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Using Simulations to Prepare for College and Careers in Information Technology

Kathy Michelle Landers
Walden University

Walden University

College of Education

This is to certify that the doctoral dissertation by

Kathy H. Landers

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Review Committee
Dr. Carla Lane-Johnson, Committee Chairperson, Education Faculty
Dr. Michael Marrapodi, Committee Member, Education Faculty
Dr. Jennifer Lapin, University Reviewer, Education Faculty

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2019

Abstract

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Kathy H. Landers

MS, Marist College, 1989

MS, SUNY Cortland, 1982

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy in Education

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Abstract

While simulators can be used in place of hands-on hardware, there was not a significant body of quantitative research supporting the use of simulators for college and career success at the secondary level in information technology (IT). The purpose of this quantitative, nonexperimental study was to determine if there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs, between those who use simulations and those who use hands-on hardware. Kolb's theory of experiential learning was the theoretical foundation for this research. The research questions examined whether there was a significant difference in the written exam grades, the hands-on exam grades, and the certification pass rates of students, based on the percentage of simulation used in their coursework. A survey was used to collect data on 60 students. A one-way Welch ANOVA indicated no significant difference in written grades between groups. A Kruskal-Wallis ANOVA showed statistical significance between groups using all simulated labs and less than 50% simulated labs, as well as between all simulated labs and 50% or greater simulated labs for hands-on grades. Fisher's Exact Test indicated that the proportion of students in the less than 50% simulated labs group who earned industry-level certifications was statistically significantly higher than the 50% or greater simulated labs group or the all simulated labs group. Implications for social change are that workers with entry-level IT skills can fill jobs in the growing IT field that offers well-paying jobs with more promising futures.

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Dedication

This work is dedicated to my mom, Nancy Fath, who was an inspiration of intelligence combined with compassion for others until she passed away in September of 2017. Nancy was a high school educator who cared for every student, and her work was grounded in community service. She always used to say, “ I don’t know where you got your smarts.” I know, mom, I know.

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Most of all, I want to acknowledge my amazing children, Jesse, Mackenzie, and Georgiannah. Thank you for the fantastic things that you do every day that keep me inspired to do amazing things.

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Chapter 1: Introduction to the Study

Information technology (IT) skill simulators can be used to supplement or replace expensive hardware for the teaching and learning of essential computer hardware and software, networking, and cybersecurity skills (Dewey & Shaffer, 2016; Gercek, Saleem, & Steel, 2016). According to Ghani (2015), advances in technology have made it possible for these objectives previously achieved by completing hands-on activities, to be completed using simulations. However, while the jobs in the IT field continue to grow (United States Bureau of Labor Statistics [BLS], 2016), there was not a significant body of quantitative research supporting the use of simulators, as opposed to hands-on hardware labs, for college and career success at the secondary level in IT.

Introduction

The field of IT consists of computer hardware, software, and telecommunication environments (Mishra, Cellante, & Kavanaugh, 2014). IT is a growing field that can provide well-paying occupations for trained individuals (BLS, 2016). However, there is a significant amount of knowledge and skill development that is required to be successful in the computer and IT field (Tagliacane, Prasad, Zajko, Elchouemi, & Singh, 2016). According to Tagliacane et al. (2016), overall, students need opportunities for alternative laboratory solutions so that they can develop the expertise that is necessary to build and maintain computerized and networked systems when access to training on physical hardware is limited. The topic of this study was the need for New York state high school students to develop skills to prepare for the summative assessments required for technical endorsement (New York State Education Department [NYSED], 2011) or the industry-level certification exams necessary for a Career and Technical Education (CTE) alternate pathway to graduation (NYSED, 2016). While instructors at the secondary level might adopt the use of simulations as an alternative methodology for teaching and learning IT skills, a gap existed in the literature on the effectiveness of using simulators in place of a hands-on hardware lab environment at the secondary level.

According to the United States Bureau of Labor Statistics (BLS, 2016), jobs in the field of computer and IT were predicted to increase at a rate of 13% over the period of 2016 to 2026. The projected increase was more substantial than the average for all other professions (BLS, 2016). The median yearly wage of $84,580 for computer and IT workers was more than double the median wage for all other occupations as of May 2018 (BLS, 2016). With the growth of opportunities in IT (BLS, 2016), high school students who want to enter this career field need to be trained with entry-level IT skills to fill entry-level jobs immediately after high school or to better prepare for postsecondary programs.

While New York, as well as many other states, offer approved school district or Board of Cooperative Educational Services (BOCES) CTE programs in the field of IT at the secondary level, hands-on hardware laboratories for teaching and learning skills can be expensive to procure and maintain (Lampi, 2013). Computer technology teachers may use simulations to replace or supplement costly hardware laboratories to achieve educational and industry objectives (Tagliacane et al., 2016). Simulations might allow the student to practice skills when working remotely, and the use of virtual environments may negate the possibility that novice users damage actual hardware (Brinson, 2015). A well-designed simulated lab could allow for feedback to the student and the opportunity to reflect and inform skill practice without the instructor being present (Ghani, 2015). Concerning social change, demonstrating college and career readiness in IT can lead to well-paying jobs and a better quality of life (BLS, 2016).

However, this study needed to be conducted because if a skill learned on a simulator was not transferable to the physical hardware, the student could have difficulty demonstrating proficiency on the New York state required technical endorsement assessments (NYSED, 2011) and industry-level certification exams necessary for a CTE alternative pathway diploma (NYSED, 2016). While some research has provided a lens into comparing skill transferability from simulations to the IT hands-on hardware environment (Lampi, 2013; Shimba, Mahenge, & Sanga, 2016), there was still a gap in knowledge concerning the summative effect of using simulations in place of hands-on hardware. Further research was needed to determine the impact on college and career readiness of secondary students training for IT careers using simulations.

The remaining sections of Chapter 1 provide the background for the study, the problem statement and the purpose of the study. The research questions and hypotheses are detailed along with the theoretical framework and the rationale for the design of the research. Definitions that are relevant to the study are provided; assumptions, scope and delimitations, limitations, and significance are discussed.

Background

While Chapter 2 provides detail concerning a review of the literature, this section offers a brief background on the research related to the scope of this project. This section highlights the knowledge gap addressed. A brief discussion concerning why this study was needed is provided.

The scope of this study considered the connection between the college and career readiness of secondary level students in New York state, preparing for a career in IT, and the use of simulations for teaching and learning in place of hands-on hardware. Therefore, a synthesis of the topics of college and career readiness in the United States, in New York state, and in CTE IT programs of study are included, as well as the benefits and challenges of learning in either a hands-on hardware environment or using simulated labs. Research findings that address agreement and ambiguity on using simulations in place of hands-on hardware are discussed.

A gap in the literature existed regarding the effectiveness of using simulations in place of hands-on hardware for learning IT skills at the secondary level (Ghani, 2015; Lampi, 2013; Shimba et al., 2016). Research at the secondary level was limited. While there were some studies available, most research in the K-12 environment focused on the use of simulations in science labs, as opposed to technology, engineering, or math (D'Angelo et al., 2014; Ghani, 2015; Lampi, 2013; Shimba et al., 2016). Research on postsecondary level education was available. However, overall, researchers were still mainly in disagreement about the effectiveness of replacing hands-on hardware labs with simulations (Ghani, 2015; Lampi, 2013; Shimba et al., 2016).

Finally, according to the BLS (2016), demonstrating college and career readiness in IT can lead to well-paying jobs. However, training requires skill practice, and physical hands-on hardware is often expensive and difficult to procure (Tagliacane et al., 2016).

Therefore, instructors may use simulations as a tool to enhance or replace hands-on hardware equipment in the teaching and learning process (Lampi, 2013; Shimba et al., 2016). However, according to Lampi (2013), the technology must not drive the tool. The tool needs to meet the objectives of what needs to be learned (Lampi, 2013). This study was required to determine if there was a significant difference in college and career readiness of New York state high school students in approved IT Content Cluster high school programs who use simulations as compared to students who use hands-on hardware.

Problem Statement

A problem exists in IT training, because an instructor may not be able to provide a hardware lab environment for hands-on instruction for every student, limiting the time that students can spend on skill practice or problem determination (Tagliacane et al., 2016). The hardware required for hands-on practice is expensive to procure and maintain, and the floor space needed to house the equipment may be limited (Gercek et al., 2016). The cost of hardware, operating systems, and application maintenance and upgrades, as well as addressing issues of scalability as the student population grows, are additional impediments to providing hands–on hardware environment for students (Gercek et al., 2016). For example, a typical network hardware lab implementation could require 2,500 square feet of space and cost upwards of $250,000 (Gercek et al., 2016). More funding would be required to employ staff to support and maintain the environment (Gercek et al., 2016).

Federal education policies in the United States demand that every high school graduate be college and career ready (Castellano, Sundell, & Richardson, 2017). In New York state, students in approved school districts or BOCES CTE programs must complete a three-part technical assessment including written, demonstration, and project components (NYSED, 2011). Skill practice is needed for the student to gain expertise in IT that would allow them to be successful passing the technical assessment required for a New York state technical endorsement (NYSED, 2011) or CTE alternative pathway to graduation (NYSED, 2016). An instructor who lacks a hands-on hardware lab with enough equipment for individual student skill practice can be challenged to provide the training required to prepare the class for the technical assessments in New York state using another methodology, such as simulations (Tagliacane et al., 2016).

Vendor and vendor-neutral certifications have become key indicators that a candidate possesses the skills necessary for an entry level-position in IT (Chasse, 2013; Lasheen, 2015; Tamar-Belgraves, 2016). Many employers preferred or required certification to confirm that the candidate had the appropriate knowledge and skills to fill the position (Chasse, 2013; Lasheen, 2015; Tamar-Belgraves, 2016). Surveys at the university level have also indicated that students understand that certifications can help them reach their IT career goals (Rob, 2015). Candidates obtain certifications from vendors such as Cisco or Microsoft, or vendor-neutral organizations, such as CompTIA or ISC2 (CompTIA, 2016; ISC2, n.d.). The company or organization that issues the certificate confirms via testing that the candidate possesses the knowledge and skills required by that position (BLS, 2016). CompTIA, an IT industry trade association, offers an IT Certification Roadmap that directs an IT professional through eight different career pathways, identifying the vendor and vendor-neutral certifications obtainable for each expertise level from novice to expert (CompTIA, 2016). The New York State Education Department (2016) has also recognized the value of IT certifications and offered an alternative pathway to graduation that allows high school students who pass four required regents examinations to substitute a passing grade on the CompTIA A+ or CompTIA Network+ for the fifth required exam. However, the question remained as to whether simulations can replace hands-on hardware labs for preparing secondary level students for college and entry-level IT careers by preparing them for passing IT industry-level certification exams when the hands-on hardware was unavailable.

As opportunities in the IT field continue to grow (BLS, 2016), it was critical to assess whether using simulations at the secondary level produced a significant difference in college and career readiness, as opposed to using hands-on hardware. The research problem at hand was whether simulations are an effective method to prepare IT Content Cluster high school students, in New York state, with the skills that they needed to pass the written and hands-on exams required for New York State Technical Endorsement when access to hands-on laboratory hardware was limited or non-existent. Additionally, were simulations an effective method to prepare IT Content Cluster high school students, in New York State, with the skills that they needed obtain a nationally recognized, industry-based certification when access to hands-on laboratory hardware was limited or non-existent?

While there was research available concerning the effectiveness of simulated lab exercises in the IT field (Ghani, 2015; Lampi, 2013; Shimba et al., 2016; Tagliacane et al., 2016), there was a lack of quantitative evidence detailing the summative effect of using simulations in preparing for technical endorsements. There was also a gap in research on using simulations to satisfy the requirements for CTE alternate pathways to graduation in IT and industry-level certifications at the secondary level. Research on simulated science labs in high schools was more abundant (D'Angelo et al., 2014; Hall, 2014; Torres, Tovar, & Egremy, 2015).

Purpose of the Study

The purpose of this quantitative, nonexperimental study was to determine if there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs, between those who use simulations and those who use hands-on hardware. The students' test results for the technical endorsement assessment and obtaining an industry-level certification were the determinants of college and career readiness used in this study. IT instructors need quantitative evidence to assess whether the use of simulations in place of hands-on hardware adequately prepares their students for college and careers.

The population for this current study included students enrolled in a New York state approved school district or BOCES CTE programs for IT (NYSED, 2018a). The list of New York State sanctioned IT programs was available on the NYSED (2018a) website. The website yielded 60 approved districts or BOCES CTE programs offering training at the secondary level in IT (NYSED, 2018a). The supported IT programs may be listed as IT or may have a different designation such as computer repair, internetworking, or cybersecurity (NYSED, 2018a).

The first set of variables explored in this chapter were the relationships between the dependent variable, student pass rates for 2017-2018 on summative technical endorsement assessments, and the independent variable, percentage of simulated labs used in place of hands-on hardware practice. The second set of variables explored was the relationship between the dependent variable, pass rate for industry-based IT certification exams, and the independent variable, percentage of simulated labs used instead of hands-on hardware practice for the 2017-2018 school year.

Research Questions and Hypotheses

Study Sample Grouping

1. All coursework labs are completed on hands-on equipment; no simulated labs are used.
2. Less than 50% of coursework labs are completed in a simulated environment.
3. Fifty percent or greater of coursework labs are completed in a simulated environment.
4. All coursework labs are completed in a simulated environment, no hands-on environment.

Research Questions

RQ1. Are there significant differences in the technical assessment written exam grades of students in the four study groups?

RQ2. Are there significant differences in the technical endorsement demonstration (hands-on exam) grades of students in the four study groups?

RQ3. Are there significant differences in the certification pass rates of students in the four study groups?

Null Hypotheses

$H_0$1. There are no significant differences in the technical assessment written exam grades of students in the four study groups.

$H_0$2. There are no significant differences in the technical assessment demonstration (hands-on) grades of students in the four study groups.

$H_0$3. There are no significant differences in the certification pass rates of students in the four study groups.

Alternative Hypotheses

H_A1. There are significant differences in the technical assessment written exam grades of students in the four study groups.

H_A2. There are significant differences in the technical endorsement demonstration (hands-on) grades of students in the four study groups.

H_A3. There are significant differences in the certification pass rates of students in the four study groups.

Types and Sources of Data

A survey was used to collect end-of-year student data for the 2017-2018 school year from the program contacts for the approved New York State IT programs, as listed on the NYSED (2018a) website. The survey asked for demographic information regarding the curriculum, assessment, and simulation packages used in the program. Finally, the written exam and demonstration scores for each student, along with the certification types and pass rates, were requested.

Theoretical Framework

The framework for this study was Kolb's (1984) experiential learning theory. Kolb's methodology was developed from the work of other theorists such as Dewey, Lewin, and Piaget. The experiential learning theory grew out of a constructivist approach, which suggested that learners build knowledge through experience, as opposed to drill and practice (Harasim, 2017).

Kolb's (1984) theoretical model defined four stages that must occur for learning to take place: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Kolb suggested that a learner should be able to reflect upon practical experience and conceptualize those skills to a new, but related, environment. Kolb's work included career development and simulations as a form of experiential education.

However, while prior research applied Kolb's (1984) theory to using simulations for teaching and learning, current research remained conflicted concerning the effectiveness of using simulations to learn IT skills and then reflect and conceptualize the skills to a hands-on hardware environment (Ghani, 2015; Lampi, 2013; Shimba et al., 2016). Therefore, an analysis of the college and career readiness of New York state high school students in approved IT Content Cluster high school programs, who use simulations as compared to students who use hands-on hardware may build upon the existing knowledge of using Kolb's theory for the teaching and learning of IT skills at the secondary level.

The next chapter provides additional detail on the evolution of Kolb's (1984) theory and the experiential learning Model. Chapter 2 includes an analysis of prior applications of Kolb's methodology and a comprehensive rationale for selecting Kolb's work as a framework for this project.

Nature of the Study

A quantitative nonexperimental survey design was selected for this study. The quantitative methodology was chosen to evaluate the statistical relationships between the variables defined in the study. The research was nonexperimental because there was no manipulation of a variable. A survey was used to identify the percentage of simulations used in approved New York state IT programs of study and the influence on college and career readiness as defined by the students' technical assessment grades and their performance on industry-level certification assessments. A current list of New York state approved CTE IT programs and contact phone numbers and e-mails, for both districts and BOCES, were available online (NYSED, 2018a). Conversely, a qualitative approach was not selected, as a qualitative methodology would not support gathering the numeric data required to analyze the study's research questions.

The study's independent variable represented the percentage of simulations used for skill practice in a secondary-level classroom in an approved program of study in New York state during the 2017-2018 school year. There were four groupings: all hands-on hardware, less than 50% simulated labs, 50% or greater simulated labs, and all coursework labs completed in a simulated environment. The dependent variables were the 2017-2018 students' technical assessment scores, and the results, pass or fail, of an industry-level certification.

A one-way ANOVA was used to test for a significant difference in technical assessment scores across four study groups, as defined in the Research Questions and Hypotheses section of this study. Technical assessment scores were expected to be continuous numeric data. However, industry-level assessment results were available as numeric or as pass/fail, depending on the assessment. Therefore, the industry-level assessment grades collected were transposed to a pass or fail, represented as a binary: 0 = fail, and 1 = pass. A chi-squared test was planned to compare the results from the four groups, as identified in the Research Questions and Hypotheses section of this study.

Definitions

The terms in this section describe the preparation of students, in approved New York state programs, for college and career readiness in IT. They are used throughout the study.

Approved New York State CTE Program: New York State Education Department Approved Career and Technical Programs offered in school districts or BOCES (NYSED, 2018a).

Approved Pathway Assessment: New York State Education Department Approved Assessments that meet the requirement for a CTE Approved Alternative Pathway or CTE 4+1 Graduation Pathway Option (NYSED, 2016).

College and Career Readiness: Satisfaction of rigorous learning standards that ensure that students are ready to compete in a worldwide and knowledge-based economy (United States Department of Education, n.d.-a)

CTE Approved Alternative Pathway or CTE 4+1 Graduation Pathway Option: New York state recognized rigorous alternative pathway to graduation recognizing student's interest and allowing a student to earn an approved pathway assessment to satisfy graduation requirements (NYSED, 2016).

Every Student Succeeds Act: Education Law, as of December 10, 2015, designed to improve education in the United States by requiring each state to submit a plan to improve graduation rates, expand opportunities for learning, and improve outcomes for students (United States Department of Education, n.d.-b).

Hands-on Hardware (IT) Lab: Laboratory using 100% real computer and networking equipment used to provide skill practice and strengthen theoretical knowledge (Tagliacane et al., 2016).

Industry-Level (or based) Certification: NYSED sample list of Vendor or Vendor-Neutral nationally recognized certifications in CTE areas. (NYSED, n.d.-b)

Industry-Level Assessment: NYSED sample list of examinations, that if the candidate was successful in passing, leads to an industry-level certification (NYSED, n.d.-b).

New York States ESSA Plan: United States Education Department approved plan, submitted by New York, state to improve graduation rates, expand opportunities for education, and improve outcomes for students (NYSED, 2018c).

Technical Endorsement: Granted when a student in a New York State approved district or BOCES program completes the requirements outlined in the Commissioner's Regulations, currently 22 credits, passing five regents of an approved alternative pathway, and passing a technical assessment (NYSED, n.d.-a).

Technical Assessment: A three-part assessment: demonstration, project, and written components (NYSED, n.d.-a).

Simulation or Simulated Lab: An imitation of a real-world process, via software Tagliacane et al., 2016).

Virtual Lab: Software images running on physical hardware, which appear to be real equipment (Tagliacane et al., 2016).

Assumptions, Limitations, Scope and Delimitations

This section includes a description of the assumptions, limitations, and scope and delimitations of the study. The assumptions define the attributes of the research, specifies what was out of the researcher's control and what requires justification to ensure relevancy. The limitations define potential faults (Warner, 2013). The scope and delimitations define the boundaries of the study (Warner, 2013).

Assumptions

The first of three assumptions was that the survey participants would answer the survey truthfully. An indicator of this was that the voluntary nature of the study allowed the participants to tell the truth or not to participate. The survey letter defined steps to preserve how the school's identity would be kept confidential, and the student's identity would be anonymous.

The second assumption was that the survey would collect the right data for the study. There was no opportunity for the participants or researcher to prejudice the data, as the assessments were from the 2017-2018 school year. This assumption was addressed by piloting the survey to 10 instructors at a CTE school and soliciting feedback on the ease of providing the information requested in the study, or on any clarifications that might be required.

Statistics citing growth in employment opportunities in the IT field and NYSED's (2016) addition of the alternative pathways to graduation options for high school students supported the third assumption: that IT remains an essential part of the secondary education program in New York state, as justified by the BLS (2016).

Limitations

The first limitation of the study was the selection of the population sample, which was a convenience sample gathered from the list of approved New York State IT programs. The opportunity for sampling bias was present as the sample of survey volunteers was not random. Other locations outside of New York state may have different criteria for college and career readiness that makes this study more difficult to generalize to a larger population. Furthermore, because the dependent variable was achievement exam data, the information was only as useful as the test and how the test matched the objectives of the simulations or hardware labs. Since the data collected were from the 2017-2018 school year, this study was dependent on the conditions during that period. A pilot of the survey to a limited group of approved programs contributed to internal and construct validity, ensuring that appropriate data were collected for the study, and increasing the probability that the independent variable, percentage of simulations used for teaching and learning, was influencing the dependent variable or assessments. Operationalization of the variables, or clearly defining them, also contributed to internal validity. Conditions may change over time and require reevaluation for the new interval. Therefore, concerning external validity, the reader should not overgeneralize the results to another region without evaluating that region's definitions for college and career readiness, or period, without assessing additional data in case the conditions change over time. Concerning confounder validity, restriction mitigated the opportunity for teaching quality to influence the dependent variable of assessment results, as all teachers in approved IT technology content cluster programs are required to be highly qualified, combining teacher education with years of technical experience (NYSED, n.d.-d). While a convenience sample of approved programs was used, the participants of the program were randomized such that students elected to participate in district or BOCES programs.

Scope and Delimitations

The problem statement dictated the study's scope and delimitations. The problem at hand was whether simulations are an effective method to prepare IT content cluster high school students, in New York state, with the skills that they needed to pass the written and hands-on exams required for New York State Technical Endorsement when access to hands-on laboratory hardware was limited or nonexistent. Additionally, were simulations an effective method to prepare IT content cluster high school students in New York State with the skills they needed obtain a nationally recognized, industry-based certification when access to hands-on laboratory hardware was limited or nonexistent?

The focus chosen supported New York state's definition for college and career readiness, as defined in the ESSA update plan (NYSED, 2018c). Measuring the result of using educational technology, in the form of simulations, may add to the literature on accomplishing New York state goals for college and career readiness in IT, and advance the knowledge of using simulations for teaching and learning.

While Kolb's theory of experiential learning provided the framework for this study, other theories were directly related to this study but did not support the nature of this quantitative study. For example, the qualitative lens used in Vygotsky's (1978) activity theory was not appropriate for this study. Existing studies applying activity theory to the use of simulations for teaching and learning examined inferences based on a pattern of tool use, as in case studies or ethnographies (Battista, 2015). Finally, the study was bounded by the eligibility of survey participants as being instructors for approved IT technology content cluster programs, and the geographical region was New York state. Therefore, the results of this study could be generalizable to educators who teach high school students in an approved district or BOCES IT program of study, in New York state, and who comply with New York States ESSA plan for college and career readiness.

Significance

According to the United States Department of Education, Office of Educational Technology (n.d.), teachers can use powerful technology tools, such as simulations, to support learning. This study may partially fill a gap in the literature on the significance of using simulations to prepare secondary level students taking technical endorsement assessments and vendor or vendor-neutral IT certification exams. The research results have the potential to effect positive social change by providing knowledge that would allow IT instructors to formulate teaching and learning plans to train high school students to pass technical endorsement assessments and certification exams when they have limited access to hands-on labs. Certified workers, with entry-level skills, can fill jobs in IT, offering good pay with more promising futures (BLS, 2016).

According to Tagliacane et al. (2016), lack of access to hands-on hardware may limit the ability of instructors to provide students with IT skills practice. At the same time, IT is a growing job field, providing opportunities for trained candidates (BLS, 2016). New York state redefined college and career readiness skills, identifying an alternative pathway to graduation that required CTE students pass a technical-assessment and be offered the opportunity to obtain an industry-level certification (NYSED, 2016). This study may provide additional information on whether simulations are an effective method to prepare IT content cluster high school students in New York State with the skills they need to pass the written and hands-on exams required for New York State Technical Endorsement, and nationally recognized, industry-based certification when access to hands-on laboratory hardware is limited or non-existent.

According to Ghani (2015), technology can be used to promote the practice of teaching and learning when the tool used matches the objectives of the program of study. This quantitative research project may advance teacher practice around secondary level IT by providing a statewide assessment of the effectiveness of using simulations for technical assessment and industry-level certification preparation. This study’s focus on summative assessments success, as opposed to individual skill practice, may provide additional information concerning the use of simulations to ensure college and career readiness in New York state in the absence of hands-on hardware.

This study may contribute to a more positive outlook on employment as a result of better understanding how to support both (a) secondary student college and career readiness and (b) industry needs in the IT field. According to the BLS (2016), well-trained individuals in IT can secure well-paying jobs, improving the quality of life of those individuals. Meeting the needs for skilled workers in the IT industry, particularly in cybersecurity, may increase employment, positively impacting the growth of the economy and the reduction of IT security incidents in the United States.

Summary

The growth of employment opportunities in the IT field, along with New York state's concentration on alternative pathways to college and career readiness, reinforced the need for this study on evaluating the usefulness of educational technology in the form of simulations in the absence of hardware. This quantitative nonexperimental survey study considered whether there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs who use simulations as compared to students who use hands-on hardware. The independent variable was the percentage of simulations used for teaching and learning; the dependent variables were technical assessment grades and earning an industry-level certification by passing an IT certification exam. The framework that supports this study was Kolb's (1984) experiential learning theory. The results of the study may add to the literature on the use of simulations for teaching and learning.

Chapter 2 of this study explores Kolb's (1984) work as a theoretical foundation for this study. It describes the available literature on college and career readiness, CTE, and the use of simulations for teaching and learning. Chapter 2 also provides areas that researchers agree on concerning virtual labs, as well as missing information or ambiguity that constituted a gap in what was known about using simulations to prepare for a college and career in IT, at the secondary level, in New York state. Chapter 3 addresses the study's design and Chapter 4 provides an analysis of the data collected. Chapter 5 presents a discussion about the findings, conclusions, and recommendations for further study.

Chapter 2: Literature Review

Introduction

This literature review explores previous research in the connection between a high school student's college and career readiness in the IT field and the use of simulations for teaching and learning in place of hands-on hardware labs.

Problem

The problem presented in Chapter 1 of this study was whether simulations are an effective method to prepare IT content cluster high school students, in New York State, for college and careers in the IT field, when access to hands-on laboratory hardware was limited or nonexistent. Federal education policies in the United States require that secondary-level students graduate high school college and career ready (Castellano et al., 2017). However, the literature quantifying the effect of using simulations to achieve readiness in IT was limited. Evaluation of state and industry-level readiness requirements along with the teaching and learning theories and methodologies that are being used to satisfy the federal requirements for college and career readiness may provide a better understanding of how educators can help students prepare for success when facing limited budgets and limited hardware accessibility.

Purpose

The purpose of this quantitative, nonexperimental study was to determine if there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs, between those who use simulations and those who use hands-on hardware. College and career readiness were defined by a student's achievement scores on the written and hands-on exams required for New York State Technical Endorsement and obtaining a nationally recognized, industry-based IT certification. Thus, this chapter examines the theories, requirements for college and career readiness in New York State and the IT Industry, as well as the studies that do or do not support the success of using of simulations in place of hands-on hardware labs.

Organization of the Chapter

Chapter 2 documents the relevance of Kolb's (1984) experiential learning theory (ELT) to both hands-on learning and training using simulations, as a theoretical base for this study. Existing studies that identify the current state of college and career readiness and CTE were evaluated to demonstrate the need for a focus on simulation technology. This chapter provides a critical evaluation of the studies that explore the role of hands-on hardware learning and the use of simulated computer labs for achieving IT skills mastery and college and career readiness.

Literature Search Strategy

The literature search encompassed the years 2013 to 2019. The following databases were searched: EBSCO, ERIC, the IEEE Explore Digital Library, and ProQuest Central. They yielded the resources evaluated in this chapter. In addition to peer-reviewed articles and dissertations, current government and industry websites were used to provide an understanding of the requirements that high school students needed to meet in order to be deemed ready for an IT college program or career in New York state.

Database searches that paired the keyword *simulation* with *career and technical, certifications, college and career, educational technology, hands-on, IT and skills training,* provided few relevant resources. The use of the term *simulation* was far more prevalent in research studies concerning the career and technical discipline of nursing than IT. Researchers used the term *virtual lab* in place of the term *simulation* in the relevant studies identified as evaluating the use of simulation training for the teaching and learning of IT skills. Although apparently the terms are used interchangeably, a virtual lab and a simulation are not technically the same environment. In the case of IT instruction, a virtual lab would use a virtual machine. In other words, a virtual lab environment would provide virtual images running on a physical device. Simulations, on the other hand, are software tools that mimic the features of a hardware or software environment required to provide skill practice. Therefore, *virtual lab* replaced the technically more accurate term *simulation* in the search for relevant research for this literature review.

Further efforts to locate relevant studies—pairing the keyword *virtual lab* with *career and technical, certifications, college and career, educational technology, hands-on, IT, and skills training*—resulted in a small number of applicable works evaluating the effectiveness of using simulations for IT skills training. To provide the degree of saturation necessary for a comprehensive literature review, sources that cited those initially identified studies were used.

Theoretical Foundation

Since the first half of the 1900s and the advent of behaviorism, theorists have been examining the process of learning (Harasim, 2017). However, the early behavioristic thoughts by theorists that learning occurs as a function of drilling and practicing, reinforced by positive rewards, has evolved to a more constructivist view that the learner builds knowledge through experiences, and technology often becomes the teacher (Harasim, 2017). Kolb's (2014) Theory of experiential learning, first published in 1984, is based upon this constructivist approach and was the theoretical foundation of this research project. The works of Dewey, Lewin, and Piaget are discussed as the basis for Kolb's theory.

Origins of Experiential Learning Theory

Kolb (2014) is an American theorist on education and the creator and chief executive of Experience Based Learning Systems, Inc. Kolb's interests in learning through experience, social change, career development, and professional education led to his publishing a model for experiential learning styles. From the works of John Dewey, Kurt Lewin, and Jean Piaget, Kolb identified seven themes that guided the development and contemporary applications of experiential learning theory. Applications today included social welfare, competency-based education, lifelong learning and career development, experiential education including simulations, and curriculum development (Kolb, 2014).

John Dewey (1938) developed the early theories of constructivism. Constructivism is a theory that individuals construct knowledge through experience and reflection on those experiences (Miller-First & Ballard, 2017). Dewey believed that it was the learner and not the teacher that was the center of the learning process. From Dewey's theory, Kolb (2014) selected the concept of pragmatic's or the idea that a learner would take responsibility to learn a new skill, remember it, repeat it, become competent, and then use the ability. According to Kolb, the pragmatic approach offered by Dewey provided an organizing focus for experiential education.

From Lewin's work, Kolb (2014) selected the ideas of training groups (T-groups) and action research. Lewin's (1951) T-group studies identified the fact that learning best occurs when the learner shares in the reflection process, such that observer or evaluator paired their analysis with the concrete experience of the learner. Lewin defined the methodology known as action research. Action research required that after a learner identified an initiative, completed fact-finding, and put a plan in place to accomplish the goal, a reiterative process occurred of executing a step in the project, evaluating the action, and then amending the project based on the outcome of the evaluation (Lewin, 1951).

Piaget's (1977) research was concerned with child development and how children develop logical thinking processes. Kolb (1984) was influenced by Piaget's efforts to define how learning occurs and the interactions between assimilating experiences into beliefs and accommodating beliefs to experiences. Assimilation is the experience of incorporating something learned into something already known (Piaget, 1977). Accommodation requires knowledge that is known to be adjusted based on the new experience (Piaget, 1977).

Kolb (2014) identified several guiding themes that overlapped the beliefs of multiple theorists. Both Dewey and Lewin believed in democratic values such as collaborative leadership, exchanging ideas, and that the scientific method should be used to study humans to improve the future of society (Kolb, 2014). Kolb's work included the guidance from all three theorists, Dewey, Lewin, and Piaget, which is that the structuring tenet for education is a purposeful life and self- directed learning.

Dewey, Lewin and Piaget's research had a profound influence on the process of experiential teaching and learning (Kolb, 2014). Through the study of the constructionist's theories, Kolb merged their work to develop an argument supporting competency-based education, curriculum development, and social policy to promote educating groups of people who had not previously had access to education, such as women, the poor, and minorities (Kolb, 2014). The theorist's themes provided the guiding principles for Kolb's (2014) contemporary applications of experiential education supporting programs for career development and life-long learning through internships, simulations, and on the job training.

Theoretical Propositions

According to Kolb (1984), "Learning is the process whereby knowledge is created through the transformation of experience" (p. 38). Learning is not an end-product, a learner continues to create and recreate knowledge through the experiential process (Kolb, 1984). Kolb's theory supported an active and experiential role for the students, as opposed to a didactic role characteristic of teacher-centered instruction. In experiential learning, the experience is considered to be the foundation for learning (Kolb, 1984).

According to Kolb, for learning to take place, the student must experience all four stages of the experiential learning cycle, concrete experience, reflective observation, abstract conceptualization, and active experimentation. Kolb defined four types of learners, an accommodater, a divergent, an assimilator, or a convergent. Kolb's learning styles identify the preferences that each learner type tends to gravitate toward, more profoundly, in the learning cycle.

Initially the learner was expected to experience something (Kolb, 1984). For example, in the study of networking, the student might set up a wireless router connection. This first step provides the learner with a concrete experience (CE) of doing something, as opposed to having the teacher talk about how to set up a wireless router, or just reading about how to set up the connectivity.

The second step in Kolb's (1984) experiential learning cycle was characterized by reflective observation (RO). The learner thinks about the lesson and reflects on what went well and what did not go well during the experience (Kolb, 1984). Perhaps while implementing the solution, the student discovered that the desktop that required connectivity did not have a wireless network interface card (NIC). Consequently, the completion of the connectivity was delayed for two days, while the technician waited for the delivery of a NIC card.

Abstract conceptualization (AC), the third step of the experiential learning cycle, thinking about ways to improve the experience (Kolb, 1984). In this case, the technician might conceptualize a new process whereby they check for a compatible NIC card initially, thereby eliminating an additional delay in completing the work. Before this experience, the student had assumed that all desktops came with both ethernet and wireless NICs. Therefore, the technician might theorize that all connectivity and compatibility requirements need research before implementation.

The fourth step, active experimentation (AE), expected the student to apply what they have learned to a new experiment (Kolb, 1984). The new venture might consist of a similar task, without detailed instructions, or a group of related functions that build on what they already learned (Kolb, 1984). The IT technician might streamline the process on a similar connectivity solution, or apply what they experienced during another type of installation or upgrade.

In addition to the cycle, Kolb (1984) proposed a learning style inventory that would determine how a learner may enter and cycle through the experiential learning model, as an accommodater, a divergent, an assimilator, or a convergent. According to Kolb, accommodating learners prefer concrete experiences and active experimentation. Accommodating style learners gravitate toward action-oriented careers education, law, medicine, and social work (Kolb, 1984). A diverging learning style indicated that the students approach learning through concrete experience and reflective observation (Kolb, 1984). Divergent learners tended to have careers that involve a great deal of imagination, such as drama, art, or journalism (Kolb, 1984). Abstract conceptualization and reflective observation were the preferred learning methods of an assimilating learner, who tended to gravitate toward scientific and mathematical careers (Kolb, 1984). The converging learner enjoyed abstract conceptualization and active experimentation (Kolb, 1984). Kolb described converging learners as people who were attracted to technology and engineering careers and preferred to work on technical problems using simulations, laboratory assignments, and practical applications.

Analysis of Prior Application

Researchers applied Kolb's (1984) experiential learning Theory (ELT) as a theoretical framework for the use of virtual computer labs simulations in place of hands-on hardware for studies in a variety of disciplines (Grady, 2017). Grady (2017) conducted an integrative research review that identified twenty-three studies, between 2000 and 2016, that used Kolb's experiential learning as a theoretical foundation. However, only five of the twenty-three studies demonstrated a firm connection between Kolb's theory and the results of the study. Konak, Clark, and Nasereddin (2014), authors of one of the five ELT grounded studies, concluded that researchers should focus on the effectiveness of the learning process as opposed to the technical lab environment or the specific activities. Konak et al. (2014) focused on using Kolb's experiential learning cycle to improve student's IT security skills in a virtual lab environment.

Nursing is a career field that has used simulations for skill practice to provide a safe environment for skill practice while not putting the patient at risk (Podlinski, 2016). However, a theoretical review by Lavoie et al. (2017) highlighted the fact that few of the studies examined nursing simulation through learning theories. According to Lavoie et al., a study of 182 research papers written between 1999 and 2015, were analyzed to identify the theories of teaching and learning using simulations in nursing. While 79 of the studies lacked the application of an explicit theory, 20 of the 103 papers that identified a theoretical foundation cited Kolb's (1984) experiential learning Theory

(Lavoie et al., 2017). Six out of 20 studies examined student knowledge, and another six out of 20 studies examined student satisfaction with the simulation exercise (Lavoie et al., 2017). Only one out of the 182 research projects, which is by Kameg, Englert, Howard, and Perozzi (2013), evaluated whether simulation enriched the theoretical understanding and retention of knowledge, of the students, as connected to the teaching and learning provided by the simulation scenarios. In the case of this study, Kolb's theory was applied to explain how students' engagement in a simulation could lead to acquiring knowledge (Kameg et al., 2013). The simulations included problem determination, making decisions, and reflection, core components of the experiential learning cycle in Kolb's model (Kameg et al., 2013).

In a study specific to IT, Shimba et al. (2016) cited Kolb's experiential learning theory as the theoretical basis for determining the effectiveness of using simulations versus hands-on hardware to teach networking skills. While Shimba et al., provided a section on the relevance to ELT in their findings, and they identified the fact that the group using simulations failed to verify a VLAN configuration, it was not clear that the simulation group learned the process of verifying connectivity in the concrete experimentation phase of Kolb's cycle. According to Konak et al. (2014), the concrete experience stage required a set of step by step instructions such that even a student without prior experience can be successful.

Rationale

Kolb's (1984) Theory of experiential learning was used as a theoretical base for this research as previous studies have indicated that Kolb's cycle of learning can be employed in a simulated environment to promote teaching and learning (Konak et al., 2014; Poore, Cullen, & Schaar, 2014). Kolb's original work identified contemporary uses of the experiential learning theory including competency-based education, lifelong learning and career development, and simulations as a form of experiential education. An analysis of the college and career readiness of New York state high school students in approved IT content cluster high school programs, who use simulations, as compared to students who use hands-on hardware may build upon the existing knowledge of using Kolb's theory for the teaching and learning of IT skills at the secondary level.

Poore, et al. (2014) found that Kolb's (1984) theory of experiential learning could be used to guide the use of simulation-based education for professionals in the health field. They found that the experiential learning cycle provided a theoretical foundation as well as a process for individualized learning in a simulated environment (Poore et al., 2014). The concrete experience phase occurred through the learner's participation in the simulation exercise (Poore et al., 2014). The reflective observation phase was achieved through debriefing and reflection of the simulated experience (Poore et al., 2014). Abstract conceptualization was used in considering the relevance of the activity and active experimentation was employed as the learner tested what was learned in a new simulation or situation (Poore et al., 2014). These stages of Kolb's cycle may be relevant to the teaching and learning of IT skills in a simulated environment.

The contemporary applications of Kolb's (1984) experiential learning theory applied to this study. Kolb included competency-based education in a list of contemporary applications of experiential learning theory. Technical endorsement tests and industry-level certification exams determine the competency of whether New York State students in approved IT content cluster high school programs college and career are ready (NYSED, 2011). The industry-level certification exams applied to the CTE alternative pathway as a competency for graduation (NYSED, 2016).

Finally, it was unknown if there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs, who use simulations as compared to students who use hands-on hardware. This study may contribute to the knowledge of the effectiveness of using Kolb's (1984) Theory of experiential learning to promote teaching and learning of IT skills at the secondary level.

College and Career Readiness

This study focused on the use of technology, specifically simulations, to prepare high school students for careers in IT. With that goal in mind, it was necessary to examine what was known about successful preparation at the high school level for postsecondary education or a pathway directly to employment in the IT field. According to Castellano et al. (2017), requirements for college and career success are defined at the national level, state by state, and by the employers that are looking for entry-level candidates. Understanding the requirements at each level may provide insight into the role of simulations versus hands-on hardware labs in preparing secondary level students to meet those requirements for college and career readiness.

National Requirements

The Every Student Succeeds Act (ESSA) was ratified in 2015 by President Obama, replacing the No Child Left Behind Act (United States Department of Education, n.d.-b). ESSA declared that every student must graduate from high school college and be career ready, independent of any other barrier in their path (Coppes, 2016). Each state was required to submit plans supporting the ESSA goals, for the 2017-2018 school year (Coppes, 2016). The states accountability objectives must address closing the gap on assessment proficiency, English language proficiency, and graduation rates for their schools (Coppes, 2016). States must deploy decisive intervention where the graduation rates are less than 67% (United States Department of Education, n.d.-b). Finally, each state must identify standards that are challenging, which can be the Common Core States Standards (CCSS) or another set of criteria (Coppes, 2016). While the law required commonality in achievement and completion, each state had leeway in proposing a plan that will ensure a rigorous secondary level education, as opposed to completion (Coppes, 2016).

CCSS, developed in 2010, provides a common academic platform for college readiness (Common Core State Standards Organization, 2019). However, according to Soule and Warrick (2015), preparing students for the world of work requires a broader conception of learning with new outcomes for what students know and can do, as well as new teaching and learning approaches to achieve those goals. Meeting the nation's demand for a skilled workforce in the 21st century requires that students learning take place in the context of a career area (Soule & Warrick, 2015).

State Requirements

According to the United States Department of Education (n.d.-a), students face lofty expectations while preparing for postsecondary education or a job in the workforce. ESSA and the responding state plans confront educators with the challenge of increasing the rigor of academic standards that will prepare students for college as well as getting them ready for employment (Coppes, 2016). However, studies indicated that the skill sets that needed to be successful in both college and career may not be addressed equally on a state by state basis (Achieve, 2016). Although the overall goal of ESSA, at the National level, required that high academic standards prepare students for both college and careers, the individual states must define their interpretation of what it means for a student to be college and career ready (Coppes, 2016).

Achieve (2016) is a non-profit organization that was formed in 1996 to examine the state of college and career readiness for all students. The organization has provided reports on every state's policy, as related to college and career readiness, for more than a decade. Achieve's findings focus on the actual achievements of secondary level graduates and address the need for commonality of measurements between states. In addition to evaluating whether students met math and literacy benchmarks, the Achieve study also evaluated the number of students in each state that completed a college and career readiness (CCR) course of study. The 2016 study identified a variety of CCR assessments, specific to each state in the nation. In New York, the reported percentage of students that were deemed college and career ready in 2014 was 31%, as determined by the achievement of obtaining a New York Advanced Designation Regents Diploma.

In January 2015, the New York State Board of Regents approved multiple pathways to graduation (NYSED, 2016). Previously, the New York Advanced Designation Regents Diploma required that a student obtains a score of 65 or better on nine regents' examinations (Achieve, 2016). The nine regents included comprehensive English, three mathematics regents, global and United States History, physical and life science, and an additional language (Achieve, 2016). New York State students in approved Career and Technical programs in New York State could receive a technical endorsement on their diploma by completing CTE requirements in a New York State approved course of study (NYSED, n.d.-a). However, a technical endorsement pathway was not an option for receiving an Advanced Designation Regents Diploma in New York State, indicating that there may be a need to close the gap between academic initiatives and career readiness (Achieve, 2016). A new pathway to graduation alternative moved to address the issue of including a rigorous CTE assessment, instead of a New York State Social Studies exam (NYSED, 2016).

As required by ESSA, New York state issued a plan in March of 2017, last revised January 2018 (NYSED, 2018c). The New York State Education Department incorporated a College, Career, and Civic Readiness index for each graduating 4-year cohort. In contrast to the 2016 Achieve report, the New York State ESSA plan identifies a Regents Diploma with Advanced Designation and a Regents Diploma with a CTE Endorsement as being equally weighed on the College, Career, and Civic Readiness index (NYSED, 2018c). The index offers an additional credit to students who obtain required scores on nationally recognized exams, including assessments from Certiport a

Pearson Vue Business, CompTIA, National Occupation Competency Testing Institute (NOCTI), or students completing college credits as a benefit of dual enrollment (NYSED, 2018c).

The increased importance on the role of CTE in producing students who are college and career ready in New York State supports the need for this study concerning the role of simulations in preparing secondary level IT students to meet ESSA goals. According to Soule and Warrick (2015), preparing students for a career, life, and civic responsibility requires a new approach to personalized learning. Mastering academic content within career coursework engages students in learning skills that will be useful post-graduation (Soule & Warrick, 2015).

Industry Requirements

Information technology certifications and postsecondary education have been the primary qualifications for job candidates in the IT field (Lasheen, 2015). IT certifications assure an employer that the candidate has the skill set for the open position, and typically reflect a passing grade on a vendor-sponsored or vendor-neutral examination (Chasse, 2013; Lasheen, 2015; Tamar-Belgraves, 2016). While studies indicated that employers prefer hiring an applicant that has the appropriate certifications, IT employees that have a collegiate degree are less likely to be laid off, and more likely to advance in their career (Tamar-Belgraves, 2016). Studies have found that candidates without a college degree would be more marketable if they obtain additional certifications (Tamar-Belgraves, 2016).

Research concerning the application of job seekers for IT positions primarily focuses on graduates from two or four-year collegiate programs. According to Tamar-Belgraves (2016), although high school students who are successful in obtaining industry certifications qualify to seek early entry for IT employment, the certifications should not be used to bypass a college degree. Employers were also more likely to offer internships to CTE completers who had obtained an industry-level technical endorsement (Tamar-Belgraves, 2016).

There was a gap in the literature documenting the value of the New York State approved industry-level assessments, to employers. Employers may not weight the importance of all exams on the same level. Assessments such as Pearson Vue (n.d.) Certiport or the National Occupational Competency Testing Institute (n.d.) assessments, should be evaluated against CompTIA (2016) certifications as to their value to employers. Educators in the IT field may want to prepare students for the assessments/certifications that have the most significance to employers. While the importance of CTE education to college and career readiness experienced a dramatic increased because of ESSA and New York States plan, the linkage to industry, and closing the skills gap may require tighter alignment with employers.

Career and Technical Education

According to Stone (2014), the American education system has supported an academic curriculum that was designed to prepare students for a four-year college degree. Focus on college for every student was evident in New York's plan, before ESSA, that deemed a student college and career ready if the student was able to obtain an Advanced

Regents diploma (Achieve, 2016). However, with the adopting of ESSA and New York State's plan in response to ESSA, a student's progress in securing a regent's diploma and a technical endorsement provided an additional option for students to demonstrate college and career readiness (NYSED, 2016). Therefore, a more in-depth look at the history, funding, and the applicability of IT technical endorsements, alternative pathways, and industry-level certifications may provide the benchmarking for whether these requirements can be achieved using simulations in the absence of hands-on hardware.

History

The roots of CTE can be found as far back as colonial America when apprenticeships provided a pathway to career readiness (Stone, 2014). However, the Smith Hughes Act, in 1917, introduced the role of the federal government in identifying a student's destiny and preparing the students for either leadership or relevant employment (Stone, 2014; Tamar-Belgraves, 2016). The Smith Hughes Act tracked a student to either an academic or vocational curriculum based on the student's ability to enter college or an entry-level job (Stone, 2014; Tamar-Belgraves, 2016). At this point in history, college and career readiness might be considered college or career ready (Stone, 2014; Tamar-Belgraves, 2016).

However, Dewey (1938) was vehemently opposed to the separate tracking of academics and vocations, proposing instead that vocational education should be integrated into a curriculum to help students expand, not limit, educational opportunities. The work of Dewey supported the addition of industrial arts class to middle schools and high schools under the philosophy that hands-on learning promotes intellectual learning

(Pearl, 2016). According to Pearl (2016), CTE students uphold Dewey's vision by exhibiting improved attendance, academic rigor, and transitioning to postsecondary education.

The late 1950s sparked an interest in space exploration and the National Defense Education Act (NDEA) act was passed, designed to place additional focus on STEM education and vocational careers that would provide security for the United States (Tamar-Belgraves, 2016). Four years later, in 1963, the Vocational Education Act was passed as a response to employers concerns that students needed to be prepared for the labor market to generate economic growth in the United States (Tamar-Belgraves, 2016). The Vocational Education Act increased the scope of CTE as well as providing additional funding (Tamar-Belgraves, 2016). Further amendments to the Act shifted the focus from preparing all students for employment in the labor market to funneling students with learning difficulties into the CTE vocations, giving rise to a perception the CTE education was not as desirable as academic achievement (Stone, 2014).

In 1984, the Carl D. Perkins Act authorization responded to the need to have trained workers that could bolster the role of the United States in the global economy (Stone, 2014; Tamar-Belgraves, 2016). The 2006 reauthorization to the Perkin's Act renamed vocational education to CTE and defined an integrated academic and CTE program that would prepare students for both college and career readiness (Stone, 2014; Tamar-Belgraves, 2016). The Perkins Act called for Programs of Study (POS) that integrated academics into vocational curriculums, and the establishment of articulation agreements with postsecondary programs that would provide a pathway for students to continue their education beyond high school (Stone, 2014; Tamar-Belgraves, 2016). The Perkins Act required that vocational programs strengthen their relationship with business and industry by establishing advisory councils, and that the programs lead to a credential acknowledged by industry (Stone, 2014; Tamar-Belgraves, 2016).

Funding

The Carl D. Perkins Career and Technical Education Act of 2006 provided grants to improve CTE in New York State (NYSED, 2017). According to NYSED (2017), applicants for the awards must complete an application for the upcoming school year demonstrating how the funds will be used to integrate academics, link high school to postsecondary education, or enhance the student's ability to meet or exceed the standards defined in Perkins 1V. Funding was allocated using a formula based on the school districts population of students ages five to seventeen, with a higher weighting on individuals considered below the poverty line. The Perkins allotments, by the school district, are published by NYSED annually (NYSED, 2017). However, the thirty-seven BOCES that provide shared career and technical services across the state don't levy taxes or receive Perkins funding directly (NYSED, n.d.-c). The aid goes to the individual school district that in turn provide the funding toward the shared service (NYSED, n.d.-c).

Funding remains an essential issue in procuring hands-on hardware or simulation software and the workstations that have resources capable of running the simulations (Lampi, 2013). While the local school districts provide the New York State Regents examinations, many alternative pathway exams, industry-level certification exams, and technical endorsement assessments are costly to the student to sit for the exam (CompTIA, n.d.-b). For example, the CompTIA A+ exam requires passing two tests, both priced at $211.00 each, per student (CompTIA, n.d.-b). The Network+ assessment was $302.00 per student (CompTIA, n.d.-b). However, CTE schools can take advantage of a discount by qualifying as a CompTIA Partner Academy (CompTIA, n.d.-a).

Career and Technical Education in New York State

The Board of Cooperative Educational Services was established in 1948 to provide shared educational services across the state in all but five larger cities including NYC, Buffalo, Rochester, Yonkers and Syracuse who include CTE in their local academies (Board of Cooperative Educational Services [BOCES], 2018). There are currently 37 BOCES authorized to support CTE programs whereby two or more districts request a service (BOCES, 2018). New York State’s program approval process for local districts with career and technical programs and BOCES include policies for granting technical endorsements, an alternative pathways program, and the opportunity to earn industry-level certifications (NYSED, 2011).

Technical Endorsements

With the adoption of ESSA, technical endorsements have increased in importance in New York State (NYSED, 2016). The New York State plan to address ESSA and college, and career readiness included a regent’s diploma paired with a technical endorsement, whereas the previous measurement only addressed an advanced regents’ diploma (Achieve, 2016; NYSED, 2016). Requirements for a technical endorsement included the student earning 22 credits in the CTE program, passing five regents or approved alternative pathway exams, and passing a technical assessment, the consists of a written, hands-on and project portion (NYSED, n.d.-a). The program must include work-based learning opportunities and an employability profile for each student (NYSED, n.d.-a). Upon successful completion of the education commissioner's requirements, the students earned a career and technical endorsement seal on their high school diploma (NYSED, n.d.-a). The percentage of students who obtain a technical endorsement can be found on BOCES report cards each year. However, there was a gap in the literature concerning whether there was a significant difference in pass rates of New York state high school students in approved IT content cluster high school programs, who use simulations as compared to students who use hands-on hardware.

The purpose of this quantitative, nonexperimental study was to determine if there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs, between those who use simulations and those who use hands-on hardware. The student's test results for the technical endorsement assessment was the first determinant of college and career readiness used in this study. NYSED provides a list of school districts or BOCES and the approved CTE programs at each location (NYSED, 2018a). NYSED (n.d.-b) has produced a sample list of approved assessments that for use in trade and technical programs, and additional tests can be recommended for approval to NYSED by individual CTE programs wanting to use the exam. The Computer Repair and Programming cluster suggest CompTIA: A+, Network+, and Security+, Cisco, C-Tech:

Copper Network Cabling, Fiber Optic Networking Cabling, ISCET, and TestOut: PC Pro, Network Pro, and Security Pro (NYSED, n.d.-b).

Alternative Pathways

According to the New York State Education Department (2018a), multiple pathways to graduation were adopted to recognize student interests and engage students in rigorous and relevant programs. CTE programs are an area approved by the NYS Board of Regents in 2015, and as a result, a student can substitute an approved CTE pathway assessment in place of one Social Studies Regents exams (NYSED, 2018a). However, for the 2017-2018 school year, the list of approved exams was a different list than the approved technical endorsement assessments, and the approval process was different, as well (NYSED, 2018a). The list of approved CTE assessments, in the computer technology sector, included exams from C-Tech Associates (n.d.), Certiport (Pearson Vue, n.d.), and National Occupational Competency Testing Institute (n.d.) (NYSED, 2018a). The vendor-neutral exams that were on both the technical endorsement assessment list and the approved CTE assessment list are CompTIA's A+ and Network+ exams (NYSED, 2018a). It was interesting to note that there was a third list of approved exams to be used to evaluate CTE teachers and principals in New York State which has the NOCTI in common with the CTE assessment list, but no assessments in common with the technical endorsement assessment list (NYSED, 2018a; NYSED, 2018b).

Industry-Level Certifications

In addition to demonstrating college and career readiness in a secondary-level program, securing an industry-level certification may enhance a student's employability after high school (Tamar-Belgraves, 2016). Industry-level certifications may require years of experience working in an IT job, as well as a retest or submitting continuing education credits to maintain certification (Tamar-Belgraves, 2016). In the IT field, industry-level certifications signal the employer that the candidate has acquired skills specific to an entry-level position in IT. (Whittington, 2017). Industry-level certification exams can be either vendor-specific such as Cisco or vendor-neutral, such as CompTIA (2016). While research has verified that employers prefer a candidate with skills validated by industry-level certifications, there are few studies at the high school level that demonstrate the success of the students or the methodology, simulations versus hands-on hardware, used to prepare the high school student for certification exams (Tamar-Belgraves, 2016). However, one study that included the enrollment in Florida high schools indicated that the high school graduation rate increased for students that had access to completing industry-recognized credentials (Tamar-Belgraves, 2016). According to Tamar-Belgraves (2016), the need to develop rigorous and relevant objectives for CTE at the secondary level resulted in a focus on industry credentials at the secondary level.

Hands-on Hardware and Simulation in IT Education

According to Tagliacane et al. (2016), the need for experts in the field of IT required education and training such that technicians can solve problems from both a theoretical and technical aspect. New York state's plan, in response to the implementation of ESSA, placed requirements on educators to prepare students for technical endorsements and provide the students with the opportunities to graduate with industry-level certifications (NYSED, 2018c). However, many researchers agree that their inability to give the students accesses to hands-on hardware limits meeting the requirements for every student to have adequate access to hands-on hardware to provide real-life experience (Diwakar et al., 2016; Gercek et al., 2016; Ghani, 2015; Heradio et al., 2016; Lampi, 2013; Shimba et al., 2016; Tagliacane et al., 2016). Therefore, the next section of this literature review is focused on the use of both hands-on hardware and simulation labs for acquiring theoretical and practical skills. Hands-on hardware labs are discussed initially, and then simulations, concluding with a review of studies that focus on a comparison of research regarding hands-on hardware and simulations for IT training.

Hands-on Hardware Labs

In the IT field, lab sessions are an essential element of training (Lampi, 2013). Core competencies for entry-level computer and network technicians include hands-on practice in the configuration, management, troubleshooting and repair of computers and networks, in preparation for performing IT job responsibilities (Lampi, 2013). In the IT environment, 100% actual working equipment occupy hands-on hardware laboratories, including computers and networking equipment, where the labs are configured to support educational objectives and provide the students with beneficial hands-on experience (Tagliacane, et al., 2016). Equipment in a hands-on hardware lab consists primarily of hardware and software products (Gercek et al., 2016). The next two paragraphs provide sample equipment for an entry-level IT course and an entry-level computer networking course.

For example, the equipment list for Cisco Networking Academy's IT Essentials course, which introduces students to responsibilities of an IT professional, such as, installing and maintain hardware and software, mobility devices, and networking and security, recommended one lab computer for every two students, and two computers for the instructors (Cisco Networking Academy, n.d.). The instructor needs one computer for lab demonstrations and one computer for lab activities. The specifications for the lab computers are provided by Cisco, such that the instructor can support the topologies used in the IT Essential curriculum (Cisco Networking Academy, n.d.). Smartphones and tablets are necessary for the labs on mobile devices. Every two students need a toolkit with approximately 20 items that include tools, testing, and safety equipment (Cisco Networking Academy, n.d.).

Networking Essentials is an example of an entry-level networking course offered by Cisco Networking Academy (Cisco Networking Academy, n.d.). The purpose of the course is to provide students with experience in setting up wired and wireless networks, configuring network devices, and implementing network security. The lab equipment for recommended Networking Essentials was two computers with wireless cards, a Cisco 1941 Router, a 2960 catalyst switch, a wireless N router, a smartphone or tablet, and the cables, connectors, and freeware required to connect and access the lab equipment (Cisco Networking Academy, n.d.). There are several tools such as a cable tester, wire cutter, wire stripper, and a crimping tool needed for networking labs (Cisco Networking Academy, n.d.). An instructor would need to repeat the recommended configuration for as many lab set-ups as necessary to support their students in the lab environment (Cisco Networking Academy, n.d.).

Hands-on hardware labs can be simple or complex, depending on the course objectives and the equipment required to support the associated laboratory exercises (Gercek et al., 2016). Additional requirements would be adequate floor space to house the equipment, including facilities such as power and temperature controls and staff to maintain the equipment (Gercek et al., 2016). However, in addition to course configuration, an instructor in New York state needs to consider the benefits and challenges of implementing hands-on hardware labs and to what extent they can help the students meet the requirements in New York states ESSA plan to provide students with a technical endorsement and an industry-level certification (NYSED, 2016).

Hardware Benefits

In a hands-on hardware lab, students get the benefit of learning through hands-on experience with real computers and networking equipment (Tagliacane et al., 2016). The transition from a hands-on hardware environment provides skills that are straightforward regarding performing the same skills in a real-world environment on similar equipment (Tagliacane et al., 2016). A hands-on hardware lab offers the most realistic choice for training students on the setup, maintenance, and troubleshooting of a real-world environment, as opposed to a simulated environment (Tagliacane et al., 2016). Lampi (2013) suggested that hands-on hardware access provides sensory and situational clues concerning real-world experiences. A student in a hands-on hardware learning environment may hear a bad hard drive spinning or smell an overheating component (Lampi, 2013).

Hardware Challenges

In addition to the benefits associated with using hands-on hardware, there are associated challenges. First, there is a financial cost associated with procuring and maintaining up to date equipment in an adequate facility with a qualified instructor (Diwakar et al., 2016; Ghani, 2015; Heradio et al., 2016; Tagliacane et al., 2016). For example, according to Gercek et al. (2016), the first laboratory for computer networking courses at the University of Houston-Clear Lake, occupied 2500 square feet, and cost over $250,000. Educational facilities without the budget or space for a robust, hands-on hardware lab risk an environment where every student may not have access to the equipment (Diwakar et al., 2016; Heradio et al., 2016; Konak et al., 2014; Tagliacane et al., 2016). Ghani (2015) cited a less than optimal working environment due to interference from classmates and noise intensity from equipment. Possible safety issues include the opportunity for injury to the students using high voltage connections and outlets or damage to the equipment because of untrained students trying labs for the first time (Ghani, 2015). Finally, the procurement of laboratory equipment paired with a specific curriculum may limit the range of experiences in a laboratory learning environment (Tagliacane et al., 2016).

Simulated Labs

Simulated labs are not a new tool for learning (Chisholm, 2015). Pilots have used simulators since the early 20th century to learn flight instrumentation (Chisholm, 2015).

The first simulators were essentially a replica of the actual equipment (Chisholm, 2015). However, advancements in technology gave rise to the use of simulations as more representative learning platforms in many fields such as medical, military, nuclear power, science, and engineering (Bohr, 2014; Chisholm, 2015; Ghani, 2015; Lampi, 2013).

In the IT field, the use of computerized simulation tools, such as Cisco Packet Tracer, allow students to construct, manage, and observe networks in an environment that is safe and will not affect telecommunication devices in a production network (Tagliacane et al., 2016). For example, Packet Tracer, by Cisco Systems, allows the student to construct network topologies, via a drag and drop interface, which simulates a computer network. The student can install, configure, and troubleshoot network devices and connectivity using a simulated command line interface (Cisco Networking Academy, n.d.).

The next section of this literature review is focused on the benefits and challenges associated with using simulations, the role of simulations in educational technology, and a review of research studies that investigated the role of hands-on-labs versus simulations in preparing students for success in the IT field.

Simulation Benefits

Many researchers agreed that IT simulations offer advantages to the learner's environment (Ghani, 2015; Lampi, 2013; Jovanovic et al., 2016; Shimba et al., 2016). In fact, numerous studies suggest that simulations are most effective when paired with a hands-on environment (Lampi, 2013; Shimba et al., 2016). The benefits and challenges that accompany the use of simulations for skills practice are discussed in the following paragraphs.

An evident concern by researchers was the cost associated with hands-on hardware and laboratory space for IT computer and networking equipment (Lampi, 2013; Ghani, 2015; Shimba et al., 2016; Tagliacane et al., 2016). According to Tagliacane et al. (2016), simulations were more accessible to procure than expensive hardware. For example, Cisco's Packet Tracer tool became free with Version 7.1 and was downloadable via an internet connection (Cisco Networking Academy, 2018). TestOut's Labsim offerings, such as PC Pro, Network Pro, and Security Pro offer certification exams, and the products are an authorized training tool for CompTIA certifications (TestOut, n.d.). The TestOut products are provided at a discounted price for students and educators, and the students access the product over an internet connection (TestOut, n.d.). The cost of the TestOut product decreases with an increase in the number of purchased licenses, and the product offers one free attempt at passing the course certification (TestOut, n.d.). Packet Tracer and the Labsim products are accessible in a classroom or home computer, providing additional savings by freeing up lab space (Lampi, 2013; Shimba et al., 2016). These two products are not a comprehensive list, but a sampling of products available IT learners. The intent was to demonstrate that researchers agree that ease of procurement and low cost may provide an affordable solution for student practice for technical endorsement exams and industry-level certifications (Ghani, 2015; Lampi, 2013; Shimba et al., 2016; Tagliacane et al., 2016; Zvacek, 2015).

Consistency, convenience, and flexibility are additional benefits that researchers associated with the use of IT coursework simulations (Ghani, 2015; Lampi, 2103; Shimba et al., 2016; Zvacek, 2015). According to Ghani (2015), simulations offered a more structured and less unguided learning environment for the student. Limited instructor availability can be supplemented using feedback to the student from the simulation product (Ghani, 2015). Furthermore, students can practice IT skills in an anytime/anywhere environment using simulations, and access the products simultaneous (Ghani, 2015; Jovanovic et al., 2016; Lampi, 2013). The students can access simulated labs without traveling to the hardware lab location, and there was no scheduling or set-up, or take-down time required for the use of laboratory hardware when simulations are used (Zvacek, 2015). The flexibility of simulations allows instructors to offer lab exercises that would not be possible without every variation of computer and networking equipment (Jovanovic et al., 2016). For example, with TestOut's (n.d.) PC Pro simulation product, students can practice configuring on a redundant array of independent disks level five (RAID 5) on a simulated server, without procuring expensive server hardware with three hard drives. Cisco's Packet Tracer product allows the instructor the flexibility to develop customized lab scenarios for their classroom (Cisco Networking Academy, 2018). Simulated labs can be manipulated to be as simple or complex as required by the objective of the lesson (Lampi, 2013; Shimba et al., 2016).

Simulated labs provided the opportunity for practice minus risk (Kappers & Cutler, 2016; Lampi, 2013). Safety and security concerns were alleviated when students worked on simulated labs instead of hands-on hardware (Lampi, 2013; Shimba et al., 2016). In a simulated environment, student exposure to high voltage as well as the possibility of damaging expensive hardware while practicing new skills and causing equipment downtime was eliminated (Kappers & Cutler, 2016; Lampi, 2013). Working in a simulated environment eliminated computer and network security concerns because students are not practicing skills on the actual internet attached computer or network systems that could inadvertently leave security controls disabled (Lampi, 2013). For example, it would be acceptable to practice enabling a service through a firewall in a simulated environment but enabling that same service on real hardware attached to the internet may not be allowed by an institutions IT Security Policy and could leave the system or network vulnerable to attack (Lampi, 2013). According to Mohtasin et al. (2016), simulations offered an interactive environment that allow students to learn from their mistakes without risk to the student or a hands-on hardware environment.

Simulation Challenges

While there were many benefits to using simulation for skill practice in IT, simulations also presented several challenges (Diwakar et al., 2016; Ghani, 2015; Jovanovic et al., 2016; Tagliacane et al., 2016; Zvacek, 2015). Instructors and students required training on the simulation tool (Diwakar et al., 2016; Ghani, 2015). Once trained, learning was dependent on the availability of computers and internet connectivity (Diwakar et al., 2016; Ghani, 2015). Secondly, the quality of education depended on the range of scenarios offered by the product, and the use of simulations may not indicate the seriousness of performing the task at hand (Jovanovic et al., 2016; Tagliacane et al., 2016). Finally, a simulated environment alone may not be enough to allow students to seamlessly transfer to a hands-on equipment environment (Lampi, 2013; Shimba et al., 2016).

Before using a simulation tool, researchers suggested that the educators and the students require instruction on using the product in the simulated environment (Ghani, 2015). Cisco Networking Academy (2018) offered a Packet Tracer installation tutorial and a navigation tutorial, and TestOut (n.d.) suggested that the student complete an initial module in each course on using and exploring the simulator. While most products offered training, it was an additional time commitment to learn how to use the simulator, as well as another time commitment for the instructor to complete each lab before the students attempted the assignment (Ghani, 2015). Once installed, the teacher and the student may become dependent on the simulations availability to complete their work (Diwakar et al., 2016; Jovanovic et al., 2016). Therefore, a computer, without adequate resources such and hard disk space and memory, and a lack of internet connectivity could result in learning issues for the student. (Diwakar et al., 2016; Jovanovic et al., 2016).

According to Tagliacane et al. (2016), available scenarios limited the range of training included in the product. If missing functionality and connectivity in the simulation product cause misalignment with course objectives, the instructor might consider an additional product or hands-on hardware lab environment. Products such as Cisco Networking Academy's (2018) Packet Tracer allowed the teacher to configure scenarios, however, designing and developing lab assignments require an additional time commitment for the teacher (Zvacek, 2015). Jovanovic et al. (2016) suggest that instructors create a professional environment whereby students understand that the simulation represents actual job responsibilities such that students do not interpret skill practice as game playing.

The literature suggested that a simulation may not be a complete replacement for hands-on hardware instruction (Lampi, 2013; Shimba et al., 2016). Although simulation benefits skill practice, students require some hands-on hardware training before transitioning to the workplace (Lampi, 2013; Shimba et al., 2016). Lampi (2013) suggested a blended environment, including some hands-on hardware, supplemented by skill practice on simulations.

Research Findings Agreement and Ambiguity

Although research existed concerning simulations at the high school level, most secondary school studies related to core subject areas such as science (Bohr, 2014; Torres et al., 2015). Studies focused on the use of simulated labs versus hands-on hardware for IT skill practice focused on samples primarily at the postsecondary level (Ghani, 2015; Lampi, 2013; Shimba, et al., 2016). Furthermore, according to Lampi (2013), it is crucial that the use of any tool is used to achieve pedagogical effectiveness, as opposed to being driven a teacher or student preference to use a technology tool. Several of the studies at the collegiate level focused on teacher and student preference but disagreed on the effectiveness of the tool to match learning objectives for either skill practice or overall course completion (Lampi, 2013; Ghani, 2015; Shimba et al., 2016). In this section, studies at the high school level, studies related to the effectiveness of CTE education, and the use of simulations for IT skill training at the collegiate level are discussed.

Torres et al. (2015) investigated the use of virtual labs for teaching and learning chemistry, highlighting the need for an alternative learning method due to the lack of required equipment in high school science laboratories. The quantitative research project focused on a twenty-student evaluation of a simulated chemistry lab using a Likert-type scale, and descriptive statistics (Torres et al., 2015). The study results indicated student satisfaction in ten ranked areas (Torres et al., 2015). The user help function ranked the lowest, and students consistently gave high scores for aesthetic and minimalist design, and user control (Torres et al., 2015). However, the study did not evaluate the effectiveness of the tool in meeting course objectives.

Conversely, Bohr's (2014) multistate qualitative case study focused on secondary teacher perceptions of online virtual labs versus hardware labs. Bohr surveyed teachers with two years' experience teaching hands-on hardware labs and two additional year teaching online virtual labs, resulting in 18 responses. Results of the survey identified higher teacher preference for hands-on hardware labs as opposed to virtual labs (Bohr, 2014). Bohr's results were consistent with the reviewed studies in her report, which identified six out of nineteen studies that identified virtual labs as being a successful learning tool and one strongly supported virtual labs were a suitable replacement for hands-on training. The preference for simulations cited cost savings, convenience with anyplace anytime scheduling, a safer environment, less set-up and take-down time required are consistent with the findings in the benefits section of this paper (Bohr, 2014). Bohr cited the impediments to simulation effectiveness is the lack of involvement with real equipment, and the ability to use sensory clues such as smell and touch. While these studies were an investigation high school science, the benefits and challenges pair with those identified by IT simulation researchers. Therefore, the attributes discussed might require consideration when implementing virtual labs at the secondary level, in the absence of adequate hands-on hardware. However, according to Lampi (2013), the overall effectiveness of the adopted tool, in meeting the learning objectives, also required evaluation.

At the secondary level, current research supports the need for CTE programs of study (POS; Castellano et al., 2017; Tamar-Belgraves, 2016). Researchers explored the achievements of students in college and career readiness program and the role of CTE, as well as the importance of earning industry-level certifications while in high school (Castellano et al., 2017; Tamar-Belgraves, 2016). Although focused on multiple areas of CTE education, Castellano et al.'s (2017) mixed methods study sought to estimate the extent to which the completion of a CTE program linked to the student’s overall GPA, credits earned in STEM subjects, and achievement of technical skills as represented by the student CTE GPA. The study collected qualitative data from 2,004 students, 1175 in CTE POS and 829 in non-CTE POS, in a large Western United States city school district. Castellano et al. identified CTE POS students as achieving higher GPAs, more STEM credits, and higher CTE GPAs than students not enrolled in a CTE POS. Student interviews suggested that the CTE POS students were better prepared for their next step after high school (Castellano et al., 2017). Castellano’s findings support the need for researching concerning how teachers can help students be successful in their CTE program of study, promoting college and career readiness, even in the absence of hands-on equipment.

In another study, Tamar-Belgraves (2016) performed quantitative research at fifteen districts in the state of Florida, examining the relationship between graduation rates and students earning industry-level certifications. The researcher identified a positive correlation between students who achieved industry-level certifications and graduation rates (Tamar-Belgraves, 2016). Tamar-Belgraves suggested that industry-level certifications prepare students to be competitive with students from other states, in seeking entry-level employment, or in securing entry-level skills needed to further their education at the postsecondary level.

Hansson (2017) investigated New York state's role in educating students to fill the cybersecurity job gap. Burning Glass Technologies (2018) reported that public and private employers listed 301,873 jobs opening in cybersecurity over a twelve-month period, from April 2017 to March 2018. Meanwhile, the Federal Bureau of Investigation's (2018) 2017 Internet Crime Report identified over 800 complaints received per day and victim loss at $1.42 billion. On that same report, New York state ranked 4th in internet crime, with 17,622 victims (Federal Bureau of Investigation, 2018). As part of her research, Hansson examined the role of New York State BOCES CTE Programs in providing cybersecurity education at the secondary level. Hansson's analysis concerning the overall success of BOCES POS agreed with the Tamar-Belgraves (2016) findings, as the BOCES graduation rate was more than seventeen percent higher than the New York state overall graduation rate, in 2013. However, Hansson also concluded that

New York state school districts are operating independently, and there needs to be a coordinated effort in implementing and supporting pathways for students to fill the IT cybersecurity gap.

At the postsecondary level, there was research available on the effect of using simulation in place of hands-on hardware for IT skill learning (Ghani, 2015; Lampi, 2013; Shimba et al., 2016). However, the results of the studies focused on skill sets, as opposed to a POS outcome such as passing a technical endorsement exam or earning an IT industry certification (Ghani, 2015; Lampi, 2013; Shimba et al., 2016). The researchers expressed conflicting conclusions regarding the effectiveness of simulations versus hands-on hardware (Ghani, 2015; Lampi, 2013; Shimba et al., 2016).

Lampi (2013) conducted a quantitative two-stage experimental study at the University of Zambia concerning the effectiveness of using simulations to teach IT networking skills. Lampi's concerns were the acute deficiency of networking equipment available for hands-on learning, the need for network engineers in Zambia, and that no similar study evaluated the transfer of networking skills from a simulated to a hands-on hardware environment. In the first stage, Lampi randomly assigned two groups from a 56-member sample, a virtual group and a no-virtual group (Lampi, 2013). Following classroom instruction, the virtual lab group practiced network configuration and troubleshooting skills using Cisco Packet Tracer, and the no-virtual group did not practice (Lampi, 2013). Next, both groups were asked to perform the network configuration and troubleshooting on the actual hardware (Lampi, 2013). In stage two, both groups practiced on the physical equipment before the configuration and troubleshooting tasks were measured again (Lampi, 2013). The Phase 2 posttest indicated that the group who had initially practiced configuration and troubleshooting skills using the simulator had a shorter configuration and troubleshooting time (Lampi, 2013). However, there was no significant difference between the two groups in configuration and troubleshooting accuracy (Lampi, 2103). Lampi concluded that the use of simulations is useful in the positive transfer of networking skills from the virtual to the hands-on hardware environment. However, Lampi cautioned in his recommendation section that while using virtual labs for asynchronous practice and distance education, the instructor should schedule the students on the hands-on hardware when equipment becomes available.

Ghani (2015) evaluated the effectiveness of feedback systems on 80 students enrolled in Cisco Certified Networking Associate (CCNA) courses, in a quantitative study, at DeVry University, in Addison Illinois. Students joined a group based on their class scheduling, morning, afternoon, evening, or weekends (Ghani, 2015). Traditional hands-on (HON), simulations with knowledge of correct response (KCR) whereby the simulation directs the student to the correct answer, simulations with answer until correct (AUC) whereby the student cannot progress until they answer correctly, and simulations with no feedback (NFB) identified the groupings (Ghani, 2015). The simulation tool used was the Cisco Networking Academy's (2018) Packet Tracer (Ghani, 2015). All fours groups completed the same lab assignments in their assigned environment (Ghani, 2015). As a result, Ghani determined that the Packet Tracer simulations are at least as useful, but not superior to traditional hands-on labs. Ghani's conclusion disagreed with Lampi

(2013), reporting that replacing hands-on labs with simulations provides cost saving and flexibility. Ghani's findings identified that simulated labs with the answer until correct (AUC) produced better results than simulated labs with no feedback.

Shimba et al. (2016), also cited a critical shortage of hands-on hardware equipment in developing countries, and they conducted a mixed methods comparison study between virtual labs and hands-on labs, at Tanzania's Sokoine University of Agriculture. A control group used hands-on hardware to learn to configure a simple Virtual Local Area Network (VLAN) environment on a switch between two workstations, and the experimental group used Cisco Networking Academy's (2018) Packet Tracer to learn the same VLAN configuration. (Shimba et al., 2016). Later, both groups tested by configuring the VLAN on actual hardware (Shimba et al., 2016). While the hands-on group completed the configuration, the group that learned on Packet Tracer failed to configure and verify the VLAN configuration (Shimba et al., 2016). Shimba et al. (2016) indicated that teacher and student opinion surveys supported Lampi's (2013) findings that simulations assist in skill practice. However, in contrast to Lampi's conclusions, Shimba et al., recommended that hands-on labs replace simulations for enhancing networking and problem-solving skills and that learning institutions in Tanzania make a better effort to acquire hands-on hardware for all students for networking skill practice.

While research supported the need for CTE Programs of Study resulting in industry-level certifications to achieve college and career readiness, the effectiveness of using simulations to replace hands-on hardware labs was still ambiguous (Castellano et al., 2017; Lampi, 2013; Tamar-Belgraves, 2016). Research supported the fact that even if the researcher identified a preference for a hands-on hardware lab environment, equipment may be limited (Lampi, 2013; Shimba et al., 2016). Finally, a gap existed in the research concerning if there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs, who use simulations, as compared to students who use hands-on hardware, as determined by passing a technical endorsement assessment and an industry-level assessment.

Summary

A detailed review of the literature indicated that CTE plays an essential college and career readiness role in New York state, newly redefined based upon the recent requirements from the U.S. Department Education. While researchers agreed on many benefits and challenges to using simulations or hands-on hardware, research also indicated that IT equipment was expensive, and educators may not have an opportunity to provide students with unlimited access to hands-on labs. Research, using Kolb's (1984) experiential learning theory, indicated that the learning process may be transferable from a simulated to a hands-on hardware laboratory. However, there was a gap in the literature concerning the degree of simulations used by New York state IT instructors, and whether the instructors can help their students meet the requirements set forth by the U.S Department of Education and New York state. The purpose of this quantitative, nonexperimental study was to determine if there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs, between those who use simulations and those who use hands-on hardware. Quantitatively evaluating the degree of use and effectiveness of simulations may provide additional knowledge on how IT instructor can assist their student in becoming college and career ready as well as providing insight regarding the role of simulations versus hands-on hardware in achieving that goal.

In Chapter 3, the research project is described, including the research design and rationale, methodology, and threats to validity.

Chapter 3: Research Method

Introduction

The purpose of this quantitative, nonexperimental study was to determine if there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs, between those who use simulations and those who use hands-on hardware. New York state's plan in response to the Every Student Succeeds Act specified technical endorsements and industry-level certifications as measurements of college and career readiness for students in secondary career and technical programs of study (NYSED, 2018c)

The following sections of this chapter identify the research design and rationale for the study. The methodology section includes a definition of the population and sampling, the procedures for recruiting participants and collecting data, the pilot study, and a discussion about the study instrument and the operationalization of study's constructs. There is also a discussion about threats to validity and ethical concerns.

Research Design and Rationale

The research design was a quantitative correlational design, using a survey approach to collect data. There are three research questions for the study: (a) Are there significant differences in the technical assessment written exam grades of students in the four study groups? (b) Are there significant differences in the technical endorsement demonstration (hands-on exam) grades of students in the four study groups? (c) Are there significant differences in the certification pass rates of students in the four study groups? All three questions were appropriate for the study design because a quantitative correlational design measured the relationship between the study variables (Warner, 2013).

The independent variable, represented as categories, identified the percentage of simulations the instructor used for teaching and learning, as opposed to hands-on hardware. The survey choices were as follows: (a) all coursework labs are completed on hands-on equipment, (b) less than 50% of coursework labs are completed in a simulated environment, (c) 50% or more of coursework labs are completed in a simulated environment, or (d) all coursework labs are completed in a simulated environment. The dependent variables were the written technical assessment grades, the technical-endorsement hands-on assessment grades, and the industry certification pass or fail status of the students. The grades and certification status were archival data for the students enrolled in the IT courses during the 2017-2018 school year. The written and hands-on assessment grades were continuous numeric for each student, and the certification exam pass rates were a binary pass or fail for each student. The certification exam rate was surveyed as binary because some vendor or non-vendor certification organizations, such as CompTIA (n.d.-c), share only certification status, not the actual grade, with the academic organization if that organization paid for the candidate to take the exam.

Time and resource constraints for this correlational design were minimal due to the archival nature of the data, and the advantages offered by using an electronic survey for rapid turnaround of data. The data collected were from the previous high school year, so there was no need to wait for testing to occur during the present school year.

Finally, this quantitative, correlational design study was needed to advance knowledge in the field of educational technology, concerning the use of simulation for teaching and learning, when IT hardware availability is limited. Most of the existing research used experimental designs to evaluate shorter-term goals of learning individual skills in the IT field, and other studies focus on qualitative purposes of understanding the instructor and student feelings about using simulations for teaching and learning (Lampi, 2013; Podlinski, 2016; Shimba et al., 2016). There was limited research exploring IT college and career readiness and the use of simulations, at the high school level (Lampi, 2013; Shimba et al., 2016). The correlational design chosen for this study provides information concerning the relationship between simulation use and the longer-term goals of college and career readiness, as defined by New York states ESSA plan, as well as other instructors who plan to use simulations to accomplish coursework objective (NYSED, 2018c).

Methodology

Population

The target population for the study was students enrolled in approved district or BOCES CTE IT programs, in New York state, during the 2017-2018 school year (NYSED, 2018a). However, the instructors answered the survey questions, concerning student data. There were 60 schools on the list of New York state-approved IT programs at the time of the study (NYSED, 2018a). Schools selected to participate in the study identified courses with the terms A+, Cisco, computer circuitry, computer repair or support, computer systems or technology, cyber, information systems or technology, networking or telecommunications, or PC/LAN. However, it was unknown if the schools offered the approved courses in the 2017-2018 school year, and it was unknown if the schools provided multiple sections. From the approved New York state CTE list, an estimate was that 60 schools offered IT courses with 20 students per school or 1120 students. The actual number of students might be lower if the course was not offered or higher if there were multiple sections of the course. A School Invitation Letter (Appendix A) was sent to all 60 schools, requesting a signed a Letter of Cooperation (Appendix B) and the identification of a survey participant. Following the signed Letter of Cooperation, a Participant Invitation Letter (Appendix C) was sent to the survey participant, allowing access to the Consent Form on the first page of the Survey, the Survey Questions (Appendix D), and the Attachment: 2017-2018 Student Technical Assessment Data (Appendix E). The survey asked for the number of students in the IT programs, the amount of simulation use used for teaching and learning, and student assessment and certification data.

Sampling and Sampling Procedures

The survey was used to identify whether the approved IT course or courses were offered at each of the 60 schools, during the 2017-2018 school year, the number of students enrolled in each class, and the amount of simulation use for teaching and learning. The process allowed for quantifying the number of students enrolled in the IT program and the classifying of students as belonging to one of the four groups that represented the independent variable of the amount of simulation used. The plan was to stratify the four groups to samples representing the proportion of simulation use versus hands-on hardware, as defined in the four groupings, characteristic in the actual population. Then, randomization would be employed for selecting the sample participants for the study, proportionally populating the four groups from the calculated overall sample size. However, the limited response rate of 60 participants resulted in all participant data being used, rather than stratifying and randomizing the participants.

As this study used inferential statistics, power analysis was needed to determine sample size. A calculation using power, statistical significance, and effect size predict an appropriate sample size for the planned statistical tests. Power represents whether the analysis will accurately identify an existing significant difference. Regarding calculating the sample size, accepting a power of 0.80 suggested a 20% probability of accepting a null hypothesis inaccurately. Accepting a statistical significance, or alpha level, of 0.05, indicates that the likelihood was less than 5% that the results of the analysis are caused by chance. Effect size examined how significant the difference was between groups and can only be calculated accurately after collecting the data. However, Cohen (1977), developed a scale identifying effect levels for the two tests used in this study. According to Cohen (1977), for the ANOVA, .10 is a small effect, .25 is a medium effect, and .40 is a large effect. For a chi-square, .10 is a small effect, .30 is a medium effect, and .50 is a large effect (Cohen, 1977). G*Power (Erdfelder, Faul, & Buchner, 1996) is an open source tool used for performing a power analysis and determining sample size. Using the G*Power (Erdfelder et al., 1996) tool to compute the ANOVA sample size, for four groups, using a moderate effect size of .25, a significance level of .05, and a power of .8, resulted in a total sample size of 180 students. Using G*Power (Erdfelder et al., 1996) for the chi-square, using a .3 moderate effect size, significance level .05, and power of .8 yielded an overall sample size of 143.

Procedures for Recruitment, Participation, and Archival Data Collection

This study used archival data, in the form of IT technical assessment grades, and records of students receiving industry-level certifications in the IT field during the 2017–2018 high school year. The relevant schools were sourced from the list of NYSED (2018a) approved CTE IT programs of study. An in-depth analysis of the courses indicated that courses with the terms A+, Cisco, computer circuitry, computer repair or support, computer systems or technology, cyber, information systems or technology, networking or telecommunications, or PC/LAN fall under the umbrella of IT. That initial review yielded 60 schools for possible inclusion in this study.

Following Walden IRB conditional approval, I sent an email containing the School Invitation Letter (Appendix A), to each of the 60 school's contacts listed on the NYSED (2018a) approval website explaining the study and requesting a signed Letter of Cooperation (Appendix B). I also requested the email address for an individual that could best provide data regarding the school's IT program. Once the signed Letters of Cooperation were on file with the IRB, I emailed the Participant Invitation Letter (Appendix C) to the survey participant's email provided by the school's contact person. The Participant Invitation Letter (Appendix C) contained a link to the Survey Questions (Appendix D). The participant providing the information was asked to provide informed consent as a yes or no response on the first page of the SurveyMonkey Inc. survey. The survey response contained the information to determine if the course was taught during the 2017-2018 school year, the number of students in each section, the percentage of simulations versus hands-on hardware used in the class, and some descriptive information concerning the curriculum and technical endorsement assessments used for the course. The schools that had students who are identified as being in one of the sample groupings were asked to also provide the assessment scores and certification status for the students in their IT courses.

Survey Pilot

Two weeks before sending the survey to consenting participants, the survey was piloted to improve the quality of the survey questions and increase the reliability and validity of the survey instrument. According to Warner (2013), a trial survey should be used to identify issues such as the survey taking longer than expected or to clarify confusing instructions. The pilot was planned for a small group of ten instructors, of varied disciplines, at a CTE school in New York state. While the CTE instructors who volunteered for the pilot might not have been teaching IT courses, the survey was applicable in that many CTE approved programs utilize simulations and all CTE instructors have the same requirement under New York State to certify their coursework. The plan included reviewing changes that resulted from the survey pilot with my research chairperson, requesting IRB approval if any changes in methodology resulted, and correcting problems before sending the survey to study participants. Results of the survey pilot are documented in Chapter 4.

Instrumentation and Operationalization of Constructs

The survey instrument was researcher designed and administered, using SurveyMonkey (SurveyMonkey Inc., n.d.). The survey questions asked if the approved IT course was taught at the school during 2017-2018, the number of students enrolled, and the percentage of simulations used. The survey requested student assessment and certification data.

The purpose of this quantitative, nonexperimental study was to determine if there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs, between those who use simulations and those who use hands-on hardware. The students' test results for the technical endorsement assessment and obtaining an industry-level certification are the determinants of college and career readiness used in this study. Amount of simulation use was the independent variable, and the dependent variable was technical assessment grades and industry-level certification. Therefore, closed-ended questions solicited the independent and dependent variable data along with demographics including student enrollment, curriculum used, technical-assessment used, and industry-level certifications for the 2017-2018 school year.

SurveyMonkey (SurveyMonkey Inc., n.d.) is used to develop online surveys and offers SPSS as a backend software for data analysis. The cloud-based service was founded in 1999, by Ryan Finley (SurveyMonkey Inc., n.d.). The surveys used in this study were created using SurveyMonkey. Following IRB approval, I piloted the survey to identify and correct any potential issues with survey dissemination and completion. Two weeks later, after obtaining candidate consent, I emailed an invitation letter to the school, and emailed the survey after the Letter of Cooperation was received. I also sent a follow-up email (Appendix F) to non-respondents if they did not respond to a survey request in seven days. SurveyMonkey's backend interface to IBM Corporations SPSS was used to analyze the data. Survey participants were provided with a link to complete the survey in an email. Survey questions are available in Appendix D.

Concerning construct validity, the number of students and technical assessment grades fell under the assumptions that the participant provides accurate archival data. However, the certification input needed to be reviewed for accuracy to ensure that the certification identified was an IT industry certification, such as CompTIA, Cisco, or Microsoft, as opposed to a NOCTI exam. The responses designated as "other" required manual evaluation against the CompTIA (2016) Career Roadmap for accuracy. Finally, the terminology used for the instrument mirrored the language used in the approval process for New York State IT programs of service. This assurance enhanced validity, as IT instructors are highly specialized in their career occupation and are familiar with the terminology used in the NYSED approval process and IT industry requirements.

According to Warner (2013), a survey design supports quantitative research questions, in the collection of archival data for generalizing from a sample to a population. Therefore, the survey instrument, validated by the pilot, was planned to provide data to answer the quantitative research questions. The SurveyMonkey (SurveyMonkey Inc., n.d.) tool provided an export capability to IBM Corporations SPSS analysis tools, ensuring that the data was not compromised by manually copying the data to a different analysis tool. The instrument supported a simple format to allow instructors to enter the study group that their student falls under, as well as student technical assessment results for 2017-2018 and student certification achievement. The planned pilot improved the usability, establish the reliability, and finally, project data was analyzed manually to verify construct-validity.

Operationalization

There were four variables used in the study. The independent variable was categorical based on the participants' responses regarding their use of simulations in their NYSED approved IT program during the 2017-2018 school year. The dependent variables of the technical-assessment written exam and technical assessment hands-on exam are numeric grades. The input asked for the ratio and converted the score to a zero to 100 scale. For example, if the participant responded that the student scored 785/800, the grade was converted to yield 98/100. The third dependent variable represented whether the student passed an industry-level assessment during the 2017-2018 school year. A participant answer of no was reflected as a zero, and response of yes was scored as a one. The variable name, label, type, and measure are displayed in Table 1.

Table 1

Variable, Labels, Type, and Measures

Name	Label	Type	Measure
SIMGRP	SIM Group Assignment	Categorical	Nominal
WGRADE	Written assessment grade	Numeric	Scale
HOGRADE	Hands-on assessment grade	Numeric	Scale
ITCERT	Certification Results	Categorical	Nominal

Note. Name represents the variable name in SPSS.

The variable mapping to the research questions and survey items are displayed in Table 2.

Table 2

Variables, Research Questions, and Survey Items

Variable	Research Questions	Survey Item
Relating IV SIMGRP to DV WGRADE	Research Question 1: Are there significant differences in the technical assessment written exam grades of students in the four study groups?	See Questions 3, 8
Relating IV SIMGRP to DV HOGRADE	Research Question 2: Are there significant differences in the technical endorsement demonstration (hands-on exam) grades of students in the four study groups?	See Questions 3, 8
Relating IV SIMGRP to DV ITCERT	Research Question 3: Are there significant differences in the certification pass rates of students in the four study groups?	See Questions 3, 5, 6, 7

Note. IV = independent variable. DV = dependent variable. Survey items are found in Appendix D.

Data Analysis Plan

The software planned for data analysis was IBM Corporations SPSS. Before analysis, SPSS was used for data cleaning to ensure there were no missing values or outliers that affect the outcome of the study. A frequency table was generated in SPSS to look for missing values and values that exceed the defined minimum or maximum of the expected data values. There were no missing values in the data. There was one (nonextreme) outlier, out of 60, in the written exam grades of students in the four study groups. However, a follow-up email with the participant validated the outlier to be a valid grade. Therefore; I chose to include the grade in the dataset. The research questions and hypotheses for the study are listed below.

Research Questions

RQ1. Are there significant differences in the technical assessment written exam grades of students in the four study groups?

RQ2. Are there significant differences in the technical endorsement demonstration (hands-on exam) grades of students in the four study groups?

RQ3. Are there significant differences in the certification pass rates of students in the four study groups?

Null Hypotheses

$H_0$1. There are no significant differences in the technical assessment written exam grades of students in the four study groups.

$H_0$2. There are no significant differences in the technical assessment demonstration (hands-on) grades of students in the four study groups.

$H_0$3. There are no significant differences in the certification pass rates of students in the four study groups.

Alternative Hypotheses

H_A1. There are significant differences in the technical assessment written exam grades of students in the four study groups.

H_A2. There are significant differences in the technical endorsement demonstration (hands-on) grades of students in the four study groups.

H_A3. There are significant differences in the certification pass rates of students in the four study groups.

One-way ANOVA was the statistical test planned to analyze the data in response to the first two research questions, while Pearson's chi-squared test was planned to analyze the data from the third research question. The utilization of two different tests was appropriate because of the nature of the data that was analyzed when comparing the four groups for the dependent variables. In the first two research questions, the dependent variables of the technical-assessment written exam and technical assessment hands-on exam were continuous variables and therefore appropriate for analysis using ANOVA. I selected a one-way ANOVA because there was only one independent variable. However, the dependent variable in the third question, certification pass status, was categorical and appropriate for a chi-square test. The three statistical tests to analyze each hypothesis were run and considered individually.

The first one-way ANOVA, using SIMGRP as the independent variable and WGRADE as the dependent variable, compared the group means for the dependent variable technical-assessment-written exam grade to determine whether there was a significant difference. The second one-way ANOVA, using SIMGRP as the independent variable and HOGRADE as the dependent variable compared the group means for the dependent variable technical assessment hands-on exam grade to determine whether there was a significant difference.

Initially, the one-way ANOVA must meet three assumptions. The assumption of independence demands that the groups are independent of each other. This first assumption was addressed in the study design; the defined groups are separate. The second assumption, the assumption of normality, can be tested using SPSS and a Shapiro-Wilks test to verify that the sample data represents a normal distribution population. For a Shapiro-Wilks, the null hypothesis was that the data for the group was normally distributed and the alternative hypothesis was that the data for the group was not normally distributed. A *p* value of .05 or less causes the hypothesis of normality to be rejected. A *p* value of greater than .05 indicates no findings of a divergence from normality. The last assumption requiring testing in a one-way ANOVA was the assumption of homogeneity of variance. Levene's F Test for Equality of Variance was run in SPSS to test for the assumption of variance. If the significance level was found to be greater than .05, the null hypothesis that there was not a significant difference in the variances of the four groups in the study is retained.

Assuming the analysis meets the three assumptions, the next step was to calculate the F ratios in SPSS, with an alpha = .05. If *p* is less than or equal to alpha, some of the means are statistically significant, and the null hypothesis tested should be rejected. If *p* is greater than alpha, the difference between the means is not statistically significant. If the null hypothesis is rejected, omega squared is examined to determine the strength of the association between the independent and dependent variables in the test. A post-hoc analysis (Tukey HSD or Games-Howell) determines whether each pairwise comparison is significant, and then the effect size was calculated for each pairwise comparison.

The chi-square, using SIMGRP as the independent variable and ITCERT as the dependent variable, tested the null hypothesis that there are no significant differences in the certification pass status of students in the four study groups. There are two assumptions associated with the chi-square test. First, the two variables should be categorical. The design of this research project met that assumption. Secondly, the two variables consist of two or more independent groupings. In this study, SIMGRP consisted of four independent clusters, and ITCERT consisted of two separate groupings. Therefore, this study met the assumptions for a chi-square analysis. The chi-square run in SPSS, calls for rejection of the null hypothesis if the *p* value is found to be greater than .05 If the *p* value was found to be less than .05, the null hypothesis fails to be rejected. Where *p* is greater than .05, the variables would be considered independent. Where *p* is less than .05, the variables would be regarded as linked.

Threats to Validity

The concerns for quantitative nonexperimental research included statistical conclusion validity and construct validity. Statistical conclusion validity may be a concern if the statistical assumptions for the tests are violated. The issue of statistical conclusion validity was addressed by clearly articulating the three assumptions for both the one-way ANOVA tests and the two assumptions for the chi-square test and ensuring that the assumptions were met. Construct validity was achieved by clearly defining the construct in the study. The construct was college readiness, in the field of IT, in New York State, which has been designated as the dependent variables, passing technical assessments and achieving industry-level certification. Four groups were defined as the independent variable, to identify the degree of simulation used for teaching and learning, in place of hands-on hardware. The variables were set in the study to mitigate issues with defining or accurately measuring variables.

Ethical Procedures

IRB approvals were obtained to ensure compliance with ethical research standards. The IRB approval number was 12-21-18-0515683. The 60 schools asked to participate in the study were asked to sign a Letter of Cooperation (Appendix B). The individual providing the information was asked to provide informed consent as a yes or no response on the first page of the SurveyMonkey survey. An individual who selected yes continued to the survey. An individual who chose no was redirected to a "Thank you" page, exiting the process.

There were no ethical concerns relating to recruitment. Participants could elect to participate, and they could withdraw at any time without completing the next step in the process. There was no penalty, and no reward offered other than the knowledge that the schools and instructors contributed to closing a gap in what we know about educational technology, in the form of simulations, and IT college and career readiness in New York state.

The names of participating schools were kept confidential. No identifying student information was requested that would affect the privacy of individual students. Due to the nature of this quantitative study, the reporting included the test results of the one-way ANOVA and chi-square test to determine if there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs, who use simulations as compared to students who use hands-on hardware. I am the only individual who had access to the data and knows which of the 60 schools chose to participate.

Copies of the final research report will be provided to study participants. Documentation related to the study will be kept in a locked cabinet at my home for five years and then destroyed. The paper copies will be shredded, the shredded material soaked in water, and the pulp will be composted. After five years, the electronic data will be deleted securely by overwriting the files on the computer and the external hard drive using Recuva (in Advanced mode). Survey data provided via SurveyMonkey will be deleted with the researcher's account.

Summary

The purpose of this quantitative, nonexperimental study was to determine if there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs, between those who use simulations and those who use hands-on hardware. The methodology used was a quantitative analysis to understand the relationship between the instructor's use of simulations and the student's technical assessment scores and certification pass status, during the 2018-2019 school year. A one-way ANOVA and a chi-squared test was be used to analyze data provided to determine the relationship between groups. Threats to validity and ethical issues were assessed to ensure mediation.

The next chapter addresses the results of the pilot study, data collection, and the results of the overall study.

Chapter 4: Results

Introduction

The purpose of this quantitative, nonexperimental study was to determine if there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs, between those who use simulations and those who use hands-on hardware. A survey was used to identify the percentage of simulations used in approved New York state IT programs of study and the influence on college and career readiness as defined by the students' technical assessment grades and their performance on industry-level certification assessments.

The study sample grouping, research questions, and hypotheses were defined as follows:

Study Sample Grouping

1. All coursework labs are completed on hands-on equipment; no simulated labs are used.
2. Less than 50% of coursework labs are completed in a simulated environment.
3. Fifty percent or greater of coursework labs are completed in a simulated environment.
4. All coursework labs are completed in a simulated environment, no hands-on environment.

Research Questions

RQ1. Are there significant differences in the technical assessment written exam grades of students in the four study groups?

RQ2. Are there significant differences in the technical endorsement demonstration (hands-on exam) grades of students in the four study groups?

RQ3. Are there significant differences in the certification pass rates of students in the four study groups?

Null Hypotheses

$H_0$1. There are no significant differences in the technical assessment written exam grades of students in the four study groups.

$H_0$2. There are no significant differences in the technical assessment demonstration (hands-on) grades of students in the four study groups.

$H_0$3. There are no significant differences in the certification pass rates of students in the four study groups.

Alternative Hypotheses

H_A1. There are significant differences in the technical assessment written exam grades of students in the four study groups.

H_A2. There are significant differences in the technical endorsement demonstration (hands-on) grades of students in the four study groups.

H_A3. There are significant differences in the certification pass rates of students in the four study groups.

The following sections of this chapter present the results and impact of the pilot and a description of the data collection phase of the study. The results section includes the outcomes of ANOVA and chi-square testing. Tables are included to illustrate the statistical findings.

Pilot Study

A pilot study was conducted to improve the quality of the survey questions and the reliability and validity of the survey instrument. The pilot survey was sent to a group of ten instructors, of varied disciplines, at a CTE school in New York state. The pilot participants were emailed a link to the SurveyMonkey Inc. survey and the Word document table that needed to be uploaded, representing the student technical assessment data. Following the pilot, the pilot results were reviewed with my research chairperson. There were no significant changes that would require IRB reapproval, and there was no impact on the main study regarding instrumentation, data analysis, or strategy.

The survey proved to be easily accessible from a computer. However, one participant attempted to enter responses from a mobile phone and reported difficulty with the file upload. Two participants submitted the survey without the file upload. Subsequently, the survey implementation was changed to require the file upload, and the text was added to caution the participant to upload the Word document before completing the survey. The typical time spent, as reported by SurveyMonkey Inc. was three minutes and seven seconds. However, the typical time spent may not have included completing the Word document outside of SurveyMonkey, if the participant completed the Word document before starting the survey.

After reviewing the pilot information with my chairperson, a reminder was added to question number two, advising the survey participants that they could copy and paste the web link provided to verify that the course they were teaching was on the list of approved IT courses for New York state. Another change included adding additional lines to the Word document attachment to provide for a larger number of students. Neither change was significant enough to required IRB reapproval.

Data Collection

Timeframe, Recruitment, and Response Rates

The time frame for data collection was approximately three months. An initial email containing the School Invitation Letter (Appendix A) and Letter of Cooperation (Appendix B), was sent to 60 schools that had an approved IT Program in New York State during the 2018-2019 school year. Four schools responded with a Letter of Cooperation. Following IRB approval for each school, the Participant Invitation Letter (Appendix C), a link to the Survey Questions (Appendix D) and the Consent Form were emailed to the school's contact. The email also included a Word document attachment 2017-2018 Student Technical Assessment Data (Appendix E) that needed to be completed and uploaded to the survey.

The four schools yielded a response rate of 60 participants over three of the groupings, less than 50% of coursework labs completed in a simulated environment, 50% or greater of coursework labs completed in a simulated environment, and all coursework labs completed in a simulated environment, no hands-on environment. One of the four schools offered two courses. No schools self-identified as all coursework labs completed on hands-on equipment; no simulated labs were used.

Discrepancies in Data Collection

The data collection process took longer than anticipated and yielded fewer participants than expected. Two of the four schools responded early with a Letter of

Cooperation but took until late March 2019 to complete the survey, after receiving the Follow-Up Reminder to Participants (Appendix F). Only four schools offered their support, totaling 60 participants out of the 180 for the ANOVA and 60 out of 143 for the chi-square test, as calculated initially in G*Power (Erdfelder et al., 1996). The class sizes were also smaller than expected, contributing to a lower number of participants from each school. The original estimate was 20 students per class, while some responding schools had as few as nine students.

Baseline Descriptive and Demographic Characteristics of Sample

The population for this research study included students enrolled in a New York state approved school district or BOCES CTE programs for IT (NYSED, 2018a). The list of New York State sanctioned IT programs was available on the NYSED (2018a) website. The website yielded 60 approved districts or BOCES CTE programs offering training at the secondary level in IT (NYSED, 2018a). The responding schools offered IT programs including Cisco Networking Academy: Introduction to Networking, Cisco Networking Academy: IT Essentials, TestOut PCPRO, TestOut Network PRO, TestOut Security PRO, and a self/consultant committee designed curriculum. The relevant industry-level certifications that matched the syllabi were the Cisco Certified Network Architect, CompTIA A+, CompTIA Security+, TestOut PC PRO, TestOut Network PRO, and TestOut Security PRO. The survey did not request demographic information regarding individual students, only archival test and certification data from the 2017-2018 school year.

Proportionality to Larger Population

From the approved New York state CTE list, an original estimate was that 60 schools offered IT courses with 20 students per school or 1,120 students. However, the four schools that responded, responding for five sessions, and provided an average of twelve students per class. Therefore, the new estimate for the broader population would be 720 students, and the non-probability sampling used was 8% of the population of students enrolled in a New York state approved school district or BOCES CTE programs for IT (NYSED, 2018a).

Statistical Results

This section details the results of the study. The descriptive statistics, evaluation of statistical assumptions, and the statistical analysis findings are detailed.

Descriptive Statistics

Written and hands-on assessment scores and certification data for 60 students were entered in the SPSS 25 Service Pack 2 statistical program. There were no students in the “all coursework labs are completed on hands-on equipment; no simulated labs are used” group. Thirty-seven students were in the “less than 50% of coursework labs are completed in a simulated environment” group. Ten were in the “50% or greater of coursework labs are completed in a simulated environment” group, and 13 were in the “all coursework labs are completed in a simulated environment, no hands-on environment” group. The average grade on the written assessment was a 65.218, and the average grade on the hands-on assessment was an 83.960. Twenty-three out of 60 students earned at least one Industry-Level Certification. Table 3 displays the number of participants (N), minimum, maximum, mean, and standard deviation for the written and hands-on assessment student grades.

Table 3

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Written Assessment Grade	60	17.0	97.0	65.218	15.4772
Hands-on Assessment Grade	60	48.0	100.0	83.960	15.2006
Valid N (listwise)	60				

Note. N = number of participants (students with grades).

Evaluation of Statistical Assumptions

There were three tests planned for this research project. Two one-way ANOVAs were expected to determine whether there were statistical differences between the means of Written Assessment Grades or the means of the Hands-on Assessment Grade for the four groups that were defined for the study. A chi-square test was planned to test the relationship between the number of certifications earned and the four groups defined for the study. The assumptions for an ANOVA and chi-square test are evaluated in this section.

The one-way ANOVA must meet three assumptions. The assumption of independence, the assumption of normality, and the assumption of homogeneity of variance. The assumption of independence demands that the groups are independent of each other. This first assumption was addressed in the study design; the defined groups are separate. The second assumption, the Assumption of Normality, was tested using SPSS and a Shapiro-Wilk test to verify that the sample data represents a normal distribution population. For a Shapiro-Wilk, the null hypothesis was that the data for the group was normally distributed and the alternative hypothesis was that the data for the group was not normally distributed. The test was run twice, once to examine the scores by group and again to examine the entire variable, not divided by group.

The Shapiro-Wilk test by the group for Written Assessment Grade indicated normality for all three groups ($p > .05$), while the analysis by the group for Hands-on Assessment Grade indicated that all three groups were not normally distributed ($p < .05$). Table 4 shows the results of the Shapiro-Wilk for Written and Hands-on Assessment score by group.

Table 4

Tests of Normality

		Shapiro-Wilk[a]	
	SIM Group Assignment	df	Sig.
Written Assessment Grade	Less Than 50% Simulated Labs	37	.995
	50% or Greater Simulated Labs	10	.544
	All Simulated Labs	13	.220
Hands-on Assessment Grade	Less Than 50% Simulated Labs	37	.001
	50% or Greater Simulated Labs	10	.002
	All Simulated Labs	13	.013

Note. SIM = Simulation, df = degrees of freedom, Sig. = significance.
[a]Lilliefors Significance Correction
* $p < .05$.

The Shapiro-Wilk *p*-value of .084, which is, greater than .05, indicated no findings of a divergence from normality for the entire variable Written Assessment

Grade, not divided by group. However, the Shapiro-Wilk *p* value of .000, .which is less than .05, caused the Hypothesis of Normality to be rejected for the entire variable Hands-on Assessment Grades, not divided by group. Table 5 below reflects the findings of the Shapiro-Wilk for Written Assessment Grades and Hands-on Assessments Grades.

Table 5

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
WGRADE	.124	60	.023	.965	60	.084
HOGRADE	.146	60	.003	.893	60	.000

Note. Test for Hypothesis of Normality

[a] Lilliefors Significance Correction

* $p < .05$.

The last assumption requiring testing in a one-way ANOVA was the assumption of homogeneity of variance. A Levene's Test of Homogeneity of Variances failed to verify the equality of variances in the Written and Hands-on Assessment Grades. The significance level for the Written Assessment Grade ($p = .001$), therefore $p < .05$. The Hands-on Assessment Grade ($p = .030$) was also found to be less than .05. Therefore, the null hypothesis was rejected. Both groups do not have homogeneity of variances. Table 6 shows the Levene Test of Homogeneity of Variances results for the Written Assessment Grade and the Hands-on Assessment Grade.

Table 6

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
WGRADE	Based on Mean	8.159	2	57	.001
	Based on Median	5.644	2	57	.006
	Based on Median and with adjusted df	5.644	2	41.405	.007
	Based on trimmed mean	8.014	2	57	.001
HOGRADE	Based on Mean	3.717	2	57	.030
	Based on Median	2.700	2	57	.076
	Based on Median and with adjusted df	2.700	2	52.192	.077
	Based on trimmed mean	3.516	2	57	.036

Note. Levene Test.

* $p < .05$.

The results of the normality and homogeneity assumption testing indicated that a Welch ANOVA, can be used for the Written Assessment Grades, as the first two assumptions were met, but the group variances were not equal.

The results of the normality and homogeneity assumption testing indicate that a nonparametric test, Kruskal-Wallis, should be used to evaluate the hypothesis for the Hands-on Assessment Grades, as the first assumption was met, but the assumptions of normality and homogeneity were not met. The Kruskal-Wallis could be used because the four assumptions required were met. The dependent variable of Hands-On Assessments Grade is continuous, there are two or more groups, and participants do not have scores in more than one group. The fourth assumption, a similar distribution of shape, was evaluated by examining the histograms for each group for Hands-on Assessment Scores. Each histogram displayed a negative skewness with values less than zero. The shapes were determined to be similar, satisfying the last assumption.

There were two initial assumptions associated with the chi-square test. First, the two variables should be categorical. The design of this research project met that assumption. SIMGRP and ITCERT were both categorical variables. Secondly, the two variables consisted of two or more independent groupings. In this study, SIMGRP consisted of four independent clusters, and ITCERT consisted of two separate groupings. Therefore, this study met the assumptions for a chi-square analysis. A third assumption was added when the chi-square test calculated Homogeneity of Proportions. The result of that test was that 33.3% of the cells had an expected count less than five. As the percentage was greater than 20%, the assumption of homogeneity of proportions was not met for the chi-square analysis. Therefore, Fisher's exact test (2xc) was used, rather than the Pearson's chi-square. The assumptions for the Fisher's exact test were met because the variables are dichotomous, the observations are independent, and the cell frequency was less than five. Table 7 shows the expected count as two cells (33.3%) have expected count less than five.

Table 7

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson chi-square	23.185[a]	2	.000
Likelihood Ratio	30.799	2	.000
Linear-by-Linear Association	19.609	1	.000
N of Valid Cases	60		

Note. *N* = number.

[a] Two cells (33.3%) had expected count less than 5. The minimum expected count was 3.83.

Statistical Analysis Findings

RQ1: Are there significant differences in the technical assessment written exam grades of students in the four study groups?

$H_0 1$: There are no significant differences in the technical assessment written exam grades of students in the four study groups.

A one-way Welch ANOVA was performed to determine if the Written Assessment Grade was different for high school students who used different percentages of simulations versus hands-on hardware. Student scores were classified into four groups: no simulated labs ($n = 0$), less than 50% simulated labs ($n = 37$), 50% or greater simulated labs ($n = 10$), and all simulated labs ($n = 13$). The Shapiro-Wilk p-value of .084, which is, greater than .05, indicated no findings of a divergence from normality for the Written Assessment Grade. However, Levene's Test of Homogeneity of Variance resulted in a $p = .001$, indicating the variances between the groups were heterogeneous. Written Assessment Grades were highest for the 50% or greater group (M = 68.490, SD = 8.8611), then the less than 50% simulated labs (M = 67.168, SD = 13.1525), and lowest for the all simulated labs (M = 57.154, SD = 22.5568). However, the differences between the groups were not statistically significant; Welch's F (2, 21.453) = 1.340, $p = .283$. The results of the Welch test are shown in Table 8.

Table 8

Robust Tests of Equality of Means

	Written Assessment Grade			
	Statistic[a]	df1	df2	Sig.
Welch	1.340	2	21.453	.283

Note. df = degrees of freedom, Sig = significance.
[a] Asymptotically F distributed.
* $p < .05$.

Therefore, since $p > .05$, the null hypothesis that there are no significant differences in the technical assessment written exam grades of students in the four study groups is retained. As statistical significance was not demonstrated, post hoc tests were not evaluated.

RQ2: Are there significant differences in the technical assessment hands-on exam grades of students in the four study groups?

$H_0 2$: There are no significant differences in the technical assessment hands-on exam grades of students in the four study groups.

A Kruskal-Wallis test was performed to determine if the Hands-on Assessment Grade was different for high school students that used different percentages of simulations versus hands-on hardware. Student scores were classified into four different groups: no simulated labs (*n* = 0), less than 50% simulated labs (*n* = 37), 50% or greater simulated labs (*n* = 10), and all simulated labs (*n* = 13). The test was evaluated for the three groups that contained scores. Boxplots were visually inspected, confirming a similar distribution of shape. Figure 1 represents the SPSS Box Plot for the Independent-Samples Kruskal-Wallis Test.

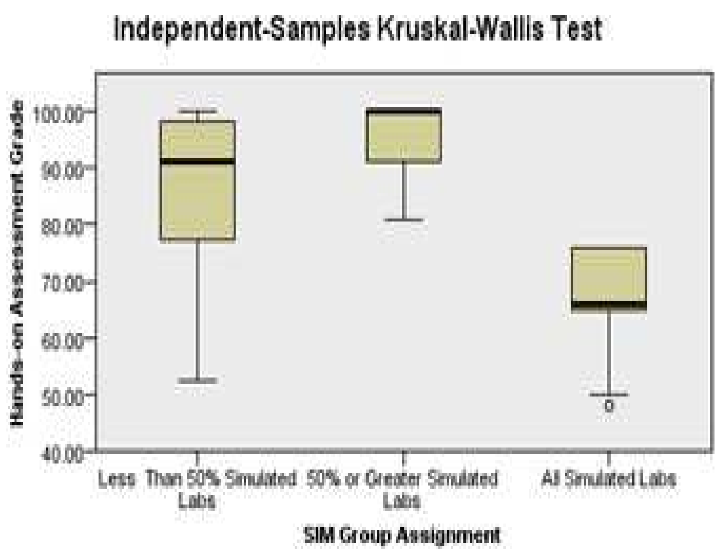


Figure 1. SPSS box Plot: Independent-samples Kruskal-Wallis test.

Median Hands-on Assessment Scores were statistically significant between the different groups, X2(2) = 23.503, p = .000. Therefore, since $p < .05$, the null hypothesis that there are no significant differences in the hands-on technical assessment exam grades of students in the four study groups was rejected. Table 9, below, represents the test statistics generated by the Kruskal-Wallis in SPSS for the data.

Table 9

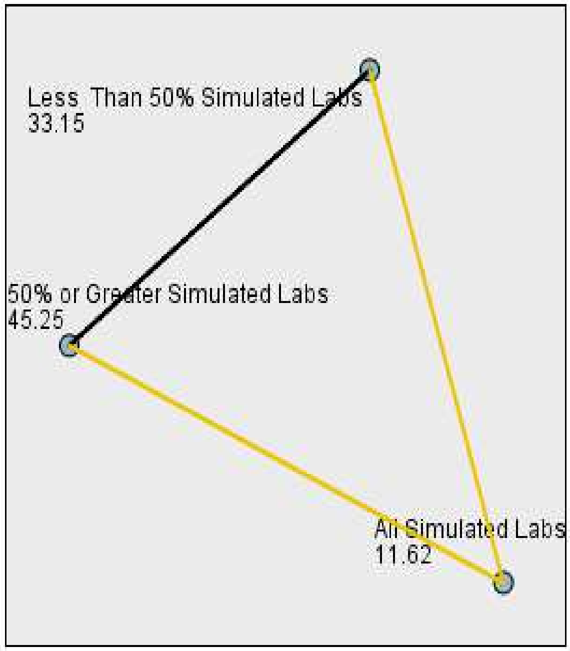
Test Statistics

	Hands-on Assessment Grade
Kruskal-Wallis H	23.503
df	2
Asymp. Sig.	.000

Note. Grouping Variable: SIM Group Assignment
*p < .05

Using Dunn's (1964) procedure with Bonferroni correction for multiple comparisons, pairwise comparisons were performed. The post hoc analysis exposed differences that were statistically significant between the all simulated labs group (mean rank = 11.62) and the less than 50% simulated labs group (mean rank = 33.15), (*p* = .000) , as well as between the all simulated labs group and the 50% or greater simulated labs group (mean rank = 45.25), (*p* = .000). There was not a significant difference between the less than 50% simulated labs group and the 50% or greater simulated labs group. Figure 2 represents the Pairwise Comparisons of SIM Group Assignment.

Pairwise Comparisons of SIM Group Assignment



Each node shows the sample average rank of SIM Group Assignment.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
All Simulated Labs-Less Than 50% Simulated Labs	21.533	5.592	3.850	.000	.000
All Simulated Labs-50% or Greater Simulated Labs	33.635	7.296	4.610	.000	.000
Less Than 50% Simulated Labs-50% or Greater Simulated Labs	-12.101	6.182	-1.957	.050	.151

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Figure 2. Pairwise comparisons of SIM group assignment

RQ3: Are there significant differences in the certification pass rates of students in the four study groups?

Null Hypothesis: There are no significant differences in the certification pass rates of students in the four study groups.

A chi-square test of homogeneity performed between the simulation group assignment (SIMGRP) and the certification results (ITCERT) resulted in two expected cell counts that were less than five. Therefore, Fishers exact test (2 x c) was conducted between simulation group assignment and the certification earned results. Sixty high school students were assigned to groups based upon the percentage of simulations used in their instruction. The sizes of the simulation groups were unequal. At the conclusion of the 2017-2018 school year, 23 students (62.2%) in the less than 50% simulated labs group had earned industry-level certifications compared to zero students (0.0%) in both the 50% or greater simulated labs group and the all simulated labs group, as presented in Table 10.

Table 10

*SIM Group Assignment * Certification Results Crosstabulation*

SIM Group Assignment	Less Than 50% Simulated Labs	Count	14	23	37
		Expected Count	22.8	14.2	37.0
		% within SIM Group Assignment	37.8%	62.2%	100.0%
		% within Certification Results	37.8%	100.0%	61.7%
		% of Total	23.3%	38.3%	61.7%
	50% or Greater Simulated Labs	Count	10	0	10
		Expected Count	6.2	3.8	10.0
		% within SIM Group Assignment	100.0%	0.0%	100.0%
		% within Certification Results	27.0%	0.0%	16.7%
		% of Total	16.7%	0.0%	16.7%
	All Simulated Labs	Count	13	0	13
		Expected Count	8.0	5.0	13.0
		% within SIM Group Assignment	100.0%	0.0%	100.0%
		% within Certification Results	35.1%	0.0%	21.7%
		% of Total	21.7%	0.0%	21.7%
Total		Count	37	23	60
		Expected Count	37.0	23.0	60.0
		% within SIM Group Assignment	61.7%	38.3%	100.0%
		% within Certification Results	100.0%	100.0%	100.0%
		% of Total	61.7%	38.3%	100.0%

The Fisher's exact test resulted in a $p < .05$, demonstrating a statistically significant difference. Table 11 presents the findings of Fisher's exact test.

Table 11

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson chi-square	23.185[a]	2	.000	.000		
Likelihood Ratio	30.799	2	.000	.000		
Fisher's Exact Test	25.141			.000		
Linear-by-Linear Association	19.609[b]	1	.000	.000	.000	.000
N of Valid Cases	60					

Note. df = degrees of freedom, Sig. = significance.
[a] 2 cells (33.3%) have expected count less than 5. The minimum expected count is 3.83.
[b] The standardized statistic is -4.428.
* $p < .05$

Therefore, the null hypothesis that there are no significant differences in the certification pass rates of students in the study groups was rejected, and the alternative hypothesis that there are significant differences in the certification pass rates of students in study groups was accepted.

Post hoc analysis consisted of pairwise comparison employing the z-test of two proportions with a Bonferroni correction. The proportion of students in the less than 50% simulated labs group that earned industry-level certifications was statistically significantly higher than the group who learned in the 50% or greater simulated labs and the all simulated labs, $p < .05$. The post hoc analysis between the 50% or greater simulated labs group and the all simulated labs group did not produce output for Fisher's exact test (2x2) because the certification results were a constant, both groups earned no industry-level certifications. Table 12 indicates the results of the post hoc testing between the less than 50% simulated labs group and 50% or greater simulated labs group.

Table 12

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson chi-square	12.173[a]	1	.000	.001	.000	
Continuity Correction[b]	9.813	1	.002			
Likelihood Ratio	16.053	1	.000	.001	.000	
Fisher's Exact Test				.001	.000	
Linear-by-Linear Association	11.914	1	.001	.001	.000	.000
N of Valid Cases	47					

Note. df = degrees of freedom, Sig. = significance.
[a] 1 cell (25.0%) has an expected count less than 5. The minimum expected count is 4.89.
[b] Computed only for a 2x2 table.
* $p < .05$

Table 13 indicates the results of the post-hoc testing between the less than 50% simulated labs group and the all simulated labs group.

Table 13

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson chi-square	14.965[a]	1	.000	.000	.000	
Continuity Correction[b]	12.567	1	.000			
Likelihood Ratio	19.913	1	.000	.000	.000	
Fisher's Exact Test				.000	.000	
Linear-by-Linear Association	14.666[c]	1	.000	.000	.000	.000
N of Valid Cases	50					

Note. df = degrees of freedom, Sig. = significance.
[a] 0 cells (0.0%) had an expected count less than 5. The minimum expected count was 5.98.
[b] Computed only for a 2x2 table.
[c] The standardized statistic is -3.830.
* $p < .05$

Summary

The data analysis results indicated that the null hypothesis could not be rejected for the first research question, but it could be rejected for research questions two and three. Written technical assessment scores indicated that there was no significant difference between groups. An analysis of the hands-on technical assessment scores indicated statistical significance between the all simulated labs group and the less than 50% simulated labs group, as well as between all simulated labs group and 50% or greater simulated labs group. There was not a significant difference between less than

50% simulated labs group and 50% or greater simulated labs. The proportion of students in the less than 50% simulated labs group that earned industry-level certifications was statistically significantly higher than the group who learned in the 50% or greater simulated labs group or the all simulated labs group.

Chapter 5 addresses an interpretation of these findings, the limitations of the study, recommendations for further research, and the implications of this study.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

Chapter 5 provides a study overview, including an interpretation of the findings, the limitations of the study, and recommendations for further research. The implications of the study, including impact on positive social change, methodological, theoretical, and empirical, are also covered in this section. Lastly, recommendations for practice are discussed.

The purpose of this quantitative, nonexperimental study was to determine if there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs, between those who use simulations and those who use hands-on hardware. A survey was used to identify the percentage of simulations used in approved New York state IT programs of study and the influence on college and career readiness as defined by the students' technical assessment grades and their performance on industry-level certification assessments. The data were analyzed using a one-way Welch ANOVA for written scores, a Kruskal-Wallis for hands-on scores, and a Fisher's exact test for the certification data. Written exam scores indicated no significant difference between groups. Hands-on exam scores showed statistical significance between the all simulated labs group and the less than 50% simulated labs group, as well as between all simulated labs group and the 50% or greater simulated labs group. The proportion of students in the less than 50% simulated labs group that earned industry-level certifications was statistically significantly higher than the group that learned in the 50% or greater simulated labs group or all the simulated labs group.

Interpretation of Findings

This section provides an interpretation of Chapter 4 findings, aligned with the peer-reviewed literature and Kolb's (2014) theory of experiential learning, the theoretical foundation of this research project.

RQ1: Are there significant differences in the technical assessment written exam grades of students in the four study groups?

Results from the data analyzed for Research Question 1 indicated that there was no significant difference between the three groups with participants, less than 50% simulations, 50% or greater simulations, and all simulations. There were no participants in the "all coursework labs are completed on hands-on equipment"; no "simulated labs are used" group. According to Tagliacane et al. (2016), the use of computerized simulation tools allows students to construct, manage, and observe networks in an environment that is safe and will not affect telecommunication devices in a production network. The results of the data analyzed for Research Question 1 extend Tagliacane's findings that simulations are a useful tool to teach networking skills, as assessed using written technical assessments. Kameg et al. (2013), evaluated whether simulations enriched the theoretical understanding and retention of knowledge of the students as connected to the teaching and learning provided by the simulation scenarios. The results of this research question support the findings of Kameg et al., using Kolb's theory of experiential learning to explain how students' engagement in a simulation can lead to acquiring knowledge (Kameg et al., 2013). The findings also support Ghani's (2015) determination that simulations are at least as useful, but not superior to, traditional hands-on labs. The written assessment grades were highest for the 50% or greater group (M = 68.490, SD = 8.8611), then the less than 50% simulated labs (M = 67.168, SD = 13.1525), and lowest for the all simulated labs (M = 57.154, SD = 22.5568). The median grades were higher for the groups that incorporated some degree of hands-on hardware supporting the premise that numerous studies suggested that simulations are most effective when paired with a hands-on environment (Lampi, 2013; Shimba et al., 2016).

Kolb's (1984) theory of experiential learning was used as a theoretical base for this research, as previous studies have indicated that Kolb's cycle of learning can be employed in a simulated environment to promote teaching and learning (Konak et al., 2014; Poore et al., 2014). Kameg et al. (2013), evaluated whether simulation enriched the theoretical understanding and retention of knowledge, of the students, as connected to the teaching and learning provided by the simulation scenarios. In the case of my study, Kolb's theory was applied to explain how students' engagement in a simulation could lead to acquiring knowledge (Kameg et al., 2013). Poore et al. (2014) found that Kolb's (1984) theory of experiential learning provided a theoretical foundation as well as a process for individualized learning in a simulated environment. The concrete experience phase occurred through the learner's participation in the simulation exercise (Poore et al., 2014). The reflective observation phase was achieved through debriefing and reflection of the simulated experience (Poore et al., 2014). Abstract conceptualization was used in considering the relevance of the activity and active experimentation was employed as the learner tested what was learned in a new simulation or situation (Poore et al., 2014**).** The results for Research Question 1 indicated no significant difference between the three simulation groups for written assessment grades. Therefore, the benefit of using simulations in support of Kolb's (1984) theoretical framework would require additional research.

RQ2: Are there significant differences in the technical endorsement demonstration (hands-on exam) grades of students in the four study groups?

Results from the data analyzed for Research Question 2 exposed differences that were statistically significant between the all simulated labs group (mean rank = 11.62) and the less than 50% simulated labs group (mean rank = 33.15), (p = .000) , as well as between the all simulated labs group and the 50% or greater simulated labs (mean rank = 45.25), (p = .000). There was not a significant difference between the less than 50% simulated labs group and the 50% or greater simulated labs group. The results support Tagliacane et al.'s (2016) assertion that a hands-on hardware lab offers the most realistic choice for training students on the setup, maintenance, and troubleshooting of a real-world environment, as opposed to a simulated environment. Although simulation benefits skill practice, the results of Research Question 2 confirm findings by Lampi (2013) and Shimba et al. (2016) that students require some hands-on hardware training before transitioning to an actual hardware environment. Shimba et al. found that while the hands-on group completed a VLAN configuration, the group that learned on simulations, failed to configure and verify the VLAN configuration. The results of this research extend the findings of Shimba et al. from an individual skill-based assessment to summative evaluation. The analysis confirms that, as Lampi suggested, a blended environment, including some hands-on hardware, supplemented by skill practice on simulations may provide the best environment for preparing to demonstrate skill on hands-on hardware successfully. These results confirmed the findings of Lampi and Shimba et al. that suggested that simulations are most effective when paired with a hands-on environment.

Kolb's (1984) Theory of experiential learning was used as a theoretical base for this research, as previous studies have indicated that Kolb's cycle of learning can be employed in a simulated environment to promote teaching and learning (Konak et al., 2014; Poore et al., 2014). Prior research indicated that Kolb's experiential learning theory could be used as the theoretical basis for determining the effectiveness of using simulations versus hands-on hardware to teach networking skills (Shimba et al., 2016). According to Kolb, for learning to take place, the student must experience all four stages of the experiential learning cycle, concrete experience, reflective observation, abstract conceptualization, and active experimentation. However, as the differences between groups incorporating hands-on hardware and the group that used all simulation were significant, further research would be needed to determine if one or more of the phases of Kolb's theory of experiential learning had not been satisfied. For example, while Shimba et al. (2016) provided a section on the relevance to ELT in their findings, and they identified the fact that the group using simulations failed to validate a VLAN configuration, it was not clear that the simulation group learned the process of verifying connectivity in the concrete experimentation phase of Kolb's cycle.

RQ3: Are there significant differences in the certification pass rates of students in the four study groups?

The analysis of the data for Research Question 3 indicated that the proportion of students in the less than 50% simulated labs group that earned industry-level certifications was statistically significantly higher than the group who learned in the 50% or greater simulated labs group or the all simulated labs group, $p < .05$. Researchers agreed that the ease of procurement and the low cost of simulations for IT training may provide an affordable solution for student practice for technical endorsement exams and industry-level certifications (Ghani, 2015; Lampi, 2013; Shimba et al., 2016; Tagliacane et al., 2016; Zvacek, 2015). However, the findings for Research Question 3 did not indicate that students in the groups with higher simulation use obtained more industry-level certifications than students in the lower than 50% simulations group. These findings support Lampi's (2013) assertion that simulations are useful in the transfer of networking skills from simulations to the hands-on hardware environment, but the instructor should still schedule the students on the hands-on hardware when equipment becomes available. IT certifications assure an employer that the candidate has the skill set for the open position, and typically reflect a passing grade on a vendor-sponsored or vendor-neutral examination (Chasse, 2013; Lasheen, 2015; Tamar-Belgraves, 2016). While students in the 50% or greater simulation group and the all simulations groups did not earn any industry certifications, further research would need to identify why the students did not sit for industry-level certification exams.

This research question connects with Kolb's (1984) contemporary applications of experiential learning theory, specifically competency-based and experiential education, including simulations. The obtainment of an industry-level certification represents competency-based education, and the research question investigated whether there were significant differences in the certification pass rates of students, based upon the percentage of simulations used to prepare for the industry-level certification exam.

Limitations of the Study

This study's limitations include a deficit in generalizability to high school students not enrolled in a New York state-approved IT program during the 2017-2018 school year. A convenience sample of approved programs and survey volunteers was used, negating the possibility of collecting a simple random sampling. While the power-analysis sample size calculations resulted in a sample size of 180 for the ANOVAs and 143 for the chi-square, a smaller sample size of four schools, totaling five classes and 60 students responded to the survey. The smaller sample size contributed to the study being less generalizable to the entire population of New York state high school students enrolled in an approved IT program during the 2017-2018 school year.

Other states may have different criteria for college and career readiness that makes this study more difficult to generalize outside of New York state. Additionally, as the data collected was from the 2017-2018 school year, this study was dependent on the conditions during that period. Therefore, concerning external validity, the reader should not overgeneralize the results to another state without evaluating that state's definitions for college and career readiness, or to another school year without assessing additional data in case the conditions have changed over time.

The study did not ask the instructors why students did not sit for industry-level assessments to understand if a simulation grouping felt less prepared, or if an instructor did not offer an industry certification. The industry certification pass rate in a simulation grouping may have been influenced by an instructor or a curriculum. Furthermore, because the dependent variable was achievement exam data, the information was only as trustworthy as the test and how it matches the objectives of the simulations or hardware labs, which was not evaluated as a confounding variable.

Recommendations

While this study helps partially fill a gap in the literature concerning the effectiveness of using simulators in place of a hands-on hardware lab environment, it is limited in scope to quantitative results regarding secondary level students in approved IT programs in New York state. This section provides recommendations for further study.

Curriculum and Assessment Alignment

According to Lampi (2013), technology tools must be used to achieve pedagogical effectiveness, as opposed to being driven by a teacher or student preference. Several of the studies at the collegiate level focused on teacher and student preference but disagreed on the effectiveness of the tool to match learning objectives for either skill practice or overall course completion (Ghani, 2015; Lampi, 2013; Shimba et al., 2016). A qualitative study could provide additional knowledge regarding whether the effectiveness of the simulation tool used matched the learning objectives for the hands-on technical assessments or the industry-level certification exams.

Increase Generalization by Increasing Population

One of the issues encountered in this study was a lower response than expected. The result was a lesser ability to generalize to all high school students in New York state in approved IT programs during the 2017-2018 school year. An additional study might be executed by including all the Cisco Networking Academies across the United States, at the secondary level. This effort would involve understanding the requirements for each state for which an academy was included.

Kolb's Learning Cycle and Hands-On Assessments

In this study, as the differences between groups incorporating hands-on hardware and the group that used all simulation were significant for the hands-on assessment, further research would be needed to determine if one or more of the phases of Kolb's (1984) Theory of experiential learning had not been satisfied. Additional knowledge could be gained regarding Kolb's experiential learning process by examining the missed questions and interviewing the student to identify the missed phase in Kolb's learning cycle. For example, according to Konak et al. (2014), the concrete experience stage required a set of step by step instructions such that even a student without prior experience can be successful.

It would be interesting to evaluate the learner as an accommodator, a divergent, an assimilator, or a convergent. Kolb described converging learners as people who were attracted to technology and engineering careers and preferred to work on technical problems using simulations, laboratory assignments, and practical applications. It could add to the body of knowledge regarding Kolb's theory of experiential learning to know if there was a significant difference in the scoring of the convergents on technical endorsement assessment and industry-level certifications in the field of IT.

Longitudinal Study on Career Preparation

The scope of this research encompassed secondary level students in approved IT programs in New York state during the 2017-2018 school year. A longitudinal study designed to explore the career readiness students in entry-level IT jobs, who fell into the different simulation use groups could provide additional information regarding whether the simulation use prepared the student for the workplace. This study could be expanded to a larger population, including other states.

Qualitative Study: Value of Industry-Level Certifications

Information technology certifications and postsecondary education have been the primary qualifications for job candidates in the IT field (Lasheen, 2015). My study collected data regarding the number of students who passed industry-level IT certifications during the 2017-2018 school year. However, it is not known if the students had the opportunity, the funding, or the motivation to sit for an exam. It is unknown if the students in the groups who use a higher percentage of simulations do not feel prepared to take a certification exam. The students and instructors may not be aware of the changes regarding ESSA and New York state's requirements for an alternative pathway to graduation. A qualitative study exploring student and teacher knowledge of ESSA, CTE's requirements for technical endorsement or alternative pathways to graduation, employer requirements, and student comfort levels might be beneficial in understanding why more students are not taking industry-level certification exams.

Implications

My research is significant because it adds to the literature concerning the use of simulations for teaching and learning. While simulators might be used in place of hands-on hardware, there was not a significant body of quantitative research supporting the use of simulators for college and career success at the secondary level in IT. This section details my study's potential impact for positive social change, methodological, theoretical, and empirical implications, and recommendations for practice.

Potential Impact for Positive Social Change

Individual. According to the United States Department of Education (n.d.-a), students face lofty expectations while preparing for postsecondary education or a job in the workforce. This quantitative research project may advance teacher practice around secondary level IT by providing a statewide assessment of the effectiveness of using simulations for technical assessment and industry-level certification preparation. This study's focus on summative assessments success, as opposed to individual skill practice, may provide additional information concerning the use of simulations to ensure college and career readiness in New York State, in the absence of hands-on hardware. Potential impact for positive change would be that simulations are used in a manner to improve learning such that students could be better prepared to pass technical assessments and industry-level certifications and be better prepare for college and careers in the field of IT.

Family. Families experience advantages and hardships based upon their economic situation. According to the BLS (2016), jobs in the field of computer and IT were predicted to increase at a rate of 13% over the period of 2016 to 2026. The median yearly wage of $84,580 for computer and IT workers was more than double the median wage for all other occupations as of May 2018 (BLS, 2016). With the growth of opportunities in IT (BLS, 2016), high school students, who want to enter this career field, need to be trained with entry-level IT skills to fill entry-level jobs immediately after high school or to better prepare for postsecondary programs. Implications for social change suggest that skilled workers, with entry-level skills, can fill jobs in the growing IT field, offering well-paying jobs with more promising futures. This research contributes to the literature that would promote the appropriate use of simulations to build those entry-level skills.

Organizational. Vendor and vendor-neutral certifications have become key indicators that a candidate possesses the skills necessary for an entry level-position in IT (Chasse, 2013; Lasheen, 2015; Tamar-Belgraves, 2016). Many employers preferred or required certification to confirm that the candidate has the appropriate knowledge and skills to fill the position (Chasse, 2013; Lasheen, 2015; Tamar-Belgraves, 2016). A contribution to positive social change at the organizational level may be that companies would be able to find skilled workers with industry-level certifications, as a result of the growing knowledge of appropriate simulation use and recognition of the value of industry-level certifications.

Societal. Burning Glass Technologies (2018) reported that public and private employers listed 301,873 job openings in cybersecurity over twelve-months, from April

2017 to March 2018. Meanwhile, the Federal Bureau of Investigation's (2018) 2017 Internet Crime Report identified over 800 complaints received per day and victim loss at $1.42 billion. On that same report, New York state ranked 4th in internet crime, with 17,622 victims (Federal Bureau of Investigation, 2018). Hansson (2017) investigated New York state's role in educating students to fill the cybersecurity job gap. Hanson concluded that New York state school districts are operating independently, and there needs to be a coordinated effort in implementing and supporting pathways for students to fill the IT cybersecurity gap. This research might have a societal impact in promoting the appropriate use of simulations to train high school students to fill these available cybersecurity positions, encouraging a coordinated effort to provide both simulations and hands-on hardware, and resources for students who cannot afford to take certification exams.

Methodological, Theoretical, and Empirical Implications

The methodological implication of the study resulted in 56 out of 60 schools that did not return a Letter of Cooperation (Appendix B), in response to a School Invitation Letter (Appendix A). One school that did not elect to participate responded that they would have responded to my Director. Other schools cited a lack of time to complete the survey. The methodological implication resulted in minimized generalizability for my research.

The theoretical implications of the study indicated that students would demonstrate better success regarding the hands-on technical assessments if instructors acquired hands-on hardware for all students for networking skill practice, as suggested by

Shimba et al. (2016). However, additional research may be needed to substantiate this implication to determine that the transfer of skills to the hands-on environment is not the result of a missed step in Kolb's (1984) cycle of learning.

The empirical or real-world implication was that there were no students in the group that used all hands-on hardware and no simulations. According to Ghani (2015), advances in technology have made it possible for these objectives previously achieved by completing hands-on activities, to be completed using simulations. All schools surveyed were using simulations to some degree. However, without pursuing a qualitative or mixed methods study, it is unknown whether the decision to use simulation was made to enhance learning, or if it was a reaction to the expense or unavailability of hands-on hardware.

Recommendations for Practice

Several recommendations for practice could enhance the teaching and learning of IT at the secondary level, in preparation for college and careers. According to Lampi (2013), technology tools must be used to achieve pedagogical effectiveness, as opposed to being driven by a teacher or student preference to use a technology tool. Tools need to be continually evaluated to make sure that they are meeting the objectives of the coursework, summative assessments, and industry requirements. Educators need to ensure that they are familiar with New York state and employer requirements to ensure that they are producing skilled candidates for college and careers. Results of this study indicate that not all students are attempting industry-level certifications, even though they provide an alternative pathway to graduation, and are sought after by employers when hiring entry level candidates. Additionally, as suggested by Hansson (2017), New York state should exercise coordinated effort in implementing and supporting pathways for students to fill the IT cybersecurity gap. A concerted effort might include ensuring that districts have access to hands-on hardware, and vouchers to finance students taking industry-level certifications.

Conclusion

The purpose of this quantitative, nonexperimental study was to determine if there was a significant difference in college and career readiness of New York state high school students in approved IT content cluster high school programs, between those who use simulations and those who use hands-on hardware. In New York, the reported percentage of students that were deemed college and career ready in 2014 was 31%, as determined by the achievement of obtaining a New York Advanced Designation Regents Diploma. This research attempted to provide clarity regarding the industry, nation, state, and CTE requirements for college and career readiness, and the use of simulation to help students develop the skills needed for college and career in IT, as evaluated by technical assessments and industry-level certifications.

I surveyed New York state high schools that had approved IT programs. While lack of participation in my study limited generalizability, results suggested that all schools are utilizing simulations, however, for hands-on technical assessments, data analysis and a review of the literature confirmed that simulations are most effective when paired with a hands-on environment. Additionally, only 23 out of 60 students had sat for at least one certification exam. I am confident that the findings of this study will contribute to the limited research that is available concerning secondary students preparing for college and careers in the field of IT in New York state. This quantitative research project may advance teacher practice around secondary level IT by providing a statewide assessment of the effectiveness of using simulations for technical assessment and industry-level certification preparation.

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Appendix A: School Invitation Letter

Dear CTE Program Contact,

My name is Kathy Landers. I am a doctoral student at Walden University's PH.D. in Education Program. I am kindly requesting your participation in a doctoral research study that I am conducting titled: Using Simulations to Prepare for College and Careers in IT. The study examines whether simulations are an effective method to prepare IT Content Cluster high school students, in New York State, with the skills that they need to pass the exams required for New York State Technical Endorsement, and pass industry-level certifications when access to hands-on laboratory hardware is limited or non-existent. Your school is invited to participate in this research project because it has an approved New York state information technology program.

The study involves completing a short online survey regarding your IT offering and completing and uploading, to the survey, a Word document listing your student's technical-endorsement exam results for the 2017 to 2018 school year (excluding student name or any identifying information).

Participation is voluntary, and participants may withdraw from the study at any time. Participation in the study is confidential, no identifying information regarding the school or the individual completing the survey will be shared. Student identifying information is not requested.

If your school would like to participate in the study, please provide me with the email of the individual that could best provide data regarding your information technology program data.

A Letter of Cooperation is required to identify the data that is being shared. I have attached a template to this letter. You may also use your own form if the data being shared is clearly documented, as in paragraph two in the sample letter below. Electronic signatures are acceptable. Please e-mail the signed letter directly to IRB@mail.waldenu.edu and kathy.landers@waldenu.edu.

Your school's participation in the research will be of great importance to assist in social change in advancing teacher practice by providing a statewide assessment of the effectiveness of using simulations for technical assessment and industry-level certification preparation. Certified workers, with entry-level skills, can fill jobs in information technology, offering well-paying jobs with more promising futures. Thank you for your time and participation.

Sincerely, Kathy Landers, Doctoral Student, Walden University

Appendix B: Letter of Cooperation

School Name
Contact Information:

Date:

Dear Kathy Landers,

Based on my review of your research proposal, I give permission for you to conduct the study entitled Using Simulations to Prepare for College and Careers in IT within the *Name of School*. As part of this study, I authorize you to contact the individual's email who can provide the answers to the electronic survey questions and collect the electronic survey data. Individuals' participation will be voluntary and at their own discretion.

We understand that our organization's responsibilities include stipulating a participant's email who can provide anonymous student archival data, in the form of IT technical assessment grades, and records of students receiving industry-level certifications in the IT field during the 2017–2018 high school year, and the percentage of simulations used versus hands-on hardware for skill training during the 2017-2018 high school year. We reserve the right to withdraw from the study at any time if our circumstances change.

I understand that the student will not be naming our school in the doctoral project report that is published in ProQuest.

I confirm that I am authorized to approve research in this setting and that this plan complies with the organization's policies.

I understand that the data collected will remain entirely confidential and may not be provided to anyone outside of the student's supervising faculty/staff without permission from the Walden University IRB.

Sincerely,
Authorization Official:
Contact Information:
e-Signature: Please provide email address ______________________

Please e-mail the signed letter directly to IRB@mail.waldenu.edu and kathy.landers@waldenu.edu.

Appendix C: Participant Invitation Letter

Dear Invitee,

My name is Kathy Landers. I am a doctoral student at Walden University's PH.D. in Education Program. I am kindly requesting your participation in a doctoral research study that I am conducting titled: Using Simulations to Prepare for College and Careers in IT. The study examines whether simulations are an effective method to prepare IT Content Cluster high school students, in New York State, with the skills that they need to pass the exams required for New York State Technical Endorsement, and industry-level certifications when access to hands-on laboratory hardware is limited or non-existent. You are invited to participate in this research project because you are at a school that has an approved New York state information technology program.

The study involves completing a short online survey regarding your IT offering and completing and uploading, to the survey, a Word document listing your student's technical-endorsement exam results for the 2017 to 2018 school year (excluding student name or any identifying information).

Participation is voluntary, and participants may withdraw from the study at any time. Participation in the study is confidential, no identifying information regarding the school or the individual completing the survey will be shared. Student identifying information is not requested.

If you would like to participate in the study, please click on the survey link below to learn more about the study, decide if you would like to participate, and start or exit the survey.

Your school's participation in the research will be of great importance to assist in social change in advancing teacher practice by providing a statewide assessment of the effectiveness of using simulations for technical assessment and industry-level certification preparation. Certified workers, with entry-level skills, can fill jobs in information technology, offering well-paying jobs with more promising futures. Thank you for your time and participation

Sincerely,

Kathy Landers, Doctoral Student, Walden University

Link to Survey:

Appendix D: Survey Questions

1. Consent Form
2. Did your school offer the New York State Education Department approved information technology course listed on http://www.p12.nysed.gov/cte/ctepolicy/approved.html during the 2017-2018 school year? (You can copy and paste the link to verify the course listed for your school.)

   ☐ Yes ☐ No

3. If the course was offered, what curriculum/courseware was used?

   Examples: Cisco Networking Academy: IT Fundamentals, TestOut: PC PRO

4. If the course was offered, which choice below represents the percentage of coursework completed on hands-on hardware, as opposed to simulations?

   ☐ All coursework labs were completed on a hands-on equipment, no simulated labs were used.

   ☐ Less than fifty percent of coursework labs were completed in a simulated environment.

   ☐ Fifty percent or greater of coursework labs were completed in a simulated environment.

   ☐ All coursework labs were completed in a simulated environment, no hands-on environment.

Appendix D: (Continued)

5. How many students took the information technology course during the 2017-2018 school year? Example: 23

6. If the course maps to an industry-level certification, please provide the name of the information technology industry-level certification.

Examples: Cisco CCNA, CompTIA A+, TestOut Security PRO, None

7. If the course maps to an industry-level certification, how many students sat for that exam during the 2017-2018 school year? Example: PC PRO:7, CompTIA A+: 12

8. If the course maps to an industry-level certification, how many of your students earned that certification during the 2017-2018 school year? Example: PC PRO: 6

9. Please complete and upload the Word document attached to the survey email for each student who took this course during the 2017-2018 school year. (Student data is anonymous.) You will need to upload the file to complete the survey.

Appendix E: Attachment: 2017-2018 Student Technical Assessment Data

Student No.	Written Technical Assessment Score	Points Possible on Written Technical Assessment Score	Hands-On Technical Assessment Score	Points Possible on Hands-On Technical Assessment Score
1				
2				
3				
4				
5				
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7				
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Appendix F: Follow-Up Reminder to Participants

Follow-up reminder – request for participation – Survey for the research study entitled *Using Simulations to Prepare for College and Careers in IT*

Dear Invitee,

Please remember that the Survey for the research study entitled *Using Simulations to Prepare for College and Careers in IT* is open and accepting responses. There is still time to participate until ________.

Your participation is very much appreciated. Please follow the link below to access the survey.

Sincerely,

Kathy Landers, Doctoral Student, Walden University

Link to Survey: