ray Society (now ARRT) were established (ARRT, 2019b; ASRT, 2019b; Cullian & Cullian, 1995; Young & McElveny, 1996). To "control the technicians" and eventually develop a process to certify radiographers, these physician-led organizations helped establish the credentialing exam for radiographers (Cullian & Cullian, 1995, p. 149).

In their centennial review, Cullian and Cullian (1995) explained the ARRT certified 89 x-ray equipment operators in 1922. The first exam consisted of 20 essay-type questions and required participants to handwrite their responses in addition to submitting various images they had taken, including mastoids, frontal sinuses, and images of the teeth. The ARRT exam has since been turned into a computer-based exam in which students are given 220 questions, 20 of which are pilot questions and are not used in determining the examinee's overall score. Students are permitted 3.5 hours to complete the exam (ARRT, 2019b). Eligibility requirements for students to sit for the ARRT radiography credentialing exam requires students meet the following requirements: (a) complete an ARRT-approved educational program in radiography and (b) adhere to ARRT Standards of Ethics, which include the types of behavior expected and professional values which should be demonstrated in all situations related to patients and their safety (ARRT, 2020b).

The ARRT radiography credentialing exam includes 33 questions on patient care; 53 questions on radiation physics, divided among subtopics of radiation physics and radiation protection; 50 questions on image production, divided into image acquisition and technical evaluation, equipment operation and quality assurance; 64 questions on procedures, with subtopics of the head, spine, and pelvis procedure, thorax and abdomen procedure, and extremity procedures (ARRT, 2020c). The content is publicly available for anyone interested in reviewing in preparation for the exam.

2-year Technical Colleges

Two-year technical colleges are multifunctional. Offering educational and workforce training opportunities in addition to economic development services, 2-year technical colleges offer an array of services both locally and globally. Students attending technical colleges in Georgia may earn technical certificates, diplomas, or associate degrees (TCSG, 2020). In 2017, 5.9 million students were enrolled in 2-year institutions (National Center for Education Statistics, 2018a). Students attending 2-year technical colleges vary greatly in age, socioeconomic background, and employment status (Visher et al., 2012). Most students attending technical colleges are older, nontraditional students who have full-time jobs (Killiam & Degges-White, 2017). According to the National Center for Education Statistics (2018b, 2018c), in 2017 67.4% of students enrolled in 2-year colleges were under 25 years old, and 32% were over the age of 25; 78% worked part-time and 50% full time. A U.S. Department of Education Stats in Brief (Cataldi et al., 2018) check this reported 52% percentage of first-generation college students attended 2-year institutions compared to 28% at 4-year institutions. Students attending 2-year colleges may earn certificates, learn job skills, or earn credits toward baccalaureate programs (Dortch, 2014).

Technical College System of Georgia and Radiologic Technology Programs

The TCSG is composed of 23 colleges, which offer "technical, academic and adult education and training focused on building a well-educated, globally competitive workforce for Georgia" (TCSG, 2020). Out of the 23 colleges in the system, 18 currently offer an associate's degree in RT. All but one institution, Southern Crescent Technical College, is programmatically accredited by the JRCERT.

The RT program curriculum is state mandated and discussed annually at RT Instructional Faculty Consortium Committee (IFCC) (Appendix C) meetings. Faculty from each individual technical college attend and vote on changes and modifications with direction from TCSG leadership. In the spring of 2014, the RT IFCC members were charged with reducing the number of credit hours to the program related to the Complete College Georgia and Complete College America initiatives (Georgia Department of Education, 2012). Prior to reduction of the curriculum, the RT associate degree program required over 90 credit hours. The IFCC followed the guidance of TCSG leadership and agreed to reduce the curriculum to 73 credit hours. According to the January 10, 2014 minutes, programs were given autonomy to implement the new curriculum as early as Fall of 2015, whereas others started in Spring of 2017 (Appendix C).

Currently, RADT programs in TCSG all teach the same content; however, each program has different prerequisites and competitive selection criteria as seen in Table 2. The data in Table 2 were collected from the Program Director Survey instrument (Appendix B) and include a list of the TCSG technical college programs used in the study, the criteria used in their selection process, and the standardized test used in the competitive selection process as of May 2019.

Table 2

TCSG RT Published Program Selection Criteria Target Sample

Technical college	Courses used for selection	Standardized test
Technical College A	ENGL 1101, MATH 1111 or MATH 1101, BIOL 2113 and BIOL 2113L, ALHS 1090	PSB-HOAE
Technical College B	ENGL 1101, MATH 1111, BIOL 2113 BIOL 2113L, BIOL 2114, BIOL 2114L and ALHS 1090	TEAS
Technical College C	ENGL 1101, ENGL 2130; MATH 1111, 1103 or PSCY 1101, SPCH 1101, BIOL 2113, BIOL 2113L, BIOL 2114 and BIOL 2114, ALHS 1090, *ISMA 1100, *COLL 1060	TEAS
Technical College D	ENGL 1101, PSYC 1101, Humanities/Fine Arts elective and General Education electives, MATH 1111 (or MATH 1101), ALHS 1090, RADT 1010, BIOL 2113, BIOL 2113L, BIOL 2114, BIOL 2114L.	PSB-HOAE
Technical College E	MATH 1111, ENGL 1101, ENGL 2130, PSCY 1101, SPCH 1101, BIOL 2113, BIOL 2113L, BIOL 2114 and BIOL 2114, ALHS 1090, *ALMA 1000, *COLL 104	TEAS

Note. Information published as of May 2019

Competitive Selection

Competitive selection or competitive admission is defined as a competitive process used for programs which have limited spaces and includes additional requirements beyond general admission to a college (Columbus State Community College, 2019). The competitive selection

process of any RT program must be nondiscriminatory while selecting students who possess the cognitive and noncognitive abilities to be successful in their program (JRCERT Standards, 2019b; Ochs & Adams, 2008). Competitive selection for health science educational programs is essential due to several considerations: (a) limited clinical spots, (b) high number of applicants, and (c) the need to meet accreditation standards. Admission criteria for health care programs are extremely competitive. Capturing the most qualified students to maximize the limited clinical spots makes a competitive selection process imperative (Ingrassia, 2016; Kudlas, 2006; Prideaux et al., 2011; Salvatori, 2001). Comparing RT programs who used a competitive selection to fill spots to programs that used a noncompetitive selection process, Kudlas (2006) found those using a competitive selection process had higher completion rates.

Allied health educational programs, including RT programs, must limit the number of students entering their programs to adhere to the JRCERT accreditation standards (Knickman et al., 2015). RT programs accredited by the JRCERT are highly competitive, allowing programs to be selective in their admissions process. Students pursuing degrees leading to registry eligibility may graduate from their program; however, not all students selected using the competitive selection process pass the credentialing exam on the first attempt. Completing an accredited program and passing the credentialing exam are critical for allied health students. Passing the primary RT exam provides employment opportunities and the foundation to pursue advanced degrees or certificates in other medical imaging modalities.

Schools of Interest

Three technical colleges located in the southeastern United States were included in the study. According to each college's website and the National Center for Education Statistics, (a) Technical College A Campus 1 and Campus 2 are considered small city campus settings, (b) Technical College B is considered a large suburb education setting, and (c) Technical College C

is considered a rural fringe campus setting. These three colleges represent four distinct RT JRCERT accredited programs in the TCSG. The Program Director Questionnaire data indicated all four programs require a competitive selection process for their RT.

Technical College A has two distinct RT programs. Campus 1 reported 125 students started their program between 2015 and 2018, with 109 completers (Appendix A). The program effectiveness data indicated 88 students took the ARRT radiography credentialing exam, with 78 passing the first attempt (Appendix A). Technical College A, Campus 2 reported 57 students started their program between 2015 and 2018 with 48 completers (Appendix D). The program effectiveness data indicated 48 students took the ARRT radiography credentialing exam, with 45 passing on the first attempt (Appendix D). Technical College A publicly reported the individual cohort pass rates, separated by year, in their program effectiveness report. The program directors or designated faculty member for each program completed and submitted the Program Director Survey Instrument (Appendix B). The data from the survey instrument was used to validate the publicly reported disaggregate data.

Technical College B reported 100 students started their program between 2015 and 2018, with 89 completers (Appendix E). The program effectiveness data indicate 89 out of 89 students passed the ARRT radiography credentialing exam on the first attempt (Appendix E). Technical College B publicly reported each individual cohort's pass rate already separated by year. Technical College B's program director completed and submitted the Program Director Survey Instrument (Appendix B). The data from the survey instrument was used to validate the publicly reported disaggregate data.

Technical College C reported 58 students in their program between 2015–2018, with 40 completers (Appendix F). Technical College C reports their program effectiveness data as a 5-year average. To disaggregate the data by year, the program director of Technical College C

completed and submitted the Program Director Survey Instrument (Appendix B). The survey instrument collected disaggregated data, indicating the number of Technical College C students who took the exam and passed it on the first attempt from 2017 to 2019.

Technical College D reported 63 students started their program between 2015 and 2018, with 51 completers (Appendix G). The program effectiveness data indicate 49 out of 50 students passed the ARRT radiography credentialing exam on the first attempt (Appendix G). Technical College D publicly reported each individual cohort's pass rate separated by year. Technical College D's program director completed and submitted the Program Director Survey Instrument (Appendix B). The data from the survey instrument were used to validate the publicly reported disaggregate data.

Technical College E reported 41 students in their program in 2015–2018 (Appendix H). The available program effectiveness data indicate 17 out of 20 students completed the program between 2015 and 2016. The number of first-time pass rates for the ARRT radiography credentialing exam on the first attempt for 2015–2016 was reported as 10 out of 17 (Appendix H). Technical College E's program director completed and submitted the Program Director Survey Instrument (Appendix B). The data from the survey instrument was used to validate the publicly reported disaggregate data.

Selection Criteria

Selection criteria for health science programs varies. Most health science programs consider only cognitive data, such as GPA and standardized test scores, whereas others include noncognitive data in the form of interviews or letters of recommendation, learning style and personality traits (Ingrassia, 2016; Prideaux et al., 2011). The use of cognitive data is well documented in medical programs for nursing students and outcomes on the NCLEX-RN; however, no one model has been identified as being most effective in predicting student success

(Blozen, 2017; Carrick, 2011; Cherkis & Rosciano, 2015; Mesner & Hughey, 2016; Oranye, 2016; Reinhardt et al., 2019). Only cognitive data were used for the study.

Predictor Variables (Input Variables)

Academic predictors leading to successful completion of nursing and allied health programs has long been sought after. A review of the literature showed the quest to identify criteria that will best predict nursing student success is robust; however, literature focusing on the predictive success of RT students is lacking. The significant shortage of nurses drives the continued focus on identifying predictor variables leading to higher completion rates and successfully passing the NCLEX-RN on the first attempt. Predictors of success in RT education programs have been investigated. However, the literature is outdated and includes noncognitive data such as interviews and letters of reference (Ingrassi, 2016). Multiple studies on predictors of success in various allied health programs have been conducted, but few many studies have investigated pass rates on credentialing exams as outcomes (Salvatori, 2001).

Interviews, specifically multiple mini-interviews (MMI) have been used as noncognitive measures of personality characteristics which identify applicants who are most suitable for clinical settings (Ingrassi, 2016; Ochs & Adams, 2008; Oranye, 2016; Pau et al., 2016). Rutz (2004) suggested using an interview process could lead to legal concerns. For that reason, colleges in the TCSG no longer conduct interviews in their competitive selection process.

Psychological Service Bureau Health Occupations Aptitude Exam

The PSB-HOAE has been used since 1955 to evaluate a person's "readiness, competence, and prerequisite knowledge" for health care related educational programs (PSB, 2019). The PSB-HOAE measures abilities, skills, knowledge, and attitudes important for success in health care related career fields (PSB, 2019). Academic aptitude, Spelling, Reading Comprehension, Information in Natural Sciences, and Vocational Adjustment Index are the five sections used to

evaluate potential health science students, including RT students. The Academic aptitude section includes verbal, arithmetic, and nonverbal sections. Technical College A has used the PSB Health Occupations Aptitude Exam (PSB-HOAE) in their competitive selection process for the past 15 years. The PSB-HOAE is used to assess a student's "readiness, competence and prerequisite knowledge to successfully meet the learning challenge" of allied health programs (PSB, 2019). In a retrospective predictive study conducted on associate degree RT students at Arkansas State identified college GPA and the science portion of the PSB-HOAE as a significant predictor of success regarding student completion (Hawking et al., 2013). Again, performance on the ARRT radiography credentialing exam was not considered.

According to the PSB-HOAE (2018) *Technical Manual*, the content validity for the PSB-HOAE was developed by using preliminary surveys or relevant concepts, detailed item specifications, and both qualitative and quantitative analyses. Content validity is not published for the PSB-HOAE. After contacting the PSB support team, I was able to obtain an excerpt from a PSB *Technical Manual* via email. Stipulations to use the information from the technical manual include sharing my dissertation upon completion. To ensure content validity for the PSB Health Occupations Aptitude Examination (3rd edition), the makers of the exam used preliminary surveys of relevant concepts, detailed item specifications, and both qualitative and quantitative item analysis (PSB, 2019). The content of the PSB-HOAE (3rd edition) was based on a variety of important factors, including course content, texts, expert judgment, scholastic activities students were expected to perform during their education, and knowledge and skills students were expected to demonstrate while in their chosen program (PSB, 2019). This approach is consistent with the process described by Ary et al. (2013) in seeking evidence of all relevant knowledge to develop a test that "represents a balanced and adequate sampling of all the relevant knowledge, skills, and dimensions" for the test (p. 243).

Test of Essential Academic Skills

The TEAS is a current, standardized test often used as competitive selection criteria for nursing programs (Bremner et al., 2014; Van Hofwegen et al., 2019). Information on content validity of the ATI TEAS is published and available upon request. Content validity for the ATI TEAS exam was achieved by using a blueprint development process. A steering committee consisting of nurse educators and content experts in reading, English and language usage, mathematics, and science math were brought together to create a list of content areas, objectives and knowledge and skills and abilities for a successful first year in nursing school (ATI, 2020). Content analysis workshops, blueprint surveys, and blueprint content meetings, were also included in the blueprint development process. During the process, each item is reviewed to ensure alignment to one content category. In addition, bias reviews are conducted to address issues related to diversity and gender. Multiple statistical analyses are conducted, and items flagged by statistical criteria were sent for further evaluation by content experts (ATI, 2017).

In a study on veteran students enrolled in a nursing education program, Van Howegen et al. (2019) used a logistic regression model to examine the importance of GPA and TEAS scores for successful completion of nursing programs and passing the NCLEX-RN on the first attempt. Van Howegen et al. reported selective science grades above the median score (3.41) did not predict successful nursing program completion nor the NCLEX-RN pass rates. However, students at or above the median score did have higher nursing program graduation GPAs. Van Howegen et al. indicated TEAS scores were not good predictors of nursing program graduation GPA, completion, or NCLEX-RN pass rates. A cross-sectional study examining the relationship between TEAS scores and first semester performance of nursing students enrolled in bachelor's degree level nursing programs located in the southeastern United States identified a cut score of 78 on the TEAS as a predictor of success for first-semester nursing students (Bremner et al.,

2014). The TEAS-RN was developed for nursing graduates, but some RT programs are using it as a part of their competitive selection criteria. No current studies linking TEAS-RN score to RT program performance were found.

Grade Point Average and Standardized Tests

Prerequisite or selective GPAs, and standardized tests have been used to determine which students are best suited for nursing and allied health care programs (Agho et al., 1999; Ingrassia, 2016; Kudlas, 2006; Ochs & Adams, 2008; Olsen, 2017; Oranye, 2016; Robert, 2018; Romeo, 2013; Salvatori, 2001; Van Hofwegen et al., 2019). Using GPA to predict student completion rates is well represented throughout the literature (Ochs & Adams, 2008; Olsen, 2017; Romeo, 2013; Schmuck & Cook, 2018; Van Hofwegen et al., 2019). Overall GPA and selective GPA have been identified as important factors in predicting student success for student pursing health care degrees (Agho et al., 1999; Olsen, 2017; Salvatori, 2001). Anatomy and physiology and chemistry have been identified as selective courses commonly found in selective admission (Agho et al., 1999; Anderton et al., 2016). Salvatori (2001) suggested overall GPA was the best predictor of academic performance in any discipline, whereas science GPA was a good predictor of academic success for medical students. A quantitative study in Australia identified anatomy and physiology scores as significant predictors of successful program completion for first-year health science students (Anderton et al., 2016). Although dated, Kwan et al.'s (2009) correlational study indicated math and science performance as predictors of successful completion and passing credentialing exams for Canadian students enrolled in a radiation science program. Although Anderton et al.'s (2016) study found anatomy and physiology grades as significant predictors of program completion of health science students, it did not find mathematics as a significant predictor of success. In addition, Anderton et al.'s study was focused on health science students and not specific to RT students. Studies investigating math

and science GPAs as successful predictors on performance on the ARRT radiography credentialing exam were not found in the review of the literature.

A retrospective descriptive correlational study on associate degree nursing students found scores on the Health Education Systems, Incorporated Admission Assessment (HESI A2) were significant predictors of passing the NCLEX-RN on the first attempt (Robert, 2018). Robert (2018) reported preadmission science scores and the HESI A2 were significant predictors on successful student completion. There are no current studies available to relate selective GPA and associate degree RT student performance on the first attempt of the ARRT radiography credentialing exam.

Technical College A has used the PSB Health Occupations Aptitude Exam (PSB-HOAE) in their competitive selection process for the past 15 years. The PSB-HOAE is used to assess a student's "readiness, competence and prerequisite knowledge to successfully meet the learning challenge" of allied health programs (PSB, 2019). The PSB Health Occupations Aptitude version is divided into five parts (a) Academic Aptitude, (b) Spelling, (c) Reading Comprehension, (d) Information in the Natural Science, and (e) Vocational Adjustment Index (PSB, 2019).

The Test TEAS is a current, standardized test often used as competitive selection criteria for nursing programs (Bremner et al., 2014; Van Hofwegen et al., 2019). A study on veteran students enrolled in nursing education programs, Van Howegen et al. (2019) used a logistic regression model to examine the importance of GPA and TEAS scores for successful completion of nursing programs and passing the NCLEX-RN on the first attempt. Van Howegen et al. reported selective science grades above the median score (3.41) did not predict successful nursing program completion nor the NCLEX-RN pass rates. However, students at or above the median score did have higher nursing program graduation GPAs. Van Howegen et al. indicated TEAS scores were not good predictors of nursing program graduation GPA, completion, or

NCLEX-RN pass rates. A cross-sectional study examining the relationship between TEAS scores and first semester performance of nursing students enrolled in bachelor's degree level nursing programs located in the southeastern United States identified a cut score of 78 on the TEAS as a predictor of success for first-semester nursing students (Bremner et al., 2014). The TEAS was developed for nursing graduates but some RT programs are using it as a part of their competitive selection criteria. No current studies linking TEAS scores to RT program performance were found.

Predictor Variable (Environmental Variable)

RADT 1085 Radiologic Equipment

RADT 1085 Radiographic Equipment is a 3-credit semester hour course which focuses on the basic knowledge of fluoroscopic and mobile equipment requirements and design, beam restriction, filtration, quality control and quality management principles of analog and digital systems. Analog systems or systems that use X-ray film to capture the radiographic image are phasing out of the field, due to digital system availability and cost effectiveness. RADT 1085 covers much of the Image Production category on the ARRT radiography credentialing exam. The Image Production category of the credentialing exam is divided into two sections: (a) image acquisition and technical evaluation and (b) equipment operation and quality assurance. Based on the national results for the ARRT radiography credentialing exam, the equipment operation and quality assurance section has consistently been the lowest scored area among all students taking the exam when compared to the other sections (ARRT, 2017, 2018, 2019a). Using RADT 1085 Based on The I-E-O model for higher learning, RADT 1085 as a single course could be considered a "within-institution environmental experience" (Astin & Antonio, 2012, p. 99). The final GPA from RADT 1085 Radiographic Equipment supports the environmental aspect of The I-E-O theoretical framework. Although the curriculum across all TCSG RT programs is

consistent, the time a course is taught varies among programs, especially regarding the didactic courses related to radiologic physics.

RADT 1085 Radiologic Equipment, a course developed by RT educators, includes content related to the image production category on the ARRT registry. The student learning outcomes include lab experiments that apply theoretical principles and concepts related to image acquisition and technical evaluation, in addition to equipment operation and quality assurance. Using the final GPA from RADT 1085 supports the environmental aspect of The I-E-O theoretical framework.

Dependent Variable (Outcome Variable)

ARRT Radiography Credentialing Exam

RT students must meet program requirements didactically and clinically, in addition to passing the ARRT registry credentialing exam in radiography with at least a 75 mean score to be employed (ARRT, 2018, 2019a; Schmuck & Cook, 2018). Although there has been a consistent national pass rate of 89% for first-time radiography exam takers for the last 3 years, some colleges in the southeastern United States have seen a decline. Technical College A Campus 1 had pass rates of 91.7% in 2016 and 83.3% in 2017, a decline of 8.4% (Appendix A). Although the 5-year pass rates for the ARRT radiography exam have met the 80% accreditation benchmark, the need for improvement in pass rates for Technical College A is a concern. There has also been a decline statewide. The first-time pass rate for the state of Georgia in 2017 was 91.7% and in 2018 was 86%, a decline of 5.7% (ARRT, 2018, 2019a). To address the vacancies in the medical imaging field, the substandard pass rates, and completion rates for Technical College A Campus 1, the competitive selection criteria should be thoroughly evaluated.

Theoretical Framework

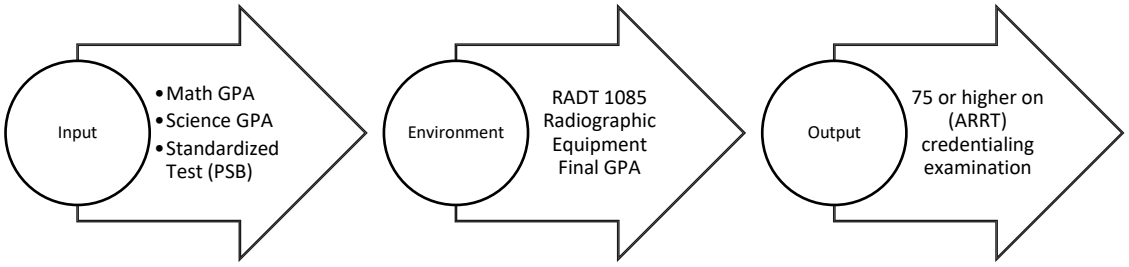
The IEO Assessment Model for Higher Education

In the context of this study, I had the intention of evaluating the usefulness of undergraduate math GPA (GPA), undergraduate science GPA, and standardized test scores (PSB-HOAE, TEAS) in program admissions. These are input variables measured against the outcome of scores of 75 or higher on the ARRT credentialing examination. The study identifies environmental factors as associate degree level RT programs in 2-year Georgia technical colleges.

The theoretical framework for the study is the I-E-O assessment model for higher education. The I-E-O model emphasizes input, output, and environmental factors are necessary variables must be considered when assessing any project in education (Astin & Antonio, 2012). Astin (1991) described input as a student's personal qualities and talents, developed before entering an educational program. Outcomes were identified as the overarching goal of what an educational program is seeking to develop regarding a student's abilities and environmental factors refer to what a student may have experienced during the educational program. Astin's first educational research investigated the productivity of Ph.D. (Astin, 1991). Students and sought ways to encourage more interest in graduate work in the sciences. Astin found the largest contributing factor to successful program outcomes was the preexisting skill set of the student (1991). Figure 3 shows the relationships between The I-E-O model and the independent variables in this study.

Figure 3

Relationship of the I-E-O Model



Summary

The literature shows a variety of cognitive variables used in the competitive selection of nursing students including GPA, standardized tests, and critical thinking skills. Although a few studies related to RT education were conducted, most of them focused on bachelor's degree level programs and student completion rates rather than first-time pass rate on the ARRT radiography credentialing exam. None of the studies related to RT education used math and science in conjunction with standardized test scores from the PSB-HOAE or TEAS. In addition, the literature also shows a lack of investigation in the field of RT education altogether. The fact that RT is still relatively young, when compared to nursing and other allied health educational programs, may explain the deficiency. Chapter 3 explains how the study was conducted.

Chapter 3

Methodology

The purpose of the study was to determine what valid relationships exist among competitive selection criteria used for associate degree level RT programs at technical colleges in the southeastern United States. The research method used for the study is described in the following chapter and includes the research design, methodology, and threats to validity.

To meet the purpose of the study, the following research questions were answered:

RQ1. What is the relationship between selection criteria (selective math GPA, selective science GPA, standardized test scores), RADT 1085 Radiographic Equipment final GPA, and passing scores on the ARRT radiography credentialing exam among graduates from 2-year technical colleges in the southeastern United States?

RQ2. Which standardized test (PSB-HOAE or TEAS) is a better predictor of success for passing the ARRT radiography credentialing exam on the first attempt?

Research Design and Rationale

Multiple variables related to competitive selection for RT programs were used in the study and were also related to The I-E-O assessment model of higher learning. Independent (input) variables included selection math GPA, science GPA, and standardized test scores from the PSB-HOAE or TEAS. A course embedded in the RT curriculum in the TCSG, RADT 1085 GPA, was also identified as an independent variable and served as the Environmental factor of The I-E-O model. The dependent variable, also identified as the outcome variable, was the number of graduates from the participating technical colleges, passing the ARRT radiography credentialing exam on the first attempt.

TCSG uses a 0–4.0 GPA scale. The PSB-HOAE score is reported as a raw score by some colleges and a percentile rank by other colleges. The raw score shows how many questions the student answered correctly, although the percentile rank shows how the student scored when compared to other candidates. The TEAS score is determined by the number of correct items on the test. The reported score for the TEAS is called the total score. Total score describes a student's performance on the entire exam and can be interpreted as the percentage of items answered correctly.

The methodology for the study was quantitative, nonexperimental, correlational design using retroactive ex post facto data. Quantitative, correlational research allows a researcher to collect data that is easy to quantify (Patten, 2014). Quantitative research questions investigate the relationships among variables making a quantitative approach appropriate for the study (Creswell, 2104). Correlational research has been described as nonexperimental research that may be valuable in assessing relationships, consistency, and prediction. Correlational research may use surveys to draw a sample of a population (Ary et al., 2013; Creswell, 2014; Patten, 2014). Correlation coefficients are statistics used to demonstrate the degree of relationships between two variables; however, when interpreting coefficients, it is important to remember correlation coefficients do not show causation (Ary et al., 2013; Field, 2017). Using ex post facto research is appropriate when variables of interest have already taken place and without manipulation (Ary et al., 2013; Patten, 2014). Since the independent variables and dependent variables in the study already occurred, ex post facto design as appropriate for the study.

Logistic regression was the statistical method used to answer RQ1 because the outcome variable—pass/fail—was dichotomous. The student either passed or failed on the first attempt. This type of analysis determines the odds, or probability, that the independent variables will affect the outcome of the dependent variable. The independent variables included the

competitive selection for math GPA, science GPA, standardized test scores for the PSB-HOAE and TEAS, and the GPA from RADT 1085. Logistic regression provides an appropriate method of analysis since the dependent variable is dichotomous (Agresti, 2013; Astin & Antonio, 2012; Creswell, 2014; Field, 2017; Foltz, 2020). Logistic regression is an effective technique for The I-E-O model because the statistical procedure allows for control of the input or predictor variables (Astin & Antonio, 2012). Further, Astin and Antonio (2012, p. 340) suggested the use of logit analysis when "the split between 1s and 0s is very extreme (say, greater than 90% or less than 10%)," which is the case with the sample data for the study and discussed further in Chapter 4.

Logistic regression is a general linear model for modeling the probability of an event occurring, estimating the probability that an event randomly occurs versus the probability that the event will not occur, predicting the effect a group of independent variables has on a dependent, dichotomous variable, and classifying observations by estimating the probability that an observation is in a particular category (Argresti, 2013). In his *Stats 101* vlog, Foltz (2020) identified three reasons for using logistic regression rather than other types of linear regression: (a) binary data does not have a normal distribution, which is a condition needed for most types of linear regression, (b) predicted values of the dependent variable can go beyond 0 and 1 in other types of regression, violating the definition of probability, and (c) probabilities are often not linear and may be "U" shaped demonstrating that probability is very low or very high at the extremes of the X-value. The overarching goal for using logistic regression in the study was to model, estimate, and predict the probability of first-time success on the ARRT radiography credentialing exam depending on the values of the independent variables (standardized test score (PSB-HOAE or TEAS), math GPA, science GPA, and RADT 1085 GPA).

The logistic regression model is represented using the following general formula:

$$Logit\ (pi) = ln\left(\frac{pi}{1-pi}\right) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \in$$

Independent variables—math GPA, science GPA, and RADT 1085 GPA—have interval scales of 4, 3, 2 or 1 where A = 4, B = 3, C = 2 and D = 1. The data were input into the Criteria Selection Data Form (Appendix I) by program chairs/program faculty. I reviewed the data and excluded records if any of the variables were missing. Once reviewed, the data were input into an Excel spreadsheet. For the standardized test score, the raw PSB-HOAE score was converted to a percentile by dividing the raw score by the maximum score a student could make on the PSB-HOAE. Datasets were entered into IBM SPSS Statistics for Windows, Version 26.0 since logistic regression is complex and done using a computer program (Ary et al., 2013).

With Research Question 2 I sought to determine which standardized test (PSB-HOAE or TEAS) was a better predictor of student success on the ARRT radiography credentialing exam. Proportions tests were conducted on two subsamples to determine whether the confidence intervals for the two groups were different. Two sample z-tests were conducted to determine whether the difference in proportions was significant.

Sample and Setting

Population

Data from associate's degree RT graduates from three technical colleges (four programs) in the TCSG who completed their programs between 2017 and 2019 were used for the study. According to program effectiveness reports by each RT program's website, 228 students completed the RT program and attempted the ARRT radiography credentialing exam for the six programs identified as the target sample.

According to the TCSG (date) website, there are 18 associate degree level RT programs. Of those programs, 17 are accredited by JRCERT. The 17 programs produced over 500 graduates between 2017 and 2019, according to the program effectiveness data available on each program's website and provided in Table 3. Time constraints and financial concerns would not make it feasible to investigate the data of every RT 2017–2019 graduate from Georgia's public 2-year technical colleges. The population is accessible population, which is a population a researcher has access to due to time and financial constraints associated with trying to access the entire population (Ary et al., 2013). The sample for the study was a nonrandom, convenience sampling. After I collected and reviewed the data for exclusions the total sample was 228 (*N*=228).

Table 3

Colleges of Interest and Number of Graduates for 2017–2019

Technical College	Graduates
Technical College A (Campus 1)	55
Technical College B (Campus 2)	39
Technical College C	51
Technical College D	26
Technical College E	30
Technical College F	27
Total	228

Schools of Interest

The programs of interest were Technical College A, Campus 1, Technical College A, Campus 2, Technical College B, Technical College C, Technical College D, and Technical

College E. Combined, these programs produce approximately 75 graduates per year and the number of graduates is dependent on the number of retentions. The study focused on the past 3 years of graduates; therefore, the total population was 228 students ($N = 228$). Results from the Program Director Survey revealed not every college used standardized test score in their selection process consistently. In addition, not every college reports their standardized test scores in the same manner. Data were not consistent were not used. Technical College E reported they only used the TEAS when they did not have enough students who meet criteria for selection and a student's GPA is below 3.0. Because STC did not have TEAS scores to report, their data were not included in the analysis. Although each program included other courses in their selection process, such as ENGL 1101 and PSYC 1101, these courses were not in the scope of the research study. Only Technical Colleges A, B, and C's data were used in the study.

Technical College A

Technical College A has two distinct RT programs. Both campuses used the same criteria for the competitive selection process. MATH 1111 College Algebra and Math 1101 Math Modeling were identified as math courses used for their competitive selection process. BIOL 2113 Anatomy and Physiology I and BIOL 2113L Anatomy and Physiology I Lab were identified as courses used in the selection process, although BIOL 2114 Anatomy and Physiology I and BIOL 2114L Anatomy and Physiology II Lab were not. The PSB-HOAE was the standardized test used for all 3 years. The program director and/or program faculty did provide grades for all courses on the Competitive Selection Data Form (Appendix I). The total sample size drawn from Campus 1 for 2017, 2018 and 2019 cohorts was 53 and the sample size drawn from Campus 2 was 39.

Technical College B

Technical College B identified MATH 1111 College Algebra as their required math requirement for selection. However, the Program Director Survey revealed higher level Mathematics courses are also accepted and the evidence was reported on the Competitive Selection Criteria Data Form for Technical College B. Pre-Calculus and Calculus were reported as courses allowed to satisfy the mathematics selection criteria. Technical College B uses BIOL 2113, BIOL 2113L, BIOL 2114 and BIOL 2114L in their competitive selection process. In addition, they required a minimum score of 70 on the TEAS exam. The sample size drawn from Technical College B's 2017, 2018 and 2019 cohorts were 51.

Technical College C

Technical College C identified Math 1111 College Algebra and Math 1103 Quantitative Skills and Reasoning as math courses acceptable for their competitive selection process. BIOL 2113 Anatomy and Physiology I, BIOL 2113L Anatomy and Physiology I and BIOL 2114 Anatomy and Physiology I and BIOL 2114L Anatomy and Physiology II Lab were also identified as courses used in the selection process. The sample size drawn from Technical College C's 2017, 2018 and 2019 cohorts were 26.

Technical College D

Technical College D identified MATH 1111 College Algebra, Math 1103 Quantitative Skills and Reasoning, and MATH 1101 Math Modeling as math courses acceptable for their competitive selection process. Technical College D also used BIOL 2113 Anatomy and Physiology I, BIOL 2113L Anatomy and Physiology I and BIOL 2114 Anatomy and Physiology I and BIOL 2114L Anatomy and Physiology II Lab were also identified as courses used in the selection process. In addition, Technical College D uses one occupational course, ALHS 1090 Medical Terminology, and one programmatic course, RADT 1010 Introduction to Radiologic

Technology in their selection process. The grades for these courses were not investigated since they were not in the scope of the research study. Although Technical College D did provide PSB-HOAE scores for their students, they were reported as percentile. The data collected were analyzed separate from the other colleges due to the discrepancy; however, the results were inconclusive and not included in the overall analysis.

Technical College E

Technical College E identified MATH 1111 College Algebra math requirement for selection. Technical College E also used BIOL 2113, BIOL 2113L, BIOL 2114 and BIOL 2114L in their competitive selection process. Technical College E college only uses the TEAS when a student does not have a GPA of at least 3.0 and did not report any TEAS score.

Sampling and Sampling Procedure

The Dataset

The dataset was defined in the following way (a) only graduates from the classes of 2017–2019, (b) from JRCERT accredited programs, and (c) associate's degree programs located in the TCSG. The common selection criteria included final GPAs from Anatomy and Physiology I and II, lecture and lab courses and math courses. The common environmental facto was the GPA from RADT 1085 Radiographic Equipment. The standardized test came from either a PSB-HOAE score or a TEAS score, depending on what each college required in their selection criteria.

Data from any student not completing the program who did not have complete competitive selection criteria grades available were not used in the study. In addition, data from any student who did graduate but did not take the ARRT radiography credentialing exam were excluded. Data from Technical College D and Technical College E were not included. Technical College D data were not used because the PSB-HOAE scores were reported as percentile data

rather than raw data, although Technical College E did not include TEAS scores. The sample was representative of the student population in RT education programs because students who graduated from JRCERT accredited programs were used.

Sample Size

Seven surveys were sent to RT programs in the TCSG. Of the seven surveys sent to program directors, six were completed. After review of the data, it was determined if participants included their email address at the end of the study doing so signaled their agreement to provide the cohort data used for analysis. Four programs provided emails, indicating their willingness to participate further. Using G*Power it was determined the minimum sample size needed for the study was 104. Using a medium effect size of 0.3, an error of probability of 0.05, and a power of 0.95 yielded a result of 104, which indicates a 95% chance of detecting an effect.

Using a large sample size increases the statistical power of a study and the mean and standard deviation of the sample size would be more representative of the population mean and sample size (Field, 2017; Patten, 2014). The total sample size for the study was 169 ($N = 169$).

Procedures for Recruitment, Participation, and Data Collection

This study focused on the past 3 years of graduates from six distinct RT JRCERT accredited programs at five technical colleges in TCSG. IRB approval was obtained through the university (Appendix J). Additional approval from TCSG and from individual technical colleges was acquired. Recruitment of participants was not necessary for the study due to the retrospective nature of the data; however, an invitation to participate was sent to program directors/program faculty via email and provided a link to the survey for those who were willing to participate. Once the survey link was emailed to and completed by program directors/program faculty, the results were collected and analyzed using IBM SPSS Statistics for Windows, Version

26.0. Results from the survey yielded participation from four distinct JRCERT accredited programs from three college. One college had two separate programs on separate campuses.

The independent variables identified in the study include math GPA, science GPA, scores from the PSB-HOAE or TEAS, and RADT 1085 final GPA. The dependent variable was a dichotomous variable of passing or failing the ARRT radiography credentialing exam on the first attempt. The data gathered included published and unpublished data. The published data consisted of each college's JRCERT Program Effectiveness Data and competitive selection process. The unpublished data consisted of selection criteria outcomes and any nonpublished program effectiveness data. Electronic surveys were used to collect nonpublished data using an electronic instrument previously used in similar studies. Permission to modify, adapt and reproduce the instrument has been obtained and were created in Qualtrics, Inc. (Appendix K). The survey should have taken approximately 10 minutes to complete (Appendix B).

Prior to launching the survey to 2-year public technical colleges in Georgia, a pilot study was conducted to establish content validity of the instrument and for improving the instrument (Creswell, 2014). Permission for TCSG was requested and granted (Appendix L). A revision of the permission letter included an additional college was obtained after it was discovered that none of the participating colleges reported TEAS scores (Appendix M). After permission was granted from TCSG, additional letters to each technical college were emailed to determine their individual IRB process. Only one college had an additional IRB process (Appendix N). Next, the pilot study was distributed to identified JRCERT accredited programs in the state of Georgia and consisted of a small number of participants ($N = 9$). Descriptive statistics and frequency of the data collected from pilot study was conducted to determine whether the results measured the parameters in the study. Based on the analysis, revisions to the Program Director Survey were not necessary.

Independent Variables

Psychological Service Bureau

The PSB Health Occupations Aptitude Exam (3rd edition) is divided into five parts: (a) Academic Aptitude, (b) Spelling, (c) Reading Comprehension, (e) Information in the Natural Science, and (f) Vocational Adjustment Index (PSB, 2019), totaling 305 questions. The PSB-HOAE was used and reported by three of the colleges in the sample. Results for the PSB-HOAE are reported as raw scores and percentile ranks; each college may use the raw score, although some use the percentile rank. For this study raw PSB-HOAE scores were provided by Technical College A and Technical College C and converted to scaled scores by dividing the raw score by the maximum score, or 305, the maximum raw score possible on the PSB-HOAE. Percentile scores were provided by Technical College D, and each score was converted to a scaled score by dividing the reported percentile score by the sum of all five percentile scores. The PSB-HOAE score for Technical College D were not included for RQ2 due to their use or percentile scores.

Test of Essential Academic Skills

The TEAS is divided into four parts (a) reading, (b) mathematics, (c) science, and (d) English and language usages. The TEAS has 150 scored questions. The reported score is determined by dividing the number of correct answers by the total number of questions in all test questions. According to the *Technical Manual* for the ATI TEAS the final number is identified as the student's adjusted composite score, which ranges from developmental to exemplary (ATI, 2020). The TEAS was used and reported by one of the colleges in the sample.

Math GPA

A student's selective math GPA was based on a 4.0 scale. Math courses for the study included MATH 1111 College Algebra, MATH 1101 Mathematic Modeling, MATH 1103 Quantitative Skills and Reasoning, MATH 1113 Pre-Calculus and MATH 1131 Calculus. Math

GPA was calculated by taking the total number of earned grade points and dividing the total number of earned credit hours. Program directors/program faculty were asked to use each student's transcript along with the corresponding math course number used in the selection process for each student who graduated in cohorts 2017, 2018 and 2019.

Science GPA

A student's selective science GPA was based on a 4.0 scale. Science courses used for the study included BIOL 2113 Anatomy and Physiology I, BIOL 2113L Anatomy and Physiology Lab 1, BIOL 2114 Anatomy and Physiology II, and BIOL 2114L Anatomy and Physiology II Lab. Science GPA was calculated by taking the total number of earned grade points and dividing the total number of earned credit hours for each individual science course. Program directors/program faculty were asked to use each student's transcript along with the corresponding science course number used in the selection process for each student who graduated in cohorts 2017, 2018 and 2019.

RADT 1085

RADT 1085 Radiographic Equipment was based on a 4.0 scale. The GPA for RADT 1085 was calculated by taking the total number of earned grade points and dividing the total number of earned credit hours. Program directors/program faculty were asked to use each student's transcript along with the corresponding course number for the programmatic grade for each student who graduated in cohorts 2017, 2018, 2019.

Instrumentation

Instruments created for the study included a Program Director questionnaire (Appendix B) and Competitive Selection Criteria Data Form (Appendix I). The questionnaire was an instrument created for and previously used to evaluate accredited dental hygiene programs was used. I requested permission to modify, use, and publish the instrument, which was granted by

Fehrenbach (1999) the instrument's original creator (Appendix K). The Program Director Questionnaire was used to determine what courses and standardized tests were used by each program for the competitive selection process. I created the Competitive Selection Criteria Data Form in Word. Math GPA, science GPA, and standardized test scores for the PSB-HOAE or TEAS were also used in the study. More detail about each instrument is in the following section.

Pilot Survey

The pilot survey was sent to accredited RT programs in the state of Georgia to establish validity of the Program Director questionnaire. The feedback survey included a drop-down menu with the JRCERT accredited college names. Questions in the feedback survey were

- Q1 Are instructions for completing the survey clearly written?
- Q2 Are questions easy to understand?
- Q3 Did you know how to indicate responses (e.g., click on the response, or type in "other" box)?
- Q4 At the start of the question "For the 2017 graduating cohort, how many students Started in the 2017 cohort and how many graduated in the 2017 cohort?" When you answered that question, what time frame did you think 2017 graduating cohort was SUPPOSED to cover?
- Q5 At the start of the question "Which of the following courses (or equivalent courses) were used in your college's competitive selection process for the 2017 graduating cohort?" When you answered that question, what courses did you think the question was asking about?
- Q6 At the start of the question "Did the graduating class of 2017 self-report their ARRT first-attempt registry scores to the program director?" When you answered that question, what did you think "self-report" was supposed to mean?

Nine invitations were sent, with a response rate of 56%. One of the colleges responded to the survey was not originally invited to participate; however, was provided the link by someone who did receive the invitation to participate. Another college participated in providing feedback was later added to the actual study after receiving TCSG and college IRB approval (Appendices L and M). None of the colleges provided data on their students, and only reviewed the questions for validity.

Five programs completed the Pilot Feedback Survey. Data for the feedback survey were input into IBM SPSS Statistics for Windows (Version 26.0). Descriptive statistics were selected to determine the variance between each question and were found to be in acceptable ranges. The variance is the average error between the mean and the observations made and is measured in units squared (Field, 2018). Taking the square root of the variance provides the standard deviation. The intended survey question response for Questions 1, 2, and 3 was chosen by 100% of the participants. Data from Questions 1, 2, and 3 (M =1, SD = .00) indicated all responses for these questions were answered identically. The intended survey response for Questions 4, 5, and 6 was chosen by 80% of the participants. Data from Questions 4 and 6 (M = 1.2, SD = .45) and for Question 5 (M = 3.4, SD = .89) indicated responses were close to the mean. According to Field (2017) a small standard deviation indicates the data points are close to the mean and a standard deviation of 0 means the scores were identical. Descriptive statistics for the pilot study feedback indicated the questions were appropriate for the study.

Program Director Questionnaire

The Program Director Questionnaire consisted of five sections and was created using Qualtrics. Section 1 consisted of the informed consent and asked the participant to select their college out of a drop-down menu followed by a “yes” or “no” question asking them if they agreed to participate in the online questionnaire after reviewing the informed consent.

Section 2 asked for the title of the person responding to the questionnaire and provided a drop-down menu:

Radiology Program Director

- Academic Dean
- Associate/Assistant Dean
- Radiology Program Admission/Selection Member
- Radiology Program Faculty Member

Section 3 included institutional selection characteristics based on the 2017 cohort graduation year:

- For the 2017 graduating cohort, how many students
  - Started in the 2017 Cohort
  - Graduated in the 2017 Cohort
- Which of the following courses (or equivalent courses) were used in your college's competitive selection process for the 2017 graduating cohort? Check all that apply.
  - ENGL 1101 Composition and Rhetoric
  - MATH 1101 Math Modeling
  - MATH 1111 College Algebra
  - MATH 1103 Quantitative Skills and Reasoning
  - BIOL 2113 Anatomy and Physiology I
  - BIOL 2113L Anatomy and Physiology I Lab
  - BIOL 2114 Anatomy and Physiology II
  - BIOL 2114L Anatomy and Physiology II Lab
  - Other

- Standardized tests were used in competitive selection for the Radiologic Technology graduating class of 2017?
    - Yes
    - No
    - Not sure
- What standardized tests were used in competitive selection for the Radiologic Technology graduating class of 2017
    - Psychological Service Bureau-Health Occupations Aptitude Exam (PSB-HOAE)
    - Test of Essential Academic Skills (TEAS)
    - None of these
    - Other
- Did the graduating class of 2017 self-report their ARRT first-Attempt Registry Scores to the program director?
    - Yes
    - No
    - Not sure
- Changes to the program in 2017: (Check all that apply)
    - Change in program director
    - Change in curriculum
    - Unexpected shut down
    - None of these
    - Other

Sections 4 and 5 were consistent with Section 3 but pertained to the 2018 and 2019 cohorts. The complete instrument can be found in Appendix B. The last item in the Program

Director Survey stated, "If you are willing to provide competitive selection data for Radiologic Technology cohorts who graduated between 2017 and 2019, please provide your email address below. The researcher will contact you with more information."

Program chairs and/or program faculty who agreed to collect and submit their cohort data were emailed the Competitive Selection Data Form (Appendix I) and instructions. The Competitive Selection Criteria Data Form was created in Word and saved as an Adobe pdf. The document could be typed on electronically by the participant or it could be printed out and written on. A column of selection criteria with details and a sample column were provided. The data form could hold up to eleven student's competitive selection data. The complete instrument can be found in Appendix I.

The survey was emailed from the participant's college email address and included a detailed explanation for the study and the questionnaire link. The data form was emailed to participants, after they completed the survey and agreed to participate in the next part of the study. Independent variables as the focus of the study and reported by program directors/program faculty are identified in Table 4.

Table 4

Program Director Survey Results of Independent Variables

College	Math	Science	Standardized Tests
Technical College A	X	X	PSB-HOAE
Technical College B	X	X	TEAS
Technical College C	X	X	PSB-HOAE
Technical College D	X	X	PSB-HOAE
Technical College E	X	X	TEAS[a]

Note. $N = 7$. Technical College A has two distinct RT programs using same selection criteria.
[a]Technical College E reported using the TEAS when the selection process does not produce enough students to fill the number of available spots. They did not use the TEAS in their selection process for any students in cohorts 2017–2019.

A letter granting permission to contact RT program directors and to access the archival data from each institution was obtained from TCSG and each individual college in the target sample. An email including a link to the electronic survey instrument was emailed to each college's program director (Appendix B). One of the questions in the survey asked program directors if they were willing to share cohort selection data from 2017–2019 graduates. Each program director agreeing to participate was provided a Competitive Selection Criteria Data Form specifically designed for the study via email. Once the data from the Competitive Selection Criteria Data Form is collected in electronic form, were transferred to an Excel workbook for organizational and analytical purposes. Final analysis of the data was conducted using IBM SPSS Statistics for Windows (Version 26.0). Demographic as well as any other identifying data were not collected. Numeric coding of information helped protect student confidentiality. An encrypted flash drive was used for storing the data. The flash drive was placed in a secured office cabinet located in the office of associate dean for health sciences and will be deleted after 3 years.

The Competitive Selection Criteria Data Form (Appendix I) was used in the data collection process. I created this form specifically for this study. Once the Competitive Selection Survey was piloted and administered to the six programs of interest, the form was emailed to each program director. The program directors were asked to complete a form for each graduating cohort for 2017, 2018, and 2019. For programs having more than 11 students, the program director was asked to use more than one form, identifying the page number at the bottom of the document. To make the data collection easier for program chairs, I requested letter grades be provided for the math and science GPAs as well as for the RADT 1085 GPA. Once the data were collected, they were transferred into an Excel workbook. Math, science, and RADT 1085 GPAs were assigned according to their numerical value—A=4, B=3, C=2, and D=1. The data from any

student making a D or below in RADT 1085 Radiographic Equipment were not used. Grades of A, B, or C are considered passing. Students not passing any RADT course must repeat the course. Datasets from any student repeating a RADT course were not used in the study. In addition, data from any student missing a PSB-HOAE or TEAS score, GPA from math or science, or Pass of Fail information for the ARRT radiography credentialing exam were excluded.

Validity and Threats to Validity

The use of binary logistic regression to analyze the data were valid. A chi-squared test with 2 degrees of freedom was conducted and yielded a value of 27.2 supports the validity of regression. Results of the full model, including all independent variables using the Hosmer and Lemeshow test were included in IBM SPSS Statistics for Windows, Version 26.0 output. Results for the test were not significant, indicating the final model was a better fit than the full model (Field, 2017).

An internal threat to the study included maturation. A threat from maturation occurs when the subjects change biologically or psychologically as a function of time passing (Ary et al., 2013). The retrospective data collected for the study were from students who may have matured psychologically after experiencing events related to RT education. Events such as seeing a patient die, x-raying patients who have passed away or have been involved in physical trauma, may cause students to mature psychologically.

Ethical Procedures

IRB approval was obtained through Valdosta State University. TCSG approval (Appendix J) was granted, in addition to individual college IRB approval where applicable. Student confidentiality was maintained through the study. Student information was coded by program chairs, prior to being sent to me. Coded data were kept on an encrypted flash drive and

was locked in my desk. All data collected and stored were kept in a secure, password-protected file.

Summary

Chapter 3 explains the methodology and described the population in the study. The purpose of the study was to determine the predictive validity among selective math GPA, science GPA, and standardized test scores from the PSB-HOAE, TEAS, and RADT 1085 Radiographic Equipment final GPA and outcome of interest, passing the ARRT radiography credentialing exam on the first attempt. Six accredited RT programs in the TCSG were the focus of the study. I also investigated which standardized test PSB-HOAE or TEAS, was a better predictor of student success regarding the ARRT radiography credentialing exam. Data were collected in an Excel spreadsheet and transferred to IBM SPSS Statistics for Windows, Version 26.0 for analysis. The logistic regression option was used to analyze the data related to the competitive selection criteria's ability to predict success. Proportions tests were used to analyze which of the two standardized tests was the best in predicting student success. The analysis is reported and explained in Chapter 3.

Chapter 4

Results

Using logistic regression, proportions testing and 3 years of data from 169 Radiologic Technology graduates from technical colleges in the southeastern United States, this quantitative correlational study sought to determine the predictive validity among input variables (selective math GPA, science GPA and PSB-HOAE or TEAS, environment variable (RADT 1085 Radiographic Equipment GPA), and outcome variable (passing the ARRT radiography credentialing exam on the first attempt). Logistic regression determined the odds, or probability, the independent variables affected the dependent variable of student success (ARRT radiography credentialing exam on the first attempt). Standardized test scores and GPA of BIOL 2114 were identified as significant predictors of RT student success. RADT 1085, although not significant, was the third strongest predictor. This chapter restates each research question, describes the collection process, the results of the study, and answers to the research questions.

Research Questions

1. What is the relationship between selection criteria (selective math GPA, selective science GPA, standardized test scores), RADT 1085 Radiographic Equipment final GPA, and passing scores on the ARRT radiography credentialing exam among graduates from 2-year technical colleges in the southeastern United States?
2. Which standardized test (PSB-HOAE or TEAS) is a better predictor of success for passing the ARRT radiography credentialing exam on the first attempt?

Data Collection

This retrospective study initially collected data from six cohorts of students who graduated from an associate degree RT program between 2017 and 2019, yielding data from 228 students. Data not meeting the minimum requirements were run separately to compare with data meeting the criteria. After eliminating data that did not include raw scores for the PSB-HOAE/TEAS, GPAs from math, science, and RADT 1085 GPAs, data from 169 graduates remained. The sample size met the minimum requirements determined by the G*Power described in Chapter 3. Assumptions required for logistic regression were (a) dichotomous dependent variable, (b) one or more independent variables, (c) independence of observations, (d) linearity between independent variables and logit transformation of dependent variable, and (e) no significant outliers. The dichotomous dependent variable of pass or fail on the ARRT radiography credentialing exam was met given it was a yes (1) or no (0) response. Seven independent variables were not related to the dependent variable, which met the assumption of observations. Linearity of the variables with respect to the logit of the dependent variable were found to have values greater than 2 standard deviations, which were kept in the analysis.

The sample meeting all data inclusion requirements included data from 169 graduates. Of the sample, 157 passed the ARRT radiography credentialing exam on the first attempt. Table 5 presents the numbers of graduates and first-time pass on the ARRT radiography credentialing exam. Data removed from the sample were from Technical College D and Technical College E. Technical College D yielded a dataset of 30 graduates. The PSB-HOAE scores from this cohort were reported in percentile scores rather than raw scores. Logistic regression tests were conducted and did not produce any significant data from this group of students. Data for Technical College E did not include any standardized tests scores for the TEAS. This program only uses the TEAS when a student does not meet the minimum GPA requirement of 3.0.

Logistic regression did not produce any significant data on the Technical College E group of students.

Table 5

Sample Data

College	Graduates	First-time Pass	1st Time Pass
Technical College A (1)	54	45	90%
Technical College A (2)	38	37	97%
Technical College B	51	51	100%
Technical College C	26	24	92%
Totals	169	157	93%

Note. N = 169. Technical College A has two distinct RT programs using same selection criteria.

Findings

Data of 228 students from six programs were returned from RT program directors/program faculty. Incomplete data were removed, resulting in a dataset of 169 graduates (Table 5). Of the sample, 157 (93%) successfully passed the ARRT radiography credentialing exam on the first attempt. The raw standardized tests scores reported the programs of interest was PSB-HOAE- (*n* = 118) and TEAS (*n* = 51).

Approximately 95% of the students took MATH 1111 College Algebra (*n* = 161), and the remaining dataset included MATH 1112 College Trigonometry (*n* = 1), MATH 1113 Pre-Calculus (*n* = 4), MATH 1131 Calculus I (*n* = 3). Science courses used for selection included BIOL 2113 Anatomy and Physiology I, BIOL 2113L Anatomy and Physiology I Lab, BIOL 2114 Anatomy and Physiology II and BIOL 2114L Anatomy and Physiology II Lab. Descriptive statistics revealed a PSB-HOAE/TEAS Scaled Score of M = 77.67 selection math GPA of M = 3.57, BIOL 2113 GPA of M = 3.54, BIOL 2113L GPA of M = 3.64, BIOL 2114 GPA of M =

3.46, BIOL 2114L GPA of M = 3.68, and RADT 1085 GPA of M = 3.31. Table 6 describes the minimum, maximum, mean and standard deviation of the independent variables. Variable distributions did not satisfy the normality assumption (Kolmogorov-Smirnov Test); however, the assumption of normality is not required for binary logistic regression (Field, 2018).

Table 6

Descriptive Findings of Independent Variables

Variable	Min	Max	*M*	*SD*
Scaled Test Score (PSB-HOAE/TEAS)	54.40	92.13	77.67	7.48
Math GPA	2.0	4.0	3.57	.605
BIOL 2113 GPA	2.0	4.0	3.54	.567
BIOL 2113L GPA	2.0	4.0	3.64	.601
BIOL 2114 GPA	2.0	4.0	3.46	.664
BIOL 2114L GPA	2.0	4.0	3.68	.571
RADT 1085 GPA	2.0	4.0	3.31	.665

Note. N = 169. Specific math courses were not reported on the Competitive Selection Criteria Data Form.

Logistic Regression

Using binary logistic regression, IBM SPSS Statistics for Windows Version 26.0 was used to address the research questions. Astin and Antonio (2012) recommended stepwise regression analysis when including environmental factors in logistic regression. Stepwise regression is a form of multiple regression, that adds the "independent variables (input or environmental)" to the regression equation one step at a time (Astin & Antonio, 2012, p. 301). Step 1 is considered simple regression using one independent variable, followed by Step 2,

which adds a second independent variable. For each additional independent variable, a new regression formula is created. Variables for each participant are checked to see if their significance has been reduced below an acceptable level. Any variable below the acceptable level is considered nonsignificant and therefore removed from the model.

Stepwise regression can be conducted using a forward or backward approach. The forward approach creates a model without variables called a null model. Next, the most significant variables are added individually until the preset *p* value has been reached, or until all variables have been included in the model (Field, 2017). The backward approach begins with the full model, which includes all variables. Then the least significant variable is removed, followed by the next least significant variable, until no variables are left in the model using the preset *p* value. For this study, the backward model was used. Field (2017) explained the backward method is generally preferred over the forward method due to suppressor effects. Suppressor effects occur when predictors are only significant when another predictor is held constant.

RQ1: What is the relationship between selection criteria (selective math GPA, selective science GPA, standardized test scores), RADT 1085 Radiographic Equipment final GPA, and passing scores on the ARRT radiography credentialing exam among graduates from 2-year technical colleges in the southeastern United States? A multivariable logistic regression analysis was conducted to investigate the relationship between the criteria used in a competitive selection process (score from a PSB-HOAE or TEAS standardized test, grades from preparatory courses MATH 1111 or MATH 1103, BIOL 2113, BIOL 2113, BIOL 2113L, BIOL 2114L), a postselection Radiographic Equipment course (RADT 1085), and the outcome of passing scores on the ARRT Radiography Credentialing exam. Linearity of the independent variables with respect to the logit was assumed and not tested because there were no continuous variables used. The final model was significant, chi-squared (7) = 32.06, $p < .001$. The model explained 38.9%

(Nagelkerke R^2) of the variance in passing the credentialing exam on a first attempt and correctly classified 95.3% of the cases. Sensitivity was 100%, specificity was 27.3%, the positive predictive value was 95.2%, with a 100% negative predictive value. Of the seven independent variables, two were found to be significant: PSB-HOAE/TEAS Score and BIOL 2114L, as shown in Table 7.

The final model indicates for each unit increase in the predictor variable PSB-HOAE/TEAS score there is an associated 1.25 increase in the likelihood of a student passing the credentialing exam on the first attempt. The PSB-HOAE/TEAS scores range from 0 to 100% and each unit increase in the predictor variable represents an increase of 1 percentage point on the exam. With each 1-point increase in the standardized test score the student being considered for selection is 1.25 times more likely to pass the credentialing exam on the first attempt.

The final model also indicates each unit increase in the predictor variable BIOL 2114L is associated with a 4.88 increase in the probability of a first-time passing score. It is important to note the values for the variable BIOL 2114L Anatomy and Physiology II Lab are scaled values of 0,1,2,3, or 4. An increase by 1 unit in this variable represents an increase by one corresponding grade level from F, D, C, B, and A, respectively. Thus, each increase by one grade level in the BIOL 2114L course predicts the student being considered for selection will be nearly 5 times more likely to pass the credentialing exam on the first attempt. A comparison of 1 unit increase in the scaled score for BIOL 2114L represents a 5-unit increase in the odds of passing. But an increase of 2 units in the scaled score for BIOL 2114L represents a 25-unit increase in the odds passing on the first attempt. Individual ratios progress exponentially rather than linearly, which means the odds of passing the ARRT exam on the first attempt for a student who earned an A, may be as high as 25 times the odds of passing for a student who earned a C in BIOL 2114L.

The final regression model was achieved through a stepwise process using backward selection, with the likelihood ratio estimates used to determine variables not significantly contributing to the model. It is important to note the final regression model should not be misunderstood as the only valid logistic regression model available among the given independent variables. An original full model was generated which indicated only the variable PBS-HOAE/TEAS Score was significant, $p < .001$. The full model was significant, chi-squared value (7) of 32.06, $p < .001$. The full model explained 45.2% of the variance in the dependent variable, and it correctly classified 95.9% of the cases. However, based on my experience as an educator in the radiology field, a single standardized test score may not truly be the sole significant predictor of a first-time pass on the credentialing exam. Indeed, the content validity studies for the ARRT credentialing exam also indicate otherwise leading to an examination of other potentially significant predictor variables may exist in simpler models.

From the full model, the variable with the weakest association was identified and removed. Iterations of the process were continued until only significant predictor variables remained. Five of the independent variables consecutively removed were MATH, BIOL 2113L, BIOL 2113, BIOL 2114, and finally RADT 1085. In addition, a forward selection process was conducted and found to converge to the same resulting model. However, understanding other significant models may exist, all other possible logistic regression equations containing two independent variables were constructed. Other models found included the following combinations:

PSB-HOAE/TEAS Score with RADT 1085,

PSB-HOAE/TEAS Score with BIOL 2114,

BIOL 2114L with BIOL 2114, and

BIOL 2114 L with RADT 1085.

By forward selection from these, there were no models contained three or more variables, such that each variable was a significant contributor. These outcomes indicate results can be interpreted in the context of input variables and environmental variables in the I-E-O model. For instance, among the input variables (student selection criteria), the resulting logistic regression models consistently indicate the PSB-HOAE/TEAS Score and student performance in the BIOL 2114 lecture and lab may play a more significant role in the likelihood of a first-time pass on the credentialing exam. But the other selection criteria of MATH, BIOL 2113 lecture and lab do not. In addition, the environmental variable RADT 1085 was found to be a significant predictor variable in conjunction with either the PSB-HOAE/TEAS score or the BIOL 2114L grade. In the study of content validity for the ARRT credentialing exam, this correlation is also supported.

Table 7

Stepwise Logistic Regression (Backward Selection)

Variables	SE	df	OR	95% CI	*p* value
PSB-HOAE/TEAS Scores	.06	1	1.23	1.1–1.41	.000
Math GPA	.73	1	0.88	0.21–3.7	.858
BIOL 2113 GPA	.71	1	.54	0.12-2.5	.427
BIOL 2113L GPA	.64	1	1.59	0.45–5.7	.474
BIOL 2114 GPA	.61	1	1.99	0.56–7.1	.292
BIOL 2114L GPA	.58	1	4.88	1.58–15.1	.006
RADT 1085 GPA	.51	1	2.17	0.58–8.2	.257
Constant	5.35	1	0.00		.001

Note. OR = odds ratio; CI = confidence interval. Full Model R^2 = 45.2 (Nagelkerke); Final Model R^2 = 38.9 (Nagelkerke). R^2 indicates the percent of variance explained by the model. The full model resulted in one significant predictor—PSB-HOAE/TEAS Score. The Final Model resulted in two significant predictors: PSB-HOAE/TEAS and BIOL 2114L.

Logistic regression may at times produce a significant odds ratio for a variable along with an unusually wide confidence interval, which may cause concern for the validity of the calculated odds ratio. However, the width of the confidence interval is sometimes misinterpreted because it is generated from a narrower confidence interval for the *B* coefficient for the variable. For example, the *B* value for BIOL 2114L variable was 1.586 with a 95% CI (.457, 2.721) which is sufficiently narrow to support the *B* value. Note the odds ratios are calculated by *Exp (B),* so the 95% CI (1.58,15.2) for the odds ratio of 4.88 for the BIOL 2114L variable, can be considered sufficiently narrow to support the odds ratio (Field, 2017). It is equivalent to 1.586 being situated in the calculated values of .457 and 2.721. The value of the lower limit is greater than one and according to Field (2017), “Values greater than one mean that as the predictor variable increases,

do so the odds (p. 660). Field further stated, "If the lower limit had been below one, then it would tell us there is a chance that in the population the direction of the relationship is the opposite to what we have observed" (p. 661). Examination of the dataset of the variable in question may yield further support for the validity of the odds ratio. Consider the frequencies of the scaled values for BIOL 2114L in Table 8. Notice there is very little variation in the scaled scores—for example, 124 out of 169 (73.4%) scores of 4, contrasted with only 36 scores of 3, and nine scores of 2. This lack of variation in the scores for the variable can be a contributing factor to eventual outcome of a wide confidence interval for the odds ratio. But notice that, among the nine students who had a score of 2, 77.7% of them passed the registry exam on the first attempt. But 88.9% of those who had a score of 3 passed on the first try and 96% of those who had a score of 4 passed on the first attempt. These figures support the odds ratio finding for BIOL 2114L as well—for each unit increase in the score, a corresponding increase in the proportion of students who pass on their first attempt occurs.

Table 8

Frequencies and Percentage of Selection Variables

Standardized Test	*n*	%	*n* Pass	% Pass
PSB-HOAE/TEAS	169		158	93.5
Math GPA				
A	106	62.7	100	94.3
B	53	31.4	49	92.5
C	10	25.3	9	90.0
Biology 2113 GPA				
A	97	57.4	90	92.8
B	66	39.1	64	97.0
C	6	3.6	4	66.7
Biology 2113L GPA				
A	120	71.0	115	95.8
B	38	22.5	33	86.8
C	11	6.5	10	90.9
Biology 2114 GPA				
A	95	55.6	92	96.8
B	59	34.9	53	89.8
C	16	9.5	13	81.3
Biology 2114L GPA				
A	124	73.4	119	96.0

B	36	21.3	32	88.9
C	9	5.3	7	77.8
RADT 1085 GPA				
A	72	42.6	70	97.2
B	78	46.2	73	93.6
C	19	11.2	15	78.9

Note. $N = 169$.

Proportions Testing

Proportions tests were conducted on two different subsamples. One subgroup consisted of students ($n = 51$) who had taken the TEAS. This subgroup contained only students who had earned a TEAS score greater than or equal to 70 because of their respective program's selection criteria. A second subgroup originally consisted of 118 students who had taken the PSB-HOAE. But for equitable comparison among the two subgroups, the condition of earning a score greater than or equal to 70 needed to be met for the PSB-HOAE group as well. Thus, the PSB-HOAE subgroup ($n = 95$) also only contained students who had earned a PSB-HOAE score greater than or equal to 70.

A proportion test for the TEAS group was conducted at a 95% confidence level. The null hypothesis was H_0: $p = 1$ and the alternative hypothesis was H_1: $p \neq 1$. The resulting confidence interval for the proportion of TEAS students who passed the registry on their first attempt was (.9299, 1). A proportion test for the PSB-HOAE group was conducted at a 95% confidence level. The null hypothesis was H_0: $p = .9578$ and the alternative hypothesis was H_1: $p \neq .9578$. The resulting confidence interval for the proportion of PSB-HOAE students who passed the registry on their first attempt was (.8966, .9835).

The sample proportion for the TEAS group, $P = 1$, was greater than the sample proportion for the PSB-HOAE group, $P = .9578$. Also, the lower and upper limits of the proportion confidence interval for the TEAS group was greater. To determine whether the difference in proportions was significant, a two-sample proportion z-test was conducted. The test

was two-tailed with the null hypothesis of equal proportions and an alternative hypothesis of unequal proportions. The test yielded a z value of 1.4859 with a corresponding *p* value of .1369. At a 95% confidence level, the resulting *p* value indicates the null hypothesis cannot be rejected. The difference between the proportions of the two groups is not great enough to be significant.

Summary

Using backwards logistic regression two independent variables: PSB-HOAE/TEAS Score and BIOL 2114L were found to be significant predictors of passing the ARRT radiography credentialing exam on the first attempt. Proportions tests for the PSB-HOAE and TEAS found no significant difference between the proportion of students who passed on the first attempt.

Chapter 5

V. Discussion

Having enough allied health professionals to accommodate the needs of facilities that care for the growing aging population is a concern for allied health educators. Competitive selection is a process that helps radiologic technology programs select students who will successfully complete their program of study and pass the ARRT radiography credentialing exam on the first attempt. Research on how best to predict the success of nursing and physical therapy students is well documented throughout the literature; however, the field of radiologic technology education is underrepresented. Furthermore, a lack of research on associate degree level RT programs exists.

Allied health programs receive numerous applicants but have limited numbers of clinical spots. Competitive selection is required in health science education programs to improve the chances of students completing and succeeding program coursework and credentialing exams to meet the needs of industry and to adhere to the accreditation standards related to their program. Program accreditation standards establish benchmarks related to student completion and success on credentialing exams. With increasing vacancies among radiographer positions throughout the nation, selecting students who will successfully complete their program sis imperative. Program directors and program admission personnel should consider which selection criteria are the most significant for selecting students who will be successful.

The purpose of this retrospective correlational study was to determine the predictive validity of selection criteria used in the competitive selection of associate degree level radiologic technology programs and outcome of interest, passing the ARRT radiography credentialing

exam. The independent variables included selective math GPA, science GPA, and standardized test scores from the PSB-Health Occupations Aptitude Exam or Test of Essential Academic Skills (PSB-HOAE), and RADT 1085 Radiographic Equipment Final GPA. The dependent variable, passing the ARRT radiography credentialing exam on the first attempt.

Research Questions

The research questions for the study were

1. What is the relationship between selection criteria (math GPA, selective science GPA, standardized test scores), RADT 1085 Radiographic Equipment final GPA, and passing scores on the ARRT radiography credentialing exam among graduates from 2-year technical colleges in the southeastern United States?
2. Which standardized test (PSB-HOAE, TEAS) is a better predictor of success as measured by a score of 75 or above on the ARRT radiography credentialing exam?

Study Summary

As described in Chapter 1, the significance of the study was to identify which selection criteria are best at predicting who will pass the ARRT radiography credentialing exam on the first attempt. In addition, the study investigated which standardized test is best at predicting RT student success between the PSB-HOAE and TEAS.

The results of logistic regression yielded significant associations between PSB-HOAE/TEAS scores and BIOL 2114L Anatomy and Physiology II Lab on first-time pass on the ARRT radiography credentialing exam. In addition, the type of standardized test did not have any bearing on first-time pass. Many associate degree level programs use standardized test scores as a part of their selection process, along with math and science courses. Technical College A was the only college who did not use BIOL 2114 or BIOL 2114L in their selection criteria, rather they used BIOL 2113 and BIOL 2113L. It is shown in Table 5 Technical College A had the

lowest first attempt pass rate for the 3-year average of ARRT radiography credentialing exam. Although pass rates for Technical College A were in their JRCERT accrediting benchmark of 80%, and above the average when compared to the 3-year national average of first-time pass rate of 89%, the use of BIOL 2114 for the selection process may increase student success and improve programmatic outcomes for the JRCERT. In addition, math may not need to be included in the selection process. It has been my personal experience as a health care science student, instructor, and now associate dean that many students either retake math or take additional math courses in pursuit of higher grades to increase their chances of being selected. A first-time pass on the registry may not be a valid justification for including math GPA. If higher math GPAs are not associated with increasing the chances of passing the registry, not including it in the selection process could save students money and time. Consequently, reducing the number of selection criteria could save those conducting the selection process time and effort.

Although a correlational study conducted by Kwan et al. (2009) indicated math and science as strong predictors of radiation science students in Canada, this study found math GPA and BIOL 2113 Anatomy and Physiology I lecture not to be significant predictors in first-time passing of the ARRT exam for radiographers. Results from this study associated BIOL 2114L with RT student success, which is consistent with Anderton et al.'s (2016) findings on Australian health science students that anatomy and physiology GPA significant predicted successful completion and performance in health science education programs.

Key Findings

As outlined in Chapter 1, the primary purpose of the study is to investigate the predictive validity among input variables (selective math GPA, science GPA and PSB-HOAE or TEAS), environmental variable (RADT 1085 Radiographic Equipment) and outcome variable (passing the ARRT radiography credentialing exam on the first attempt) necessary for improving the

success of radiologic technology students. the study also investigated whether the PSB-HOAE was a better predictor of success on first-time pass for associate degree level RT students, when compared to the TEAS.

The data provided convincing evidence which could be useful to RT program directors and future students who pursue careers in medical imaging. The key findings in the study are the importance of standardized test scores and anatomy and physiology courses in the competitive selection process for students entering associate degree level RT programs.

Research Question 1

Standardized Tests

The logistic regression analysis indicated a significant relationship between the standardized test score and first-time pass on the ARRT registry. The odds ratio indicated for each unit increase in PSB-HOAE or TEAS score, there was a 1.25 increase in the likelihood a student would pass the ARRT credentialing exam on the first attempt and correctly classified 95.3% of the cases. Although many RT programs use standardized tests in their competitive selection process, not all do. Technical College E reported using the TEAS in their competitive selection process when a student does not meet the 3.0 GPA requirement. Technical College E also reported the lowest 5-year first-time pass rate of 75.6% (Appendix H). The data from the study provided convincing evidence supporting the use of standardized test scores in the competitive selection process. Although students pursing the same programs are required to take the same courses for selection, they may take those courses from different colleges, different instructors, or different settings, such as online or in person. The standardized test score provides an equitable component for student competition regardless of where and how the student completed the competitive coursework.

Math Courses

The logistic regression analysis relating math GPA and first-time pass on the ARRT registry did not produce a significant relationship. The odds ratio demonstrated a change in a student's math GPA would increase the graduate's chance of first-time pass by .88. Since 95% of the math GPAs reported by program chairs came from MATH 1111 College Algebra, it was not feasible to analyze which math course was a better predictor of success. The 12 students who did not pass the ARRT radiography credentialing exam were all reported to have taken MATH 1111 College Algebra. It is unknown whether these students took other math courses prior to MATH 1111, or if any of them repeated the course for a higher grade since program directors only reported the competitive selection grade.

Science Courses

The logistic regression analysis indicated a significant relationship between BIOL 2114L Anatomy and Physiology II Lab grades and first-time pass on the ARRT registry. The odds ratio indicated for each unit of increase based on a scaled value of 0–4 there was a 4.88 increase in the probability of a first-time passing score of 75 or higher. An increase by 1 unit in this variable represents an increase by one corresponding grade level from F, D, C, B and A, respectively. Thus, each increase by one grade level in the BIOL 2114L course predicts the student being considered for selection will be nearly 5 times more likely to pass the credentialing exam on the first attempt. Although the competitive selection process for most RT programs included BIOL 2114L as selection criteria, some did not. Contrary to my expectations, BIOL 2114L Anatomy and Physiology II Lab was a stronger predictor of success for this group of students when compared to BIOL 2113L Anatomy and Physiology I Lab. Colleges using only BIOL 2113 and BIOL 2113L should consider using the second anatomy in the selection process. BIOL 2114 Anatomy and Physiology II lecture and lab include topics and exercises in the endocrine system,

cardiovascular system, blood and lymphatic system, immune system, respiratory system, digestive system, urinary system, and reproductive system (CGTC, 2020). As a former health science student, I can relate to the difficult subject matter in this course. RT programs should consider including BIOL 2113 and BIOL 2114 lectures and labs in their selection criteria to increase the probability of first-time pass on the ARRT radiography credentialing exam. When combined, these courses encompass all body systems related to human anatomy, which are important for student radiographers to understand when learning the art of radiography and when performing radiographic procedures on live patients.

RADT 1085 Radiographic Equipment

Although the relationship between RADT 1085 and first-time pass on the ARRT radiography credentialing exam was not significant, the odds ratio indicated a trend the odds of first-time ARRT pass went up by 2.3 for each unit increase, based on a scaled value of 0–4. The student learning objectives associated with RADT 1085 include basic knowledge of fluoroscopic and mobile equipment requirements and design, beam restriction, filtration, quality control, and quality management principles of analog and digital systems. As outlined in Chapter 1, RADT 1085 covers much of the Image Production category on the ARRT radiography credentialing exam, which has been identified by the ARRT as the lowest scored area among all students taking the radiography exam. Curriculum specialists and RT faculty should consider restructuring the course content in RADT 1085 to provide more hands-on lab time and dividing the content into two individual courses. Dividing the content into two individual courses, and including a separate lab for each course, would give students more time in hands-on lab activities that would reinforce student learning outcomes. In addition which semester the course is offered in the program should be considered. For example, colleges could teach RADT 1085 during a 15-week fall or spring semester as opposed to a 9- to 10-week summer semester.

Research Question 2

Two independent proportions tests were conducted to compare the proportions in two unrelated groups to investigate which standardized test, the PSB-HOAE or TEAS, is a better predictor of success as measured by a score of 75 or above on the ARRT radiography credentialing exam. One subgroup consisted of students (n = 51) who had taken the TEAS. This subgroup contained only students who had earned a TEAS score greater than or equal to 70, because of their respective program's selection criteria. A second subgroup originally consisted of 118 students who had taken the PSB_HOAE. But for equitable comparison among the two subgroups, the condition of earning a score greater than or equal to 70 needed to be met for the PSB-HOAE group as well. Thus, the PSB subgroup (n = 95) also contained only students who had earned a PSB-HOAE score greater than or equal to 70. The difference between the proportions of the two groups is not great enough to be significant. As stated earlier in chapter many RT programs use standardized tests in their competitive selection process; however, not all programs do. The evidence from the logistic regression analysis supports the use of standardized tests in the competitive selection process. When deciding which standardized test to use, program directors and admission personnel should consider the availability of information provided by each company and accessibility to student scores and data.

Conclusions

The purpose of this retrospective correlational study was to determine the predictive validity of selection criteria used in the competitive selection of associate degree level radiologic technology programs and outcome of interest, passing the ARRT radiography credentialing exam. The research questions were chosen based on the need to improve pass rates on the ARRT radiography credentialing exam and to improve success for students selected from this population. The independent variables included selective math GPA, science GPA, and

standardized test scores from the PSB-HOAE or TEAS and RADT 1085 Radiographic Equipment Final GPA. The dependent variable, passing the ARRT radiography credentialing exam on the first attempt.

Limitations

This quantitative ex post facto correlation study did have limitations which restricted the generalizability of the research findings beyond the study sample. Ex post facto data have an inherent weakness related to the integrity; however, using homogenous groups in a study improves the credibility. The sample came from the same population, same program, and all independent variables were homogenous. The study included a select number of academic factors that predict student success. Other variables, including attendance, life events, number of hours spent studying, number of hours a student works while attending school, role strain, and student's support system were not considered in the study. The number of graduate PSB-HOAE scores compared to the number of graduate TEAS scores was not comparable. Only one college in the study provided TEAS scores. Data entry errors are possible since program directors provided electronic data. Further, the study included data from standardized tests that may change formats in the future.

Recommendations

The results of the study led to several recommendations. First, program directors who do not track student success as it relates to their selection criteria should consider doing so. Collecting and analyzing student data may improve programmatic and accreditation outcomes. Second, it is recommended programs that do not currently use standardized tests in their selection criteria start including a standardized test score to improve first-time pass rates for RT students. College E was the only college that did not require a standardized test score for selection unless the selective GPA was below a 3.0. College E was also the only college that

reported first-time pass rates below the JRCERT benchmark. Third, it is recommended that the competitive selection process for associate degree level RT programs include BIOL 2114 Anatomy and Physiology II lecture and BIOL 2114L Anatomy and Physiology II Lab GPAs. College A was the only college that did not use the grades from BIOL 2114 and 2114L in their selection model. Although completion was not a focal point of the study, using the second anatomy and physiology courses in the selection process may improve completion rates and first-time pass rates. Further, the environmental variable RADT 1085, the third predictor with the third strongest association with student success, should be taught during a 15-week semester, as opposed to a 10-week summer semester. Doing so will allow the instructor to maximize the lab and hands-on experience they can offer students.

In two relatively recent studies modeling data with logistic regression, math GPA was not a significant predictor of student success. Kabiri et al. (2017) studied the effects of different input variables on success in physical therapy programs. They found performance in college algebra could not be used to predict success. In a similar study conducted by Robert (2018), math GPA was also found to not be significant in the success of associate-degree-level nursing students. Likewise, the model for this study indicates math GPA is not a significant predictor of student success. For these reasons, it is recommended that math GPA should perhaps be omitted from the selection criteria for RT programs.

Implications

Capturing the most qualified students to maximize the limited number of clinical spots makes the competitive selection process for any health-related program imperative (Ingrassia, 2016; Oranye, 2016; Prideaux et al., 2011). Although the number of health care educational programs continues to increase, the number of vacancies in the field of RT continues to rise. The findings in this study could benefit associate degree RT programs in selecting students who may

pass their credentialing exam on the first attempt. The use of standardized tests such as the PSB-HOAE or TEAS as selection criteria is supported by the findings of the study. BIOL 2114L Anatomy and Physiology II Lab had a stronger association with student success compared to BIOL 2113 Anatomy and Physiology I Lecture, BIOL 2113L Anatomy and Physiology I Lab and BIOL 2114 Anatomy and Physiology II Lecture. Program administrators may want to consider using BIOL 2114 Anatomy and Physiology II lecture and 2114L Anatomy and Physiology II Lab in their selection requirements rather than only using BIOL 2113 Anatomy and Physiology I lecture and BIOL 2113L Anatomy and Physiology I Lab. The only environmental predictor in the study was RADT 1085 Radiographic Equipment. As The I-E-O model (Astin & Antonio, 2012) implies, environmental factors may improve outcomes of success and should be considered as students are preparing for the ARRT credentialing exam while still in the program and prior to taking the exam. Overall, the data provided preliminary evidence supporting The I-E-O model of higher learning. Input and environmental factors are important in student outcomes. A student's personal qualities and talents developed before entering an educational program have a significant impact on their success. Environmental factors were identified by Astin and Antonio (2012) as something that can be controlled by the educator. Although the environmental factor (RADT 1085 Radiographic Equipment) in the study did not yield any significant findings, evidence of any correlation with RT student success was found. RT program directors should consider offering the course during a semester which would maximize the time. For example, offering the course during a 15-week fall or spring semester might prove beneficial to the overarching goal of passing the ARRT radiography credentialing exam on the first attempt compared to a shorter semester in the summer. In addition, curriculum for RADT 1085 may need to be revised to divide the student learning outcomes into two distinct courses. Doing so may give instructors the opportunity to increase the depth of study in each

topic related to image acquisition, technical evaluation, equipment operation and quality assurance, all areas identified by the ARRT as the weakest performance areas on the radiography credentialing exam.

Recommendations For Future Research

The results of the study led to several recommendations for future research. First, it is recommended the study be repeated using a sample from a similar population to check for consistency and validity. Second, further investigation is needed to determine how semester length impacts student success regarding the environmental variable, RADT 1085 Radiographic Equipment. In addition, a longitudinal study including self-reported scores from the ARRT radiography credentialing exam could provide more depth on selection criteria and student success. With self-reported scores, program directors could conduct a multilinear regression analysis, which may predict a range of performances. Overall, more research in the field of RT education needs to be conducted. The lack of literature related to RT education supports the need of further investigation.

Summary

Using IBM SPSS Statistics for Windows, Version 26.0 a backward logistic regression analysis produced a final multivariable model that was significant, chi-squared (7) = 32.06, $p < .001$. The model explained 38.9% (Nagelkerke R^2) of the variance in passing the credentialing exam on a first attempt and correctly classified 95.3% of the cases. Sensitivity was 100%, specificity was 27.3%; the positive predictive value was 95.2% with a 100% negative predictive value. Two independent variables were found to be significant: PSB-HOAE/TEAS Score and BIOL 2114L. ASRT (2019a) reported increasing vacancy rates for radiographers from 1.7% in 2013 to 8.5% in 2019. Proportions tests for the PSB-HOAE and TEAS found no significant difference between the proportion of students that passed on the first attempt. Limited

clinical space and the global pandemic from COVID will likely increase vacancy rates for radiologic technologists significantly. Improving the competitive selection process for RT associate degree level students will enable more graduates to be successful on the ARRT radiography credentialing exam, which will expand the number of registered radiologic technologists to help decrease the vacancies and improve patient care. The impact of the study is small; however, for a developing profession, this study may empower other RT educators to expand research in this field.

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Appendix A:

Technical College A Campus 1 Program Effectiveness Data

Program Effectiveness Data

[redacted] Technical College-[redacted] Campus

Five Year Completion Rate

Year	Enrollment	Graduates	Completion Rate
2015	20	18	90%
2016	40	36	90%
2017	20	18	90%
2018	24	20	83.3%
2019	21	17	80.95
Total	125	109	**Final 5 yr average: 86.85%**

Five Year Average Credentialing Examination Pass Rate

Year	# of graduates that attempted the ARRT exam	# of graduates that passed the ARRT exam on the 1st attempt	
2015	18	16	88.9%
2016	36	33	91.7%
2017	18	15	83.3%
2018	16*	14*	87.5%
2019	17	15	88.24%
Total	105	93	**Final 5 yr average: 87.93%**

*Four students from the 2018 cohort did not attempt the registry within six months of graduation.

Five Year Average Job Placement Rate

Year	# of graduates	Total # of graduates actively seeking employment	Total # working in field in 12 months after graduation	
2014	19	19	19	100%
2015	18	18	18	100%
2016	36	33	33	100%
2017	18	17	17	100%
2018	20	16	15*	93.8%
Total	111	103	102	**Final 5 yr average: 98.8%**

*Two of the students are not actively seeking employment due to a major accident/serious health issues that happened after graduation. The third student changed her career path to Biotechnology. The fourth student didn't pass on first attempt and hasn't been actively seeking employment.

Updated on 2/15/2020

Appendix B:

Program Director Survey Instrument

Program Director Questionnaire

Start of Block: Default Question Block

JS

Please review the Informed Consent

Informed Consent Form

Introduction

You are being asked to participate in a research study entitled *Relationships Between Student Selection Criteria and Student Success Among Radiologic Technology Graduates at 2-year Public Technical Colleges in the Southeastern United States* which is being conducted by Patricia Fair Wynne, a doctoral candidate at Valdosta State University under the supervision of Dr. Kenny Ott in the Dewer College of Education and Human Services. The purpose of this study is to identify selective admission criteria that predicts student success on the ARRT radiography credentialing exam on the first attempt. You will receive no benefits from participating in this research study. However, your responses may help us gain additional understanding of selection criteria and how it relates to the success of Radiologic Technology students. There are no foreseeable risks or discomforts involved in participating in this study other than those encountered in day-to-day life. Participation should take approximately 10 minutes to complete. All data in this study will be protected. Data for this study will be stored on the researcher's personal computer and external back up drive. After keeping the data for three years, the researcher will destroy both in paper and digital items. The optional Competitive Selection Data Form Should take 1.5 to 2 hours to complete, depending on the number of students in each cohort. Your participation is voluntary. You may choose not to participate, to

stop responding at any time, or skip question that you do not want to answer. You must be at least 18 years of age to participate in this study. Your participation serves as your voluntary agreement to participate in this research project and your certification that you are 18 or older.

Questions regarding the purpose or procedures of the research should be directed to Patricia Wynne at pfwynne@valdosta.edu. This study has been approved by the Valdosta State University Institutional Review Board (IRB) for the Protection of Human Research Participants. The IRB, a university committee established by federal law, is responsible for protecting the rights and welfare of the research participants. If you have concerns or questions about your rights as a research participant, you may contact the IRB Administrator at 229-253-2947 or irb@valdosta.edu.

Q1 Name of Institution:

▼ [redacted] Campus (9) ... [redacted] Technical College (30)

JS

Q25 After reviewing the Informed Consent, do you agree to participate in the online questionnaire?

- ○ Yes (1)
- ○ No (2)

Skip To: End of Survey If After reviewing the Informed Consent, do you agree to participate in the online questionnaire? = No

Q2 Title of the person responding to this questionnaire (Please choose the one that is the most appropriate)

- ○ Radiology Program Director (58)
- ○ Academic Dean (59)
- ○ Associate/Assistant Dean (60)
- ○ Radiology Program Admission/Selection Committee Member (61)
- ○ Radiology Program Faculty Member (62)

Q3 For the 2017 graduating cohort, how many students:

_____ Started in the 2017 Cohort (1)

_____ Graduated in the 2017 Cohort (2)

Q4 Which of the following courses (or equivalent courses) were used in your college's competitive selection process for the 2017 graduating cohort? Check all that apply.

- [ ] ENGL 1101 Composition and Rhetoric (1)
- [ ] MATH 1101 Math Modeling (2)
- [ ] MATH 1111 College Algebra (3)
- [ ] MATH 1103 Quantitative Skills and Reasoning (4)
- [ ] BIOL 2113 Anatomy and Physiology I (5)
- [ ] BIOL 2113L Anatomy and Physiology I Lab (6)
- [ ] BIOL 2114 Anatomy and Physiology II (7)
- [ ] BIOL 2114 Anatomy and Physiology II Lab (8)
- [ ] Other (9) _____
- [ ] Other (10) _____
- [ ] Other (11) _____
- [ ] Other (12) _____

Q5 Standardized tests were used in competitive selection for the Radiologic Technology graduating class of 2017?

▼ Yes (1) ... Not Sure (3)

Q6 What standardized test was used for the Radiologic Technology competitive selection for the graduating class of 2017

- ☐ Psychological Service Bureau-Health Occupations Aptitude Exam (PSB-HOAE) (1)
- ☐ Test of Essential Academic Skills (TEAS) (2)
- ☐ None of these (3)
- ☐ Other (4) _____

Q7 Did the Graduating class of 2017 Self-report their ARRT first-attempt Registry Scores to the Program Director?

▼ Yes (1) ... No (2)

Q8 Changes to the program in 2017: (Check all that apply)

- ☐ Change in Program Director (1)
- ☐ Change in Curriculum (2)
- ☐ Unexpected shut down (3)

☐ None of these (4)

☐ Other (5) _____

Q9 For the 2018 graduating cohort, how many students:

_____ Started in the 2018 Cohort (1)

_____ Graduated in the 2018 Cohort (2)

Q10 Which of the following courses (or equivalent courses) were used in your college's competitive selection process for the 2018 graduating cohort? Check all that apply.

☐ ENGL 1101 Composition and Rhetoric (1)

☐ MATH 1101 Math Modeling (2)

☐ MATH 1111 College Algebra (3)

☐ MATH 1103 Quantitative Skills and Reasoning (4)

☐ BIOL 2113 Anatomy and Physiology I (5)

☐ BIOL 2113L Anatomy and Physiology I Lab (6)

☐ BIOL 2114 Anatomy and Physiology II (7)

☐ BIOL 2114 Anatomy and Physiology II Lab (8)

☐ Other (9) _____

☐ Other (10) _____

☐ Other (11) _____

☐ Other (12) _____

Q11 Standardized tests were used in competitive selection for the Radiologic Technology graduating class of 2018?

▼ Yes (1) ... Not Sure (3)

Q12 What standardized test was used for the Radiologic Technology competitive selection for the graduating class of 2018

☐ Psychological Service Bureau-Health Occupations Aptitude Exam (PSB-HOAE) (1)

☐ Test of Essential Academic Skills (TEAS) (2)

☐ None of these (3)

☐ Other (4) _____

Q13 Did the Graduating class of 2018 Self-report their ARRT first-attempt Registry Scores to the Program Director?

▼ Yes (1) ... Click to write Choice 2 (4)

Q14 Changes to the program in 2018: (Check all that apply)

- ☐ Change in Program Director (1)
- ☐ Change in Curriculum (2)
- ☐ Unexpected shut down (3)
- ☐ None of these (4)
- ☐ Other (5) _____

Q15 For the 2019 graduating cohort, how many students:

_____ Started in the 2019 Cohort (1)

_____ Graduated in the 2019 Cohort (2)

Q16 Which of the following courses (or equivalent courses) were used in your college's competitive selection process for the 2019 graduating cohort? Check all that apply.

- ☐ ENGL 1101 Composition and Rhetoric (1)
- ☐ MATH 1101 Math Modeling (2)
- ☐ MATH 1111 College Algebra (3)
- ☐ MATH 1103 Quantitative Skills and Reasoning (4)
- ☐ BIOL 2113 Anatomy and Physiology I (5)
- ☐ BIOL 2113L Anatomy and Physiology I Lab (6)

☐ BIOL 2114 Anatomy and Physiology II (7)

☐ BIOL 2114 Anatomy and Physiology II Lab (8)

☐ Other (16) _____

☐ Other (17) _____

☐ Other (18) _____

☐ Click to write Choice 12 (19)

_____

Q17 Standardized tests were used in competitive selection for the Radiologic Technology graduating class of 2019?

▼ Yes (1) ... Not Sure (3)

Q18 What standardized test was used for the Radiologic Technology competitive selection for the graduating class of 2019?

☐ Psychological Service Bureau-Health Occupations Aptitude Exam (PSB-HOAE) (1)

☐ Test of Essential Academic Skills (TEAS) (2)

☐ None of these (3)

☐ Other (4) _____

Q19 Did the Graduating class of 2019 Self-report their ARRT first-attempt Registry Scores to the Program Director?

▼ Yes (1) ... No (2)

Q20 Changes to the program in 2019: (Check all that apply)

☐ Change in Program Director (1)

☐ Change in Curriculum (2)

☐ Unexpected shut down (3)

☐ None of these (4)

☐ Other (5) _____

Q21

If you are willing to provide competitive selection data for Radiologic Technology cohorts who graduated between 2017 and 2019, please provide your email address below. The researcher will contact you with more information.

_____

_____

_____

_____

_____

JS

Q22

Questions regarding the purpose or procedures of the research should be directed to Patricia Wynne at pfwynne@valdosta.edu. This study has been approved by the Valdosta State University Institutional Review Board (IRB) for the Protection of Human Research Participants. The IRB, a university committee established by federal law, is responsible for protecting the rights and welfare of the research participants. If you have concerns or questions about your rights as a research participant, you may contact the IRB Administrator at 229-253-2947 or irb@valdosta.edu.

End of Block: Default Question Block

Appendix C:

Instructional Faculty Consortium Committee Meeting Minutes

Stop!! Do Not Complete This Form before Downloading and Saving to your PC. This is an MS Word Document. Using the 'TAB' key on the keyboard works best in moving from field to field.

Instructional Faculty Consortium Committee Meeting (IFCC)

MINUTES

JANUARY 10, 2014 | 10AM-3PM | TCSG ATL BOARD ROOM

PROGRAM	Radiologic Technology
FACILITATOR	[redacted]
SECRETARY	[redacted]
ATTENDEES	

Agenda Topics

REDUCTION OF PROGRAM HOURS FOR RADT ASSOCIATES DEGREE — 1 HOUR — [redacted]

DISCUSSION

[redacted] introduced [redacted] to the RADT Faculty. [redacted] gave each faculty member an opportunity to introduce him or herself and state what college they represented.

[redacted] explained the reasons for the request in reduction of hours to the RADT program. He stated that the current TCSG policy states that Associate programs are no more than 73 credit hours. [redacted] explained to the RADT faculty that we had two choices in response to this:

1) We as a faculty of experts could reduce the program length to 73 credit hours or
2) make every attempt to reduce the hours to 73, but if we cannot, then provide a very detailed explanation as to why we cannot reduce the number of hours.

[redacted] also stated that if we do not reduce the credit hours at all or reduce them enough we would need to request a waiver and would need to work quickly on justification of that waiver. As a Committee we need to have the changes/requests to the TCSG well before March 5th. The RADT IFCC met in October 2013 and had already started working as subcommittees on the reduction of hours. A request to go ahead and begin working on this immediately was granted and the IFCC members took the floor.

CONCLUSIONS

[redacted] gave the faculty an opportunity to ask questions and during the Q & A session we learned the following:

1. The formula for calculating
Lecture= 1:1
Lab 2= 2:1
Clinic- 3:1

2. Each College would make the decision on what Semester their RADT program would start.
3. Each College would decide when courses where taught within the program.
4. The program length would be 4 semester hours (Later Clarified after lunch)

Program Length will be 4 semesters- Programs will have autonomy to determin semester start time for their individual programs (Fall, Spring or Summer) Must be implemented by Fall of 2015.

[redacted] left the meeting but did return to answer other questions regarding the number of hours and waiver process.

ACTION ITEMS	PERSON RESPONSIBLE	DEADLINE
Minutes presented to [redacted]	[redacted]	01/13/2014

Appendix D:

Technical College A Campus 2 Program Effectiveness Data

Program Effectiveness Data

[redacted] Technical College - [redacted] Campus

Program Effectiveness Data

Data Set	Results by Year	Time Frame	Results
Five year average national credentialing examination pass rate on the first attempt for the national registry examination administered by the American Registry of Radiologic Technologists (ARRT) within six months of graduation.	Class | Number of 1st time test takers | Number passing 1st attempt | Pass rate 2015 | 8 | 6 | 75% 2016 | 13 | 13 | 100% 2017 | 13 | 13 | 100% 2018 | 14 | 13 | 93% 2019 | 12 | 12 | 100% Total | 60 | 57 | 95%	2015-2019	Credentialing Exam pass rate of 5 year average = 95%
Annual program completion rate (# of students completing the program within 26 months after Drop/Add first semester of enrollment after acceptance) JRCERT Benchmark 75% CGTC Benchmark 80%	Class | Number of students who began the program | Number of students completing the program | Completion Rate 2015 | 12 | 8 | 67%** 2016 | 15 | 13 | 87% 2017 | 15 | 13 | 87% 2018 | 15 | 14 | 93% 2019 | 16 | 12 | 75% *Class of 2013- 3 students withdrew because of change of career and 1 student withdrew due to medical issues. *Class 2014 -3 students withdrew because of change of career; 1 student withdrew due to medical issues. **Class of 2015 - 3 students changed their major stating they did not want t tbe in healthcare, 1 student withdrew because of family issues. **Class of 2019 – 2 students withdrew because of change of career, 1 student was withdrawn for academic reasons and 1 student withdrew for personal reasons/code of conduct violation.	5 yr. average of 60/73 82%	Completion Rate 2015 – 67% 2016 – 87 % 2017 - 87% 2018 - 93% 2019 - 75%
Graduation Rate Beginning enrollment	Class | Number of students who began the program | Number of students graduating the program | Completion Rate 2015 | 12 | 8 | 67% 2016 | 15 | 13 | 87% 2017 | 15 | 13 | 87% 2018 | 15 | 14 | 93% 2019 | 16 | 12 | 75%	2015-2019	Graduation Rate 2015 – 67% 2016 – 87% 2017 – 87% 2018 - 93% 2019 - 75%
Job Placement Rate – five year average job placement rate based on percentage of graduates actively seeking employment* and gaining employment within 12 months of graduation JRCERT Benchmark 75% CGTC Benchmark 80%	Class | # of graduates | Total # actively seeking employment in field | Total # working in field in 12 months after graduation | % employed in 12 months after graduation 2015 | 8 | 6 | 6 | 100% 2016 | 13 | 13 | 13 | 100% 2017 | 13 | 13 | 13 | 100% 2018 | 14 | 14 | 14 | 100% 2019 | 12 | 12 | 12 | 100% Total | 60 | 58 | 58 | 100%	2015-2019	Job placement rate 5-year average 100%

*JRCERT defines "not actively seeking employment" as:

1) Graduate fails to communicate with program officials regarding employment status after multiple attempts OR
2) Graduate is unwilling to seek employment that requires relocation OR
3) Graduate is unwilling to accept employment due to salary or hours OR
4) Graduate is on active military duty OR
5) Graduate is continuing education.

Appendix E:

Technical College B Program Effectiveness Data

[redacted] Technical College
Radiography Program
Program Effectiveness Data

Credentialing Examination (ARRT) Pass Rate

Class of	Number of first time Examinees taking Registry	Number of First Time Examinees Passing the	First Time Pass Rate	Five Year Average of First Time Pass Rate
2009	18	18	100%	
2010	13	13	100%	
2011	16	16	100%	
2012	*No grads this year due to statewide semester conversion*			
2013	18	18	100%	
2014	18	18	100%	
2015	18	18	100%	100.0%
2016	18	18	100%	
2017 a	19	19	100%	
2017 b	16	16	100%	
2018	18	18	100%	

Number of Program Graduates

Class of	Number of Accepted Students	Number of Program Graduates	Program Completion Rate	Five Year Average of Program Graduates
2009	20	18	90%	
2010	20	13	65%	
2011	18	16	89%	
2012	*No grads this year due to semester conversion*			
2013	18	18	100.00%	
2014	20	18	90.00%	
2015	20	18	90.00%	
2016	20	18	90.00%	88.6%
2017 a	20	19	95.00%	
2017 b	20	16	80.00%	
2018	20	18	90.00%	

Appendix F:

Technical College C Program Effectiveness Data

ARRT National certification exam Pass Rates (5 year average)

Year	Number of 1st time examinees taking national certification exam within the most recent 5 year period	Number of first time examinees passing the national certification exam on the first attempt within the most recent 5 year period	ARRT (national certification exam) 5 year average first time pass rate
2015-2019	47	44	94%
2014-2018	53	50	94%
2013-2017	52	48	92%
2012-2016	50	46	92%
2011-2015	49	46	94%
2010-2014	49	45	92%
2009-2013	47	40	85%
2008-2012	53	45	85%
2007-2011	59	51	86%
2006-2010	60	52	87%

Appendix G:

Technical College D Program Effectiveness Data

Five Year Completion Rate

Year	# of students that began the program	# of students that completed the program	
2019	13	9	69%
2018	12	8	67%
2017	14	13	93%
2016	24	19	79%
2015	13	11	85%
Total	76	60	**Final Avg = 79%**

Five Year Average Credentialing Examination Pass Rate

Year	# of graduates that attempted the ARRT exam	# of graduates that passed the ARRT exam on the 1st attempt	
2019	9	8	89%
2018	8	7	88%
2017	12	12	100%
2016	19	19	100%
2015	11	11	100%
Total	59	57	**Final Avg = 97%**

Five Year Average Job Placement Rate

Year	# of graduates that actively sought employment	# of graduates that found employment within twelve months of graduation	
2019	7	7	100%
2018	7	7	100%
2017	11	11	100%
2016	19	19	100%
2015	11	11	100%
Total	55	55	**Final Avg = 100%**

Appendix H:

Technical College E Program Effectiveness Data

Radiologic Technology Degree Program

Credentialing Exam Pass Rate

Five-year averages of the American Registry of Radiologic Technologists (ARRT) credentialing examination pass rate not less than 75% at first attempt within six months of graduation

Year	Pass Rate on First Attempt *First Attempt within 6 months of graduation*	Number of Graduates
2015	100%	6 out of 6 graduates passed on 1st attempt
2016	36%	4 out of 11 graduates passed on 1st attempt
2017	84.6%	11 out of 13 graduates passed on 1st attempt within six months of graduation • 2 graduates did not take the ARRT exam within six months of graduation
2018	83.3%	5 out of 6 graduates passed on 1st attempt
2019	100%	5 out of 5 graduates passed on 1st attempt within six months of graduation • 1 graduate did not take the ARRT exam within six months of graduation
5 Year Average	**75.6%**	31/41 = 75.6%

Appendix I:

Competitive Selection Criteria Data Form

Competitive Selection Criteria Data Form

College Name _____

Cohort Start Date_____ Cohort Graduation Date_____

	Student										
Criteria	Example	1	2	3	4	5	6	7	8	9	10	11
PSB SCORE	250											
BIOL 2113 GPA A, B, C or D	A											
BIOL 2113L A, B, C or D	A											
BIOL 2114 A, B, C or D	B											
BIOL 2113 A, B, C or D	A											
MATH 1111, 1101 or 1103 grade A, B, C or D	C											
RADT 1085 GPA A, B, C or D	B											
Pass ARRT Credentialing Exam on the first attempt? Y or N	Yes											

Page _____ of _____

Appendix J:

Valdosta State University IRB Approval

Institutional Review Board (IRB)
For the Protection of Human Research Participants

PROTOCOL EXEMPTION REPORT

Protocol Number: 04085-2020 **Responsible Researcher:** Patricia Wynne

Supervising Faculty: Dr. Kenny Ott

Project Title: *Relationships Between Student Selection Criteria and Student Success Among Radiologic Technology Graduates at 2-Year Public Technical Colleges in the Southeastern United States.*

INSTITUTIONAL REVIEW BOARD DETERMINATION:

This research protocol is **Exempt** from Institutional Review Board (IRB) oversight under Exemption **Category 2.** Your research study may begin immediately. If the nature of the research project changes such that exemption criteria may no longer apply, please consult with the IRB Administrator (irb@valdosta.edu) before continuing your research.

ADDITIONAL COMMENTS:

- *Upon completion of this research study all data (email correspondence, survey data, participant name lists, etc.) must be securely maintained (locked file cabinet, password protected computer, etc.) and accessible only by the researcher for a minimum of 3 years.*

☒ ***If this box is checked, please submit any documents you revise to the IRB Administrator at irb@valdosta.edu to ensure an updated record of your exemption.***

Elizabeth Ann Olphie *10.06.2020*
Elizabeth Ann Olphie, IRB Administrator

Thank you for submitting an IRB application.
Please direct questions to irb@valdosta.edu or 229-253-2947.

Revised: 05.02.16

Appendix K:

Permission to Use, Modify, and Publish Instrument

From: Margaret J. Fehrenbach RDH MS <margaret@dhed.net>
Sent: Sunday, July 19, 2020 9:50 PM
To: Wynne, Patricia <[redacted]
Subject: Re: Permission to Use Questionnaire

Yes, Patricia. I give my permission. Have a wonderful career. Margaret

Sent from my iPhone

On Jul 19, 2020, at 5:31 PM, Wynne, Patricia <[redacted] wrote:

Greetings from Macon, Georgia!

Dr. Fehrenbach,

I am a doctoral student at Valdosta State University completing a dissertation in the area of Adult and Career Education. I am writing to ask written permission to use the Selection Criteria Dental Hygiene questionnaire in my research study. The title of my proposed research is "Relationships Between Student Selection Criteria and Student Success Among Radiologic Technology Graduates from Two-Year Technical Colleges in the Southeastern United States." My research is being supervised by my professor, Dr. Kenny Ott.

If permitted to use the instrument you developed, I would need to modify it and adapt questions specific to the field of Radiologic Technology. I have attached the portion I would use and have included those modifications. This instrument would be put into an electronic survey platform such as Survey Gizmo and would be sent electronically to program directors within in the state of Georgia.

In addition to using the instrument, I also ask your permission to reproduce it in my dissertation appendix. The dissertation will be published in the Valdosta State University Institutional Repository at https://vtext.valdosta.edu/xmlui/ and deposited in the ProQuest Dissertations & Theses database.

I would like to use and reproduce your Selection Criteria Dental Hygiene questionnaire under the following conditions:

- I will use the questionnaire only for my research study and will not sell or use it for any other purposes

- I will include a statement of attribution and copyright on all copies of the instrument. If you have a specific statement of attribution that you would like for me to include, please provide it in your response.
- At your request, I will send a copy of my completed research study to you upon completion of the study and/or provide a hyperlink to the final manuscript

Patricia Fair Wynne

<RADT Questionnaire For Program Chairs P Wynne Dissertation.docx>

Appendix L:

TCSG Permission Granted Letter

Technical College System of Georgia

Brian P. Kemp
Governor

Gregory C. Dozier
Commissioner

October 10, 2020

Ms. Patricia Wynne
[redacted]

Dear Ms. Wynne:

The Technical College System of Georgia (TCSG) has received the forms and documentation related to your intended dissertation research of Radiologic Technology graduate test scores at [redacted] Technical College, [redacted] Technical College, [redacted] Technical College, [redacted] Technical College and [redacted] Technical College in your doctoral research study *"Relationships Between Student Selection Criteria and Success Among Radiologic Technology Graduates at Two-Year Technical Colleges in the Southeastern United States."* We have reviewed the summary of your research, as well as the IRB document issued to you by Valdosta State University.

In accordance with the IRB process, as well as the documents you submitted to TCSG with regard to the parameters and intent of your study, we authorize you to continue with the research project with the stipulations that your research should be conducted at times that do not directly coincide with your CGTC work schedule or the schedules of any participants from the respective colleges. Lastly, please utilize your Valdosta State email for all communication related to your research and not your CGTC email.

Please make it clear to participants that the study is a personal venture associated with your doctoral studies independent of TCSG and that **participation in the study is strictly voluntary**.

If you have any questions, please do not hesitate to contact me. I may be reached at (404) 679-1663 or agallman@tcsg.edu.

Sincerely,

Anthony Gallman

Anthony Gallman, MBA
Accountability Specialist

cc: Dr. Kathryn R. Hornsby
Dr. Marjorie Kuezi-Nke
Ms. Janelle Cornwall
Mr. Richard Young
Ms. Deborah Burks
Dr. Joanne Tolleson
Dr. Katie Davis
Mr. Mitchell Fagler
Ms. Brandy Taylor

Appendix M:

TCSG Revised Permission Granted Letter

Technical College
System of Georgia

Brian P. Kemp
Governor

Gregory C. Dozier
Commissioner

November 18, 2020

Ms. Patricia Wynne
[redacted]

Dear Ms. Wynne:

The Technical College System of Georgia (TCSG) has received the forms and documentation related to your intended dissertation research of Radiologic Technology graduate test scores at [redacted] Technical College, [redacted] Technical College, [redacted] Technical College, [redacted] echnical College, [redacted] Technical College and [redacted] Technical College in your doctoral research study *"Relationships Between Student Selection Criteria and Success Among Radiologic Technology Graduates at Two-Year Technical Colleges in the Southeastern United States."* We have reviewed the summary of your research, as well as the IRB document issued to you by Valdosta State University.

In accordance with the IRB process, as well as the documents you submitted to TCSG with regard to the parameters and intent of your study, we authorize you to continue with the research project with the stipulations that your research should be conducted at times that do not directly coincide with your CGTC work schedule or the schedules of any participants from the respective colleges. Lastly, please utilize your Valdosta State email for all communication related to your research and not your CGTC email.

Please make it clear to participants that the study is a personal venture associated with your doctoral studies independent of TCSG and that **participation in the study is strictly voluntary**.

If you have any questions, please do not hesitate to contact me. I may be reached at (404) 679-1663 or agallman@tcsg.edu.

Sincerely,

Anthony Gallman

Anthony Gallman, MBA
Accountability Specialist

cc: Dr. Kathryn R. Hornsby
Dr. Marjorie Kuezi-Nke
Ms. Janelle Cornwall
Mr. Richard Young
Ms. Deborah Burks
Dr. Joanne Tolleson
Dr. Katie Davis
Mr. Mitchell Fagler
Ms. Brandy Taylor
Dr. Stephanie Meyer

1800 Century Place, Suite 400 • Atlanta, Georgia 30345-4304 • 404.679.1600

Appendix N:

Central Georgia Technical College IRB Approval Letter

10 / 20 / 2020
Date Submitted

Central Georgia Technical College
Institutional Review Board

W192020
File Number

FULL IRB REVIEW PROTOCOL SUMMARY FORM

Relationships Between Student Selection Criteria and Success Among Radiologic Technology Graduates at Two-Year Technical Colleges in the Southeastern United States
Title of Research Project

Valdosta State University
College or University

Patricia Fair Wynne	Academic Affairs	3552	pwynne@centralgatech.edu
Principal Investigator/Project Director	**Department**	**Phone Extension**	**Email address**

Address (If not a CGTC Employee)	**City**	**State**	**Phone**

Co-investigator/Student Investigator	**Department**	**Phone Extension**	**Email address**

Co-investigator/Student Investigator	**Department**	**Phone Extension**	**Email address**

Anticipated Funding Source: N/A

Projected Duration of Research: 6 **months** **Projected Starting Date:** 10/2020

Other organizations and/or agencies, if any, involved in the study:
Valdosta State University
Lanier Technical College
Ogeechee Technical College
Oconee Fall Line Technical College
Southeastern Technical College

Please answer the questions below and return this form with:

- A memo that briefly describes the intent of the project
- A completed copy of the Consent Form Checklist
- A copy of the Consent Form that will be provided to the participants
- A copy of any survey instrument to be utilized in the proposed research

I. Project Information:

A. Project Activity Status:

- ☒ **New Project**
- ☐ **Periodic Review of Continuing Project**
- ☐ **Revision to Previously Approved Project**

B. This project involves Central Georgia Technical College students or personnel

Students: ☒ **Yes** ☐ **No** **Personnel:** ☒ **Yes** ☐ **No**

C. Human Subjects from the following populations will be involved in this study

- ☐ **Minors**
- ☐ **Mentally Disabled**
- ☐ **High School Students**
- ☐ **Prisoners**

☐ **Elderly**

☐ **Other**_____
☒ **None of the above**

D. Estimated number of subjects to be studied: __125_____

II. Abstract Describing Project and Purpose (Include a description of all experimental methods to be used and design and program activities; what measures or observations will be taken in the study? If any questionnaires, tests or other instruments are to be used include a brief description and a copy of such instrument.)

The objective of this quantitative correlational research, using ex post facto data, is to identify selective admission criteria that predicts student success on the ARRT Radiography credentialing exam on the first attempt in Associate Degree Radiologic Technology programs within technical colleges in Georgia). The aim of this study is to identify criteria that serves as predictors of student success, resulting in higher completion rates, pass rates, and ultimately addressing the vacancies within medical imaging departments in the United States.

After appropriate TCSG approval, and Central Georgia Technical College IRB approval has been obtained, an email that includes a link to the electronic survey instrument will be emailed to each college's program director (**See Exhibit 1 Program Director Questionnaire**). Question 21 of the questionnaire will ask if the program director is willing to share cohort selection data from 2017- 2019 graduates. Each program director agreeing to participate will be provided a Competitive Selection Criteria Data Form specifically designed for this study via email. Once the data from the Competitive Selection Criteria Data Form is collected in electronic form, it will be transferred to an Excel workbook for organizational and analytical purposes. Final analysis of the data will be conducted using SPSS statistical program, using a quantitative, linear regression stepwise method.

This questionnaire is exempt from full human subject review since confidentiality will be maintained and information is not sensitive in nature. After the survey instrument has been reviewed and participation of the program director is confirmed, a Competitive Selection Criteria Data form (**See Exhibit 2 Competitive Selection Criteria Data Form**), will be sent to each program director for compilation.

Attached: Exhibit 1: Program Director Questionnaire
Exhibit 2: Competitive Selection Criteria Data Form

III. Protocol (Who will be the research subjects? How will they be solicited or contacted? Include any recruitment letters or other recruitment materials with this document; How much time will be required of each subject? Describe procedures to which humans will be subjected – use additional pages if necessary)

Data from the research subjects will include approximately 125 Macon Campus Radiologic Technology program from 2017-2019. Only the retrospective data from these students will be used for this study and will include competitive selection criteria as listed below:

1. Math GPA used in competitive selection process
2. Science GPA used in competitive selection process
3. Standardized Test Results used in the competitive selection process
    a. PSB and/or
    b. TEAS
4. P/F result on self-reported ARRT Radiography Credentialing Exam (This result is self-reported to the Program Director. The Program Director has access to the ARRT results and can confirm the student's passing the exam.

After IRB approval from VSU, TCSG and from each college of interest, program directors would be contacted by email with a letter of participation. The letter of participation explains the purpose and time associated with the research project. The letter of consent also provides a link to the electronic questionnaire. The questionnaire takes approximately 10 minutes to complete. An option to provide aggregate data from RT graduate cohorts from 2017-2019 related to math and science GPAs, scores on standardized tests used for selection and whether the student passed the ARRT Radiography Credentialing exam on the first attempt would be emailed to any participant agreeing to participate in this option. The time needed to complete the optional aggregate data would be approximately 1-2 hours, depending on the number of students in each cohort. The overarching goal of the researcher is to email the letter requesting participation to program directors by November 1, 2020 and collect aggregate student ex post facto retrospective data by November 30th via email from program directors.

IV. Precautions (What steps will be taken to ensure that each subject's participation is voluntary? What, if any, inducements will be offered to the subjects for their participation?)

This study included an electronic Questionnaire that begins with an Informed Consent explain the voluntary nature of participation. Participants may choose No after reviewing the Informed Consent, at which point the questionnaire would end immediately upon submitting "No". If the participant agreed to participate in the survey by selecting "Yes" they would be taken to a series of questions pertaining to competitive selection criteria used for programmatic selection and the number of students who completed their RT programs between 2017 and 2019. The questionnaire takes approximately 10 minutes to complete. An option to provide aggregate data from RT graduate cohorts from 2017-2019 related to math and science GPAs, scores on standardized tests used for selection and whether the student passed the ARRT Radiography Credentialing exam on the first attempt is also included for those choosing to participate. The time needed to complete the optional aggregate data would be approximately 1-2 hours, depending on the number of students in each cohort.

No inducements will be offered to the subjects for their participation in this study.

V. Confidentiality of data (Describe the methods to be used to ensure the confidentiality of data obtained, including plans for publication, disposition or destruction of data, etc.)

If permitted to conduct study, electronic data would be transferred to an Excel workbook for organizational and analytical purposes. Final analysis of the data will be conducted using SPSS statistical program. Demographic as well as any other identifying data will be coded numerically. Names of institutions will be de-identified and will be assigned a random name such as Madame Curie Technical College. An encrypted flash drive will be used for storing the data. The flash drive will be placed in a secured office cabinet located in the home office of researcher and all electronic and hardcopy data will be destroyed after three years.

VI. Consent (Attach a copy of all consent forms to be signed by the subjects and/or any statements to be read to the subject)

Attached: **Exhibit 1: Program Director Questionnaire**
Exhibit 3 Letter Requesting Participation/Consent

RESPONSIBILITIES OF THE PRINCIPAL INVESTIGATOR:

- Any additions or changes in procedures in the protocol will be submitted to the IRB for written approval prior to these changes being implemented
- Any problems connected with the use of human subjects once the project has begun must be communicated to the IRB Chair
- The principal investigator is responsible for retaining informed consent documents for a period of three years after the project.

I certify that the protocol and method of obtaining informed consent as approved by the Central Georgia Tech Institutional Review Board will be followed during the period covered by this research project. Any future changes to the research project will be submitted to the IRB for review and approval prior to implementation.

Patricia Fair Wynne 10/06/2020 ____ / / __
Principal Investigator Signature Co-Investigator/Student Signature (if appropriate)

Signature of IRB Chair: DJBurks				**Date:** 10/21/2020
IRB Chair: Check 1 box:	☑ **Approved**	☐ **Approved with Restrictions**	☐ **Tabled**	☐ **Disapproved**