IT PROJECT MANAGERS' EDUCATION AND CERTIFICATION IMPACT ON PROJECT SUCCESS: A COMPARATIVE STUDY

by

William J. Parker

GLENN BOTTOMLY, PhD, Faculty Mentor and Chair

SHARON GAGNON, PhD, Committee Member

WILLIAM J. McKIBBIN, PhD, Committee Member

Todd Wilson, PhD, Dean

School of Business and Technology

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Philosophy

Capella University

April 2019

Abstract

This study posited that a relationship exists between information technology (IT) project managers' technical education and commercial project management certification and project management success, also known as project efficiency, for Department of Defense (DoD) IT project managers (PMs). Specifically, this research asked, "To what extent does project management success in scope, schedule, and cost compare with PMs with STEM and non-STEM education?" "To what extent does project management success compare with PMs with a commercial certification and without a commercial certification?" "To what extent do interaction between education type (STEM and non-STEM) and commercial certification compare with project management success?" A gap in research exists on whether IT PMs with a technical education positively impact project outcomes. The IT PM community needs more studies on the extent to which commercial PM certifications impact project efficiency. The literature search failed to yield any studies on how interactive effects of IT PM technical education and certification impact project efficiency. This research used factorial multivariate analysis of variance (MANOVA) to compare education and PM certification to project efficiency. MANOVA provided for the examination of the interactive effects. The population of DoD IT PMs includes 24,534 program/project managers and information technology members, 74% male, with varying education types and PM certifications. The sample of 284 DoD IT PMs collected via Internet survey was representative of the population with 75% male respondents. MANOVA tested the research question hypotheses. A Mann-Whitney post hoc test confirmed the MANOVA results. Both tests concluded that no relationship exists between undergraduate STEM education and commercial PM certification and project outcomes on scope, schedule, and cost. This study suggests that organizations should recruit project managers with either a STEM

or non-STEM degree. To improve IT project efficiency, this study suggests that organizations should not make the attainment of commercial PM certification compulsory, as the benefits balance tilts more toward the individual's career than project management success. Voluntary commercial PM certifications do have value for the individual PM interested in career advancement. Further research is recommended using secondary data.

Dedication

This study is dedicated to my lovely wife and children. My family and especially my wife have been steadfast in support throughout this challenging journey. My wife encouraged me while making personal sacrifices to support my education. Without their assistance, I would have little chance of reaching a successful finish. Much love and a grateful thank you.

Acknowledgments

I would like to acknowledge my dissertation committee, Dr. Glenn Bottomly, PhD (Chair), Dr. Sharon Gagnon, PhD, and Dr. William McKibbin, PhD, for their support in completing this dissertation. I would particularly like to thank my mentor, Dr. Bottomly, for his patience and experience in guiding me through the dissertation process, which enabled me to successfully integrate the DoD information collection process with my dissertation process. I was blessed to have Dr. Bottomly join me on this journey. I would also like to acknowledge Mr. Tim Hamm, Mr. Chris Johnson, and Ms. Stephanie Bruce for their assistance and support in navigating the DoD Information collection approval process. I would also like to acknowledge Dr. Shenhar and Dr. Dvir for the use of the Project Success Assessment questionnaire. Finally, I would like to acknowledge Sister Mary Flavia and Sister John Norton for providing me with a strong foundation in mathematics required for quantitative research.

Table of Contents

List of Tables

List of Figures

CHAPTER 1. INTRODUCTION

Background of the Problem

Information technology (IT) project managers lead IT project teams and are ultimately responsible for the overwhelming number of IT project failures. According to the Standish Group CHAOS report, nearly two-thirds of IT projects fail to deliver on initial scope, schedule, and cost (Standish Group, 2013; Standish Group, 2015). The problem of failed IT projects is more pronounced in large IT projects than smaller efforts. Bloch, Blumberg, and Laartz (2012) found that large IT projects, projects over $15 million, fail more than half of the time. Failure of such large projects, known as "Black Swans," can threaten the viability of a company in 17% of the 5400 projects reviewed. In one case, a large retailer failed on successive $1.7 billion and $600 million IT projects and had to file for bankruptcy (Bloch et al., 2012). The Department of Defense (DoD) defines major automated information systems (MAIS) projects as those exceeding $165 million (Kendall, Gilmore & Halvorsen, 2015). One DoD MAIS IT project, USAF Expeditionary Combat Support System Program, failed to deliver any capability with $1.1 billion lost (Aronin, Bailey, Byun, Davis, & Wolfe, 2011). This study will directly contribute to the body of knowledge of IT project managers' critical success factors.

The purpose of this quantitative, comparative research, using the project success assessment questionnaire (Ahmed & bin Mohamad, 2016; Shenhar, Levy, & Dvir, 1997), will be to test the critical success factor (CSF) theory (Avots, 1969; Pinto & Slevin, 1989; Shenhar, Tishler, Dvir, Lipovetsky, & Lechler, 2002). This research will compare the IT project manager's undergraduate education type and commercial project management certification to project efficiency for U.S. Department of Defense (DoD) IT projects. Prior research concentrated on project success impacted by the project managers' level of education (Coleman, 2014; Ropponen & Lyytinen, 2000) and training certification (Abu-rumman, 2014; Catanio, Armstrong, & Tucker, 2013; Nazeer & Marnewick, 2018; Robertson, 2015; Starkweather & Stevenson, 2011b). Prior research has not addressed the undergraduate education type, nor the interactive effects of education and certification.

Research, starting with the seminal work of Brooks (1974), has identified the failure of IT projects to deliver promised scope on time and within budget. Brooks (1974) demonstrated that project manager optimism leads to exaggerated estimates and inability to take proper action when early problems arise, ultimately leading to project failure. Lack of project management knowledge in scheduling leads software project managers to add personnel, which makes the problem worse (Brooks, 1974). IT software projects fail due to lack of project management soft skills. Software professionals find project management soft skills to be much more important to software project success than technical knowledge in software engineering (Agrawal & Thite, 2006). In both studies, these gaps in project management skills contribute to high project failure rates. In an opposing view, Ropponen and Lyytinen (2000) found a relationship between a project manager's level of education in computing and the ability to manage cost and schedule project risk. The study focused on education level versus type.

The seminal works of Bullen and Rockart (1981) and Pinto and Slevin (1987) solidified the dominant project management theory of critical success factors (CSF). Of the two, Pinto and Slevin (1987) article is most cited of the recent works on IT project management and aligns with the dominant project management guide: the Project Management Body of Knowledge (PMBoK®; Project Management Institute, 2013).

According to McManus and Wood-Harper, only one in eight IT projects succeed (as cited in Rivera-Ruiz & Ferrer-Moreno, 2015). Emam and Koru (2008) noted that roughly 28-38% of IT projects fail to deliver on time and within budget. Kappelman, McKeeman, and Zhang (2007) point out that 20 percent of IT projects are canceled before completion and that number doubles for larger projects. Warren (2014) cited 85% of the United Kingdom public sector IT projects having difficulty, suggesting higher public sector IT projects failure rates. Project managers are responsible for these failures and should be the starting point on the journey to improve project success.

In the public sector, project managers continue to be selected based on technical expertise and general problem-solving ability (Darrell, Baccarini, & Love, 2010). IT professional skills, like software engineering, are considered hard skills. These technical skills that get the IT professionals selected as project managers differ from the soft skills required to manage the project. Scholars in the literature define soft skills as the combination of leadership and project management (Carvalho & Rabechini, 2015; Pandya, 2014; Stevenson & Starkweather, 2010). IT project managers must lead the project team and manage the project processes. "Project managers who cannot effectively lead or communicate pose a serious risk" to project success (Kappelman et al., 2007, p. 33; Müller & Turner, 2010).

Project managers selected for their technical expertise do not possess the managerial skills required to oversee the many processes involved in developing software (Agrawal & Thite, 2006; Darrell et al., 2010; Dulaimi, 2005; Kappelman et al., 2007). Dulaimi (2005) also suggested that project managers with engineering education and background focus too much on the technical aspects of the project and overlook essential leadership requirements. Müller and Turner (2010) identified developing personnel and strategic managerial perspective, as contributing to IT project success. Schmidt, Lyytinen, Keil, and Cule (as cited in Kappelman et al., 2007) recognized insufficient project manager communication skill as a top-six indicator of project failure. Coleman (2014) did not find a correlation between the project manager's education level and project manager success, recommending further study on the type of education and training. Coleman (2014) focused on the project manager's level of education; this study will focus more on the kind of education, science technology engineering and math (STEM) versus non-STEM at the bachelor's degree level.

Statement of the Problem

The business problem is the failure of project managers to deliver on scope, schedule, and cost, resulting in a high rate of IT project failure. The research problem statement is how a program manager's education type and training, as evidenced in project management related certifications, relates to project scope, schedule, and cost performance on DoD IT projects. The research literature on IT project management success indicates that we know critical success factors contribute to project success (Bredillet, 2010; Mir & Pinnington, 2013; Serrador & Turner, 2015; Toor & Ogunlana, 2010). We know that the leading project management professional training certification, PMP®, has not correlated to project efficiency in limited studies (Abu-rumman, 2014; Catanio et al., 2013; Nazeer & Marnewick, 2018; Robertson, 2015; Starkweather & Stevenson, 2011b). We do not know that IT project managers with a technical education positively impact project efficiency due to mixed results in the literature (Agrawal & Thite, 2006; Darrell et al., 2010; Dulaimi, 2005; Kappelman et al., 2007; Karanja & Zaveri, 2012; Rehman, Khan, & Khan, 2011; Smith et al., 2011). We do not know the extent to which the project manager's education and certification predict project efficiency. We do not know the possible interaction effects of education and certification on project efficiency.

Project efficiency, measured by scope, schedule, and cost, is also referred to as project management success in the literature (Bredillet, 2010; Mir & Pinnington, 2013; Savolainen, Ahonen, & Richardson, 2012; Serrador & Turner, 2015). The project management literature differentiates between project management success and overall project success (Cook-Davies, 2002; Shenhar et al., 1997). The project management success construct of project efficiency correlates to overall project success (Serrador & Turner, 2015).

The Project Management Institute (PMI) Project Management Professional (PMP®) certification has become the de facto commercial certification for project management; however, other project management certifications are available, such as IT Infrastructure Library (ITIL®) Foundation credentials, CompTIA Project+ certification, and Projects in Controlled Environments (PRINCE 2) (Abu-rumman, 2014; Frey, 2013). The academic literature does not support a relationship between project management certifications and project manager's successful completion of projects. Catanio et al. (2013) found no link between project management certification and higher project success rates. Abu-rumman (2014) also found limited evidence that the certification of project managers impacts project outcomes. Starkweather and Stevenson (2011b) findings indicated that PMP® certification was the least valued project management competency and no relationship exists between PM certification and project success.

Purpose of the Study

The purpose of the study is to contribute to the project management body of knowledge in the area of critical factors affecting project manager performance on IT projects to improve project outcomes. IT project failure is hindering the ability of organizations to capitalize on innovation in the field of information technology. IT projects that fail to implement the technology across the organization withhold or limit the realization of the technological benefit. The body of knowledge within project management must be enhanced to improve IT project delivery. In the Kappelman et al. (2007) study, the top 17 of 53 early warning signs for project failure came from people and process versus technical risk. Failing to deliver IT within scope, schedule, and cost reduces the business case for the new technology and prevents the organization from keeping up with follow-on technology enhancements. Better education and training of project managers may contribute to improved IT project outcomes (Aramo-Immonen, Koskinen, & Porkka, 2011); however, more research is needed.

Significance of the Study

Understanding the relationship between project managers' education and training and project efficiency on U.S. DoD IT projects will provide valuable information to the greater IT project management community. Company executives, chief information officers, and portfolio managers hold project managers accountable for project efficiency. Research has linked project efficiency success to overall project success (Serrador & Turner, 2015). Organizational leaders need to select and develop better IT project managers to improve IT project outcomes.

Most commercial organizations select project managers based on previous technical background; and academic research suggests that project managers picked based on technical competence focus too much on technical issues and lack project management and leadership skills (Agrawal & Thite, 2006; Dulaimi, 2005). The DoD selects project managers from both technical and nontechnical backgrounds with a mix of commercial certifications. As a result, the DoD IT PM community provides a research opportunity to compare project efficiency across groups with varying education and training. The study will also examine the interactive effects of different combinations of education and training certification. The results could help organizations better select and train IT project managers. Additionally, the results will contribute to recent research on the education and training of project managers.

Several studies have examined the appropriate mix of hard technical skills and project management skills in education programs. Pant and Baroudi (2008) noted that educational institutions continue to place more emphasis on hard (technical) skills at the expense of soft skills in project management (p. 127). While technical expertise is considered a prerequisite for selecting project managers, experienced project managers focus more on project management skills essential for project success (Pandya, 2014). Udechukwu, Chipulu, Marshall, Ashleigh, and Williams (2015) identified the importance of a holistic curriculum combining both engineering and project management content. Ramazani and Jergeas (2015) suggested educational institutions and training agencies consider both project management and technical skills versus maintaining "just technical skills" (p. 51). Niederman, Ferratt, and Trauth (2016) identified the need to achieve "the right balance of technical and nontechnical skills within an education program" for management positions (p. 45). This study will add to the research body of knowledge in support of continued research on the project manager's education and training.

Research Questions

The dissertation will contribute to the following research problem statement: Does a program manager's education type and training, as evidenced in project management related certifications, relate to project scope, schedule, and cost performance on U.S. DoD IT projects. The study will attempt to answer the following research questions:

1. To what extent does project management success in scope, schedule, and cost compare with project managers (PMs) with STEM and non-STEM education?

2. To what extent does project management success in scope, schedule, and cost compare with PMs with a commercial certification and without a commercial certification?

3. To what extent do interaction between education type (STEM and non-STEM) and commercial certification compare with project management success in scope, schedule, and cost performance?

Definition of Terms

Commercial Project Management Certification. Developed by a certification granting association for practitioners, certifications are typically based on standards validated by an examination and confirmed minimum real-world experience in project management, and occasionally minimum needs of organizations (Project Management Institute [PMI], 2013).

Cost. The financial resources expended on a time-phased project used as a basis for comparing budget to actual results (PMI, 2013).

Project Efficiency. (Pinto & Slevin, 1987; Pinto & Slevin, 1989) Project efficiency, measured by scope, schedule, and cost, is also referred to as project management success in the literature (Bredillet, 2010; Mir & Pinnington, 2013; Savolainen et al., 2012; Serrador & Turner, 2015). The project management literature differentiates between overall project success and project management success (Cook-Davies, 2002; Shenhar et al., 1997). Success criteria provide the dependent variables for measuring success (Müller & Jugdev, 2012). Project efficiency consists of the dependent variables of scope, schedule, and cost (Bredillet, 2010; Mir & Pinnington, 2013; Pinto & Slevin, 1987; Serrador & Turner, 2015).

Project Management Success. See project efficiency. The terms *project management success* and *project efficiency* are used interchangeably in the literature (Bredillet, 2010; Mir & Pinnington, 2013; Savolainen et al., 2012; Serrador & Turner, 2015).

Project Manager Competence. The ability of a project manager to perform his or her responsibilities. One of thirteen critical success factors (CSF) from CSF theory outlined in the work of Pinto and Slevin (1989) and later refined in the Belassi and Tukel (1996) and Shenhar et al. (2002) studies. The success factors "are the independent variables that make success more likely" (Müller & Jugdev, 2012, p. 758). The construct is represented in this study by the independent variables of STEM undergraduate education and commercial PM certification.

Project Management Training. Training in the specific practitioner skills required by the project manager to lead project teams and manage projects. Training provides more practice specific skills than the knowledge gained through education programs. Project management training can be specific to standards and processes within an industry or organization. Project management training frequently combines project management particular skills, such as schedule, cost, scope, and stakeholder management, with business management and leadership skills (PMI, 2013; Niederman et al., 2016; Pandya, 2014; Pant & Baroudi, 2008). Commercial project management certification granting associations provide evidence of project management training via an examination (PMI, 2013).

Science, technology, engineering, or mathematics (STEM) undergraduate degree. Bachelor of Science degree in fields of study that includes mathematics, physical sciences, biological/life sciences, engineering/technologies, and computer and information sciences (U.S. Department of Education [USDE], 2012).

Schedule. A series of linked activities with planned dates, durations, milestones, and resources (PMI, 2013).

Scope. The sum of the products, services, and results to be provided as a project (PMI, 2013).

Research Design

This dissertation used a quantitative method. The study involved an exploratory, comparative model to explore the statistical relationship among variables without specifying the direction of the influence. This dissertation used a factorial multivariate analysis of variance (MANOVA) or the nonparametric Mann-Whitney test. Sekaran and Bougie (2013) state that "an exploratory study is undertaken when not much is known about the situation at hand" or no information is available on similar problems (p. 96). No known study has examined the interaction effect of project managers' education and certification on project efficiency, nor any study that compared education type for project managers. An exploratory study is more appropriate because the findings may not be generalizable to the entire community of project managers (Sekaran & Bougie, 2013, p. 97) without further study, as could be the case studying DoD IT project managers.

The independent variables are a project manager's education type (STEM, non-STEM) and commercial project management certifications. The dependent construct is project efficiency on DoD IT projects, based on the dependent variables of cost, schedule, and scope from survey data. The researcher completed the DoD Information Collection process to obtain approval for surveying DoD IT project managers. The Defense Acquisition University agreed to sponsor the study.

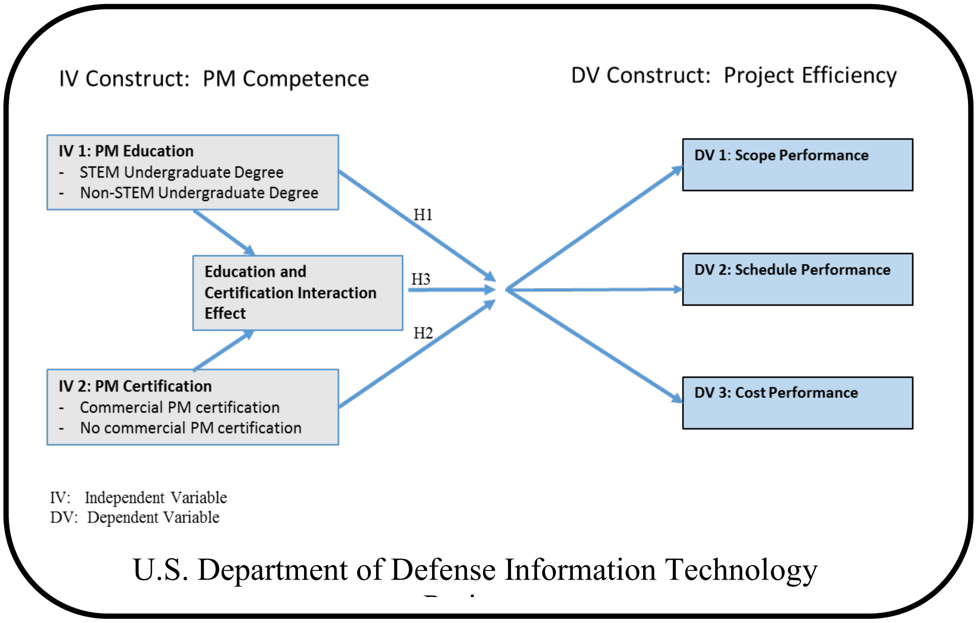


Figure 1. Conceptual Framework of Variable Relationships

To set a paradigm for examining the research problem, the researcher must establish a theoretical perspective. An epistemology endeavors to explain how people know what people know. The epistemology of objectivism enlightens the positivist view that leads to quantitative research (Crotty, 1998).

The dominant IT project management research paradigm for the past couple of decades has been the Critical Success Factors (CSF) theory supported by the positivism philosophical orientation (Smyth & Morris, 2007). CSF theory is rooted in Daniel (1961) article where he states that “to an increasing extent, a manager's effectiveness will hinge on the quality and completeness of the facts that flow to him and on his skill in using them” (p. 121). Daniel (1961) proposed nine questions for executives that involved planning, costs, performance, information collection, and information dissemination. Rockart (1979) and Bullen and Rockart (1981) updated and expanded CSF theory. The work of Pinto and Slevin (1987) modernized CSF and the ten factors in the study closely link to the nine project management domains in the PMBoK®

(Project Management Institute, 2013). While not cited directly, readers can identify CSF theory in Pinto's recent work with Serrador on Agile methodologies' success. In the study, cost, time, scope goals and stakeholder expectations serve as metrics for Agile IT project management success (Serrador, & Pinto, 2015).

The literature review conducted by Tesch, Kloppenborg, and Stemmer (2003) found a significant number of journal articles and thesis papers dedicated to the nine knowledge areas of the PMBoK® from 1999 to 2001. Current literature on the performance of IT project managers is based on CSF theory (Ahmed & bin Mohamad, 2016; Starkweather & Stevenson, 2011b; Warren, 2014). While other research studies do not directly reference CSF theory, the literature discusses critical factors in project failures with a positivist theoretical underpinning (Agrawal & Thite, 2006; Darrell et al., 2010; Emam & Koru, 2008; Ewusi-Mensah, 1997; Kappelman et al., 2007).

This study will test the critical success factors of project manager competence (Pinto & Slevin, 1989; Shenhar et al., 2002), project schedule/plan, technical tasks, and personnel (Pinto & Slevin, 1987; Pinto & Slevin, 1989) related to education and certification of project managers. Slevin and Pinto (1986) identified the project schedule/plan as a CSF. The schedule is an optimal way of measuring progress against the project schedule (p. 4). Studies, while recognizing other factors, continue to rate meeting schedule as a crucial CSF (Jethani, 2013; Oak & Laghate, 2016; Whitney & Daniels, 2013). Dubey (2011) found that schedule influenced the view that methodology was more significant than other factors, confirming the importance of finishing within tight schedules on software projects. This study will contribute to the ongoing theoretical discussion on the importance of a project schedule.

The personnel CSF involves paying attention to selecting and training the project manager and other vital personnel who contributes to making a project successful (Pinto & Slevin, 1989). Several studies cite the importance of education and certification as principal factors that potential employers value in project managers (Ramazani & Jergeas, 2015; Rehman et al., 2011). While qualitative studies show the importance of certifications for selecting project managers and perceptions of success (Armstrong, 2015; Baird & Riggins, 2012; Blomquist, Farashah, & Thomas, 2018; Dubois, Hanlon, Koch, Nyatuga, and Kerr, 2015; Nicholas & Hidding, 2010; Rivera-Ruiz, & Ferrer-Moreno, 2015); several quantitative studies fail to link certifications to project efficiency (Abu-rumman, 2014; Catanio et al., 2013; Nazeer & Marnewick, 2018; Robertson, 2015; Starkweather & Stevenson, 2011b). In a study of project managers seeking voluntary project management certifications, "collected 10 years apart (2004 and 2014)," Blomquist et al. found that voluntary project management certifications benefit is more aligned with looking good to prospective employers than being good at project management (p. 498). The study will contribute to confirming or refuting the relative importance of a commercial certification.

The technical tasks CSF includes the need for the project manager to have adequate technical skill required to successfully execute the project (Pinto & Slevin, 1989). Shenhar and Dvir (1996) highlight the need for project managers to possess technical skills. Other research finds that project managers selected for their technical expertise do not possess the managerial skills required for software project success (Agrawal & Thite, 2006; Darrell et al., 2010; Dulaimi, 2005; Kappelman et al., 2007). This research will contribute to the body of knowledge either refuting or confirming the importance of technical education for project success.

Even emerging alternative theories of IT project management, such as the adaptive project management theory of rethinking project management (RPM), recognize CSF theory of classical project management, as the dominant paradigm (Söderlund, 2011; Svejvig & Andersen, 2015). Cicmil and Gaggiotti (2018) concluded that a "growing body of evidence" exists, based on Rethinking Project Management, that university education in project management move beyond "perceived instrumental-technical nature of the field towards a theoretically informed, multidisciplinary and applied academic" approach, referred to as responsible project management education (p. 217).

Some of this recent literature influenced by the Agile Manifesto has shown a constructionism theoretical perspective; however, such articles struggle with a standard definition of project success (Batra, Xia, VanderMeer, & Dutta, 2010; Beck et al., 2001; Sewchurran, Smith, & Roode, 2010; Svejvig & Andersen, 2015).

Adolph, Kruchten, and Hall (2012) proposed a grounded theory of IT project management that involved human social factors. Based on the qualitative research, the four-stage Reconciling Perspectives process attempts to converge individuals' points of view about the software project. The process emphasizes individual abilities' importance in bringing the project to successful completion (Adolph et al., 2012). The theory identifies social factors and individual abilities as significant project cost drivers.

In assessing why IT project managers pursue professional certifications, Blomquist and Thomas (2004) suggested the influence of McClelland's trichotomy of needs theory. Trichotomy of needs theory suggests the individual need for affiliation, power, and achievement. This research may explain why IT project managers continue to pursue certifications despite the increasing academic research that suggests no link to project success.

As a secondary result, the study could refute the competing project management theory of social construction recently proposed by Sewchurran et al. (2010) for explaining information system project management. Sewchurran et al. focus on the importance of stakeholder relationships over critical success factors in contributing to project success. The study could also have implications for contingency theory as performance may be impacted by the context of project efficiency (Müller & Turner, 2010; Shenhar et al., 2002).

Assumptions and Limitations

Assumptions

The author assumes that there are no studies that explicitly compare the education type and training certifications of U.S. Department of Defense project managers with project outcomes. The study also assumes that the survey data collected from the various U.S. Department of Defense project managers is representative of actual secondary data on DoD IT projects.

Limitations

Some limitations exist for this study. First, the population of DoD IT project managers is significantly smaller than the overall population of project managers; therefore, the study may have limited applicability to the greater project management community. Second, if the study shows a relationship between project managers' education and training and project performance, a relationship does not guarantee causation. Additionally, the research is a member of the DoD IT project management community and must guard against personal bias.

Organization of the Remainder of the Study

The researcher organized the remainder of the study as follows. To establish a common understanding of the problem in Chapter 2, a literature review of IT project management best practices and frameworks will be provided. Next, in Chapter 3, the researcher will outline the methodology. In Chapter 4, the researcher presents the findings of the quantitative analysis of the survey data. Finally, in Chapter 5, the researcher will offer a review of the research findings with recommendations for practice and further research.

CHAPTER 2. LITERATURE REVIEW

This review of the literature on information technology (IT) project management focuses on the relationship between a project manager's education type and commercial training certifications with project performance. For the past three decades, information technology software projects have failed to achieve the triple constraint of project scope, schedule, and cost management. IT projects continue to fail at an alarming rate.

To alter the trend of high project failure in IT development projects, IT community members recognize the requirement for better business and project management training to supplement IT technical training. Approximately two-thirds of IT projects fail to deliver within the original scope, schedule, and cost (Standish Group, 2013; Standish Group, 2015). Multiple Standish Group CHAOS reports point to an improving trend in project success from less than one-quarter successful projects to a still abysmal one-third success rate on IT projects (Catanio et al., 2013). IT project success rates will not continue to grow to acceptable rates without project managers who combine project management and leadership competence with technical competence.

Methods of Searching

This structured review attempted to identify gaps in the research on IT project management qualifications that require further study. This review will contribute to the following research problem statement: Does a program manager's competence, as evidenced by project management certifications and undergraduate education type predict project scope, schedule, and cost performance on U.S. DoD IT projects. The literature review will cover the research relevant to the approved dissertation research topic to include both seminal and current work. This review will aid in refining the research philosophical perspective. The literature review provides evidence to support dissertation conclusions.

The researcher performed a structured examination of the literature in several phases. The phases included:

- a preliminary search using source keywords,
- an extended backward search based on the bibliographies of articles found,
- a search for literature reviews,
- a forward search to pinpoint seminal works based on the number of times cited on Google Scholar;
- a forward search based on articles citing the articles from the original search, and
- a review of recent dissertations on IT project management.

The study of existing literature confirmed the need for additional study on the research problem.

The problem statement keywords provided a foundation for the initial search. Original search articles helped refine the dissertation problem statement. Based on several library databases used, the following keywords and Boolean phrases were intermixed in multiple iterations:

- information technology project manager,
- software project manager,
- project manager AND information technology OR information system,
- project manager AND certification,
- project manager AND training OR education,

- project manager AND education,
- project manager AND training OR certification,
- project management theory,
- project management epistemology, and
- project management theoretical perspective.

Articles were selected based on primary, secondary, and tertiary study criteria.

Second, a search within the bibliographies of the primary article was conducted to locate potential seminal works. This step also provided for a more thorough analysis of the works cited by the authors. An additional benefit of researching previous works included establishing supporting research theories for the study and competing theories.

After that, the researcher conducted a specific search for literature reviews. The researcher chose previous literature reviews from information technology project management (Kloppenborg & Opfer, 2002; Oak & Laghate, 2016; Savolainen et al., 2012; Tesch et al., 2003) and general project management (Kiridena & Sense, 2017; Svejvig & Andersen, 2015). Literature reviews from various periods assist in identifying possible seminal works that remain relevant beyond one period. Studying literature over time helps researchers recognize potential shifts in basic epistemology and theoretical perspective (Crotty, 1998).

The researcher then reviewed the bibliographies from initial articles, to include the six literature reviews. Possible seminal works were checked in the Google Scholar academic search engine to identify the number of times the article was cited. The researcher selected seminal works based on a vast number of times the article was cited in follow-on research. Additionally, the researcher recognized seminal works for how the research potentially altered the paradigm or approach to the body of knowledge in the field.

Finally, a search of the library databases was accomplished for current IT project management dissertations closely linked to the research problem. Robertson (2015), Coleman (2014), and Frey (2013) provided three dissertations very closely related to, yet distinct from, the research topic. The three essays confirm the germaneness of the research topic. Also, the recent dissertations review would confirm whether or not the topic had been thoroughly covered by recent research or a body of knowledge skills gap still existed.

Theoretical Orientation for the Study

Critical success factors (CSF) theory of project management began with Daniel (1961) stating that "to an increasing extent, a manager's effectiveness will hinge on the quality and completeness of the facts that flow to him and on his skill in using them" (p. 121). Daniel (1961) posted nine questions for executives that involved planning, costs, performance, information collection, and information dissemination. The seminal works of Rockart (1979), Bullen and Rockart (1981), and Pinto and Slevin (1987) codified the literature on CSF theory. Pinto, Slevin, and associates provided the preponderance of oft-cited, seminal work on project management (Pinto & Mantel, 1990; Pinto & Prescott, 1988; Pinto & Slevin, 1987; Pinto & Slevin, 1988; Pinto & Slevin, 1989; Slevin & Pinto, 1986). The work of Pinto, Slevin, and associates closely linked to the leading project management guide, the PMBoK® (Project Management Institute, 2013). Of the six CSF studies, the Pinto and Slevin (1987) work is the most cited in recent works on project management. Before the development of CSF as a project management theory, Brooks (1974) identified similar factors that lead to the downfall of IT projects.

IT project research, starting with the seminal work of Brooks (1974), identified the failure of IT projects to deliver promised scope on time and within budget. Lack of project management knowledge in scheduling led software project managers to add people, which worsened the problem (Brooks, 1974). Brooks (1974) work predates CSF theory; however, his empirical study covers many of the same project success factors from CSF theory. In the seminal study, Brooks (1974) established, through quantitative analysis of five separate software engineering projects, that project manager optimism leads to inflated cost estimates and failure to take proper action on early problems. This inaction leads to project failure. Lack of project management scheduling knowledge leads software engineer project managers to add personnel. Per Brooks (1974) Law, adding people to a late project makes it more behind.

Pinto and Slevin (1987) combined a thorough review of previous theoretical frameworks on critical success factors with a survey to establish an empirically-based project management framework. The framework provided a potential measurement instrument for success. Fifty-two University of Pittsburgh MBA students, who had participated in a project, were asked to identify critical success factors. Two experts then categorized the responses into ten critical success factors. The goal of this article was to develop an empirically-based framework for critical success factors that validates the previous theoretical models cited in the literature review.

For an often cited seminal work on CSF theory, the Pinto and Slevin (1987) study has several limitations or potential biases not directly discussed or addressed by the authors. Using part-time MBA students could potentially be a sample of convenience with several flaws. The researcher did not consider that such critical success factors theory could have been part of the MBA curriculum and biased student responses. Potentially without experience from which to draw, the students were asked to take the project manager's perspective. The researchers provided no insight into the students' project management experience. The authors defined project success for those surveyed as one that resulted in organizational change versus the "pragmatic definitions, including meeting schedule, budget, and performance criteria" (p. 24).

This definition of success does not fully align with other CSF works that identify the triple constraint as success measures for which most project managers are held accountable. Follow on work by Pinto, Slevin, and associates provided empirical support for the CSF theory and the temporal nature of success factors (Pinto & Mantel, 1990; Pinto & Prescott, 1988; Pinto & Slevin, 1988; Pinto & Slevin, 1989).

Shenhar, Dvir, and associates represent another prolific research team, who significantly furthered project management research (Dvir & Shenhar, 1992; Shenhar & Dvir, 1996; Shenhar et al., 2001; Shenhar et al., 1997; Shenhar et al., 2002). While not specifically related to project management, the first insight into an expanded view of success for technology efforts appears in the Dvir & Shenhar (1992) study on success criteria for strategic business units in the technology industry. The researchers proposed expanded measures of success beyond profitability to include the short-term view of economic performance and the longer view of successfully preparing for the future (Dvir & Shenhar, 1992, p. 35). Shenhar and Dvir adopted the expanded view of success in later studies on project success.

Shenhar and Dvir (1996) developed a model contingent on project types with expanded independent and dependent variables from CSF theory-based studies. The researchers proposed a two-dimensional topology of projects based on four levels of technological uncertainty and three levels of project scope (Shenhar & Dvir, 1996, p. 629). Structural contingency theory of organizations provided for projects to be studied separately from the mother organizations, as projects often exhibit different characteristics (Shenhar & Dvir, 1996). Structural contingency theory within the organizational structure provided a starting point for the contingency perspective of projects (Hanisch & Wald, 2012). For contingency theory in project management, projects would exhibit consistent relationships among factors and measurements within a given project context versus a general set of universal factors (Söderlund, 2011).

Shenhar et al. (2002) provided further empirical research supporting a contingency theory of project management by examining multiple project dimensions. The study did identify some common success factors across different projects in the study; however, project-specific factors emerged related to high-uncertainty projects required different management from low-uncertainty type projects (Shenhar et al., 2002). The study strongly supported the hypothesis that success factors depend on project context. The competence of the project manager influences the outcome of high-scope, low-uncertainty, and high-uncertainty projects. The results of the study widened the range of both success factors and success criteria. Other project management contingency theory-based studies have also expanded the success factors, success criteria, and project typology (Ahimbisibwe, Cavana, & Daellenbach, 2015; Cserhati & Szabo, 2014; Mazur, Pisarski, Chang, & Ashkanasy, 2014). Contingency theory success factors show significant commonality with the CSF theory success factors (Pinto & Slevin, 1989; Shenhar et al., 2002), demonstrating that contingency theory is a complementary theory to CSF theory.

More recent literature identifies the project manager’s soft skills as contributing to successful programs. The studies tend to be based on a constructionist theoretical perspective. This perspective appears in the writing of Sewchurran et al. (2010), which attempts to outline an underlying theory to give coherence to IT project management research. The theoretical perspective of constructivism that challenges the prevailing view that project management success can be earned by following an established project management best practices, quantified and measured as reasons for IT project outcomes. The article calls for further research conducted using a methodology and methods based on constructionism.

The complexity theory of project management, also referred to as Rethinking Project Management (RPM) and Project Management Second Order (PM-2), attempts to reach an improved understanding of projects in the complex social processes that exist in project execution (Cicmil, Williams, Thomas, & Hodgson, 2006; Ojiako, Johansen, & Greenwood, 2008; Pollack, 2007; Saynisch, 2010; Svejvig & Andersen, 2015). In discussing complexity theory, Atkinson, Crawford, and Ward (2006) theorize that influencing factors, inter-dependencies, and emerging factors unknown at project initiation contribute to project complexity and uncertainty. Complex projects involve long timeframes for completion and substantial size with many inter-dependencies (Rezvani et al., 2016). Defining success in complex projects is a challenging issue (Toor & Ogunlana, 2010).

The literature review by Svejvig and Andersen (2015) on the project management theory of rethinking project management (RPM) shares the constructionism perspective as an alternative to classical project management based on CSF theory. The literature review puts forward the idea that traditional project management points to critical factors that impact project outcomes, merely adhering to CSF theory does not ensure success.

Qualitative studies from the RPM perspective cited improved team morale, stakeholder satisfaction, and alignment with organizational objectives (Baird & Riggins, 2012; Dubois et al., 2015; Nicholas & Hidding, 2010; Rivera-Ruiz, & Ferrer-Moreno, 2015; Smith, Bruyns, & Evan, 2011). Contrary to Brooks (1974) deeming project leaders' optimism a contributor to failure, Smith et al. identified a project manager's optimism as a salient factor in overall project success. In the case studies, 12 project managers used customer relationships and team morale as success metrics. Smith et al. (2011) did not cite successful delivery regarding the triple constraint. Rezvani et al. (2016) defined success regarding effective communications, troubleshooting unexpected crisis, clear project mission, and top management support. The advantage of these methods was a deep dive into the project manager's experience. The studies lacked a consistent definition of project success and evidence on whether the success criteria resulted in actual project delivery within the triple constraint or positive economic outcomes.

Scholars and practitioners have credited New Agile project management processes with influencing successful project outcomes. In a case study of a software consulting firm, Bernier, Dubé, and Roy (2012) credit Agile methodologies of eXtreme Programming and Scrum for successful delivery to a financial software client on time and at the contract price. The consultants defined success regarding the delivery of an operational system, and the client immediately contracted for additional system functionality (Bernier et al., 2012). This project could indeed be a success; however, the perspective for defining success could limit the value of the findings. The consulting firm insisted the contract include 21 client staff members dedicated to the project (Bernier et al., 2012). Success may turn to failure when considering the additional $3-5 million labor cost from the customer. Perspective is essential when defining success.

Review of the Literature

The business problem is the failure of IT project managers to achieve success on the triple constraint of project scope, time, and cost. McManus and Wood-Harper stated that only one in eight IT projects succeed (as cited in Rivera-Ruiz & Ferrer-Moreno, 2015). The Standish Group's (2013) report on 2012 CHAOS (as cited in Coleman, 2014) results shows that only 39% of projects deliver on time, within cost limits, and meet user requirements. While this represents a continuing improvement from previous CHAOS reports, practitioners cannot accept a failure rate over 60% given the rising cost of IT projects.

Project Manager Education and Training Background

Trepidation around the influence of the project manager's education and training on IT project performance has been an ongoing concern addressed in the literature. Better education and training of project managers may contribute to improved IT project outcomes (Aramo-Immonen et al., 2011). Researchers continue to seek the right balance of technical and project management training in educational institutions and training agencies (Niederman et al., 2016; Pandya, 2014; Pant & Baroudi, 2008; Udechukwu et al., 2015). Ramazani and Jergeas (2015) recommended universities and training activities include both project management and technical skills in curricula.

As a leader, the project manager must guide the project team and influence stakeholders to create the collaborative synergy required for success. Project managers must also address the triple constraint of scope, time, and cost management (Catanio et al., 2013). Emam and Koru (2008) cited the project manager's inability to manage budget and schedule as significant contributors to delivered projects failing to meet expectations. Emam and Koru (2008) demonstrated that IT project cancellation rates range "from 11.5 to 15.5 percent" (p. 88). Of the projects that managed to avoid cancellation, almost one-quarter did not deliver on schedule and within budget due to the project manager's lack of schedule and cost management. More recent literature recognized the importance of the triple constraint expressing it as project efficiency and added the concern of satisfying project stakeholder expectations to the concerns of the project manager (Serrador & Pinto, 2014). A project leader conveys his integrity and project vision to build relationships with various project stakeholders through effective communications (Dubois et al., 2015).

Project management literature identified the need for technical competence in education and training. Some researchers suggested technical competence as a prerequisite for selection as a project manager (Pandya, 2014; Ropponen & Lyytinen, 2000). Through the years, computer processing speeds increased, high-level programming languages appeared, and computer-aided software engineering (CASE) tools came online to help the development process; however, IT project managers continued to fall short of successful delivery. Project managers require technical expertise to keep pace with changing technology (Marion, Richardson, & Earnhardt, 2014; Pandya, 2014).

Three things contribute to adverse IT project outcomes: processes, products, and people. For people employing processes and tools in managing a project, technical knowledge is needed to oversee the features and specifications (Pandya, 2014). Soft skills are those leadership and project management skills required to motivate the team and influence stakeholders. As research shows, many IT project managers have significant technical knowledge; however, they lack sufficient project management and leadership skills to lead successfully. Project leaders require both skills for project manager competence. Education and certification serve as evidence of project manager competence.

Project Manager Technical (Hard) Skills

While significant research points to project management and leadership skills as more crucial to project success, practitioners cannot ignore technical factors. Agrawal and Thite (2006) cited the need to keep up with the latest technology and continuous learning about challenges experienced by software project leaders. Barki, Rivard, and Talbot (1993) identified team members' lack of requisite knowledge as a risk for project failure. Some project management literature emphasized the importance of technical skill for project management success (Brill, Bishop, & Walker, 2006; Dubois et al., 2015; Niederman et al., 2016; Oak & Laghate, 2016).

Ropponen and Lyytinen (2000) found that a project manager's level of software engineering education in computing predicted the project manager's ability to mitigate project cost and schedule risk. Using a survey of 80 project managers and analysis of variance, the researchers empirically delineated six factors of software development risk: (a) scheduling and timing risks, (b) system functionality risks, (c) subcontracting risks, (d) requirements management risks, (e) resource usage and performance risks, and (f) personnel management risks (Ropponen & Lyytinen, 2000, p. 98). The researcher found the hiring of well-educated project managers reduced cost and schedule risk; however, "technological attributes did not influence resource usage and performance risk in any way" (p. 107). The study focused on the level of technical education versus comparing the type of education. Several authors have focused on research involving the project manager education level, not the education type (Ahsan, Ho & Khan, 2013; Pant & Baroudi, 2008; Starkweather & Stevenson, 2011a; Stevenson & Starkweather, 2010; Udechukwu et al., 2015).

Pandya (2014) conducted a qualitative study on project leader competencies beyond the essential technical capabilities. The study consisted of four senior project manager interviews with a minimum of fifteen years' experience. While identifying the need for soft skills, each of the four subjects viewed technical ability as a given or prerequisite. Two participants named technical knowledge as the priority for selecting a project leader (Pandya, 2014, p. 43).

In the public sector, project managers continue to be selected based on technical expertise and general problem-solving ability (Darrell et al., 2010). IT professional skills, like software engineering, are considered hard skills. Technical skills that get the IT professionals selected as project managers differ from the soft skills required to manage the project. Scholars in the literature define soft skills as the combination of leadership and project management (Carvalho & Rabechini, 2015; Pandya, 2014; Stevenson & Starkweather, 2010). IT project managers must lead the team and manage the project processes (Müller & Turner, 2010).

Project Manager Leadership (Soft) Skills

IT professionals list project management and leadership skills as significantly more critical to IT project success as software engineering technical knowledge (Agrawal & Thite, 2006). Project managers selected based on technical expertise too often do not possess the leadership and management skills required for successful supervision of software development teams (Agrawal & Thite, 2006; Darrell et al., 2010; Dulaimi, 2005; Kappelman et al., 2007). Dulaimi (2005) suggests that IT project managers with engineering background focus too much on the technical details. Orchestrating the entire project demands a significantly different skill set than providing technical leadership. The gaps in project management leadership skill contribute to high project failure rates. In the Kappelman et al. study, the top 17 of 53 early warning signs for failure came from people and process versus technical risk. "Project managers who cannot effectively lead or communicate pose a serious risk" to project success (Kappelman et al., 2007, p. 33). Project managers in the public sector continue to be selected based on general problem-solving ability and technical savvy (Darrell et al., 2010).

Lack of project management skills contributes to IT project failure (Carvalho & Rabechini, 2015; Catanio et al., 2013; Rivera-Ruiz & Ferrer-Moreno, 2015). Schmidt, Lyytinen, Keil, and Cule pointed to the lack of communication skill as a top-six indicator of project failure (as cited in Kappelman et al., 2007). Brooks (1974) breaks down communication into two components: training and intercommunications. Project teams, to include the project manager, require training that they cannot partition in the technology, project goals, and work plan (Brooks, 1974).

Project leaders must also train. Corbató as cited in Brooks (1974) notes that long projects must account for technical and project process training. Dulaimi (2005) identified development as an essential dimension in project manager behavior. Darrell et al. (2010) included training as a critical component of team-building, one of the interpersonal skills required by project managers. Scholarly research identified interpersonal skills as most important for a project manager (Briner, Geddes, & Hastings, 1990; Serrador & Turner, 2015; Toor & Ogunlana, 2010).

Dulaimi (2005) pointed to three critical project management behaviors: managing the project's resources; organizing and coordinating; and information handling. Müller and Turner (2010) identified developing and strategic perspective within the managerial and intellectual dimensions of leadership, respectively, contribute to IT project success. Brooks (1974) cited the lack of cost and schedule estimates combined with a lack of knowledge as factors in how to correct schedule slippage by software engineers managing the projects as salient contributors to project failure. Kappelman et al. (2007) listed poorly documented requirements, ineffective schedule planning and management, and no change process control as central process risks inhibiting project success. Emam and Koru (2008) cited the project manager's inability to manage budget and schedule as significant contributors to delivered projects failing to meet expectations. Project management certifications have provided evidence of project management skill.

PM Certification Impact on Project Outcomes

With the exponential growth in Project Management Professional (PMP®) certifications from the Project Management Institute (PMI) and the PMBoK® becoming the de facto commercial guide to project management, researchers might start with the hypothesis that project management certifications are critical to project success. PMP® certifications have grown from 1000 in 1993 to 412,503 in 2010 (Catanio et al., 2013). Other project management certifications, such as Projects in Controlled Environments (PRINCE 2) and ITIL® Foundation credentials that started as an IT project management certification, have also thrived (Abu-rumman, 2014; Frey, 2013).

The academic literature does not support a relationship between project management certifications and project manager's successful completion of projects. Nazeer and Marnewick (2018) concluded that project management certification did not influence project performance on South African IT projects. Catanio et al. (2013) found no higher project success rate among certified project managers and uncertified project managers in a quantitative study that included 43 certified and 44 uncertified project managers. For project managers with a PMP certification, Abu-rumman (2014) also found "limited evidence to suggest it has any significant impact on the relative success or failure of projects" (p. 5). Starkweather and Stevenson (2011b) findings indicated that PMP® certification was the least valued of 15 core project management competencies and that there was no difference in project success rates between PMP®-certified project managers and uncertified project managers.

In another Starkweather and Stevenson (2011a) study, recruiters' and IT executives' discussed suggestions for improvement in the delivery of the project outcomes. The study noted that IT executives favored soft skills over technical skills. The study noted disconnects between the value IT recruiters placed on PMP® at 50% valued it, and only 15% of IT executives saw it as valuable. One drawback of the studies is that researchers mostly focused on the impact of the PMP® certification. Robertson (2015), in a quantitative dissertation, using secondary data from

1,444 RGS consulting firm projects found PMP® certification correlated with poorer project outcomes.

In a quantitative, correlation-based dissertation, Frey (2014) found a positive relationship between an industry certified project manager and project success. In addition to the PMP®, Frey (2014) included ITIL® Foundation credentials, CompTIA Project+ certification, and other certifications. The author acknowledges the limitations "that survey results in this population of IT practitioners may not be the same in other populations or other industries" (p. 9), and the study did not guarantee causal relationships. Frey's (2014) identification of a positive relationship between project management certification points to a potential benefit of this study's research problem. Frey offered a different result from the recent research, indicating a gap in the literature still exists. Studying defense project managers provides the opportunity to study IT project managers with and without commercial project management certifications.

Findings

The research literature on IT project management success indicated that critical success factors are known to contribute to project success (Bredillet, 2010; Mir & Pinnington, 2013; Serrador & Turner, 2015; Toor & Ogunlana, 2010). In applying critical success factor theory to project success, researchers and practitioners must consider the temporal and contextual impact on success factors' relationship to project success (Pinto & Prescott, 1988; Pinto & Slevin, 1989; Shenhar et al., 1997). Context also impacted the selection of success measures (Shenhar et al., 2001; Shenhar et al., 2002).

Some empirical evidence exists that the leading project management professional training certification, PMP®, has not correlated to project efficiency in limited studies (Abu-rumman, 2014; Catanio et al., 2013; Nazeer & Marnewick, 2018; Starkweather & Stevenson, 2011b).

More research is required to confirm or refute the limited findings. Shackman (2015) found "insufficient evidence to indicate whether accreditation, certification, and credentialing will improve program outcomes" (p. 110). More research is needed to determine whether certification benefit program and project outcomes (Shackman, 2015). A gap in research exists on whether or not IT project managers with a technical education positively impact project outcomes; the literature provided mixed results (Agrawal & Thite, 2006; Darrell et al., 2010; Kappelman et al., 2007; Karanja & Zaveri, 2012; Pandya, 2014; Rehman et al., 2011; Smith et al., 2011). The extent to which the project manager's education and certification predict project efficiency has not been sufficiently studied. The researcher found no evidence of the possible interactive effects of the IT project manager's education and certification on project efficiency.

Project efficiency, operationalized as scope, schedule, and cost, is also referred to as project management success in the literature (Bredillet, 2010; Mir & Pinnington, 2013; Savolainen et al., 2012; Serrador & Turner, 2015). The project management literature differentiates between project success and project management success (Cooke-Davies, 2002; Shenhar et al., 1997). The project management success construct of project efficiency correlates to overall project success (Serrador & Turner, 2015).

Critique of Previous Research Methods

A review of research covered in this literature review must include an evaluation of the methods used in seminal works referenced in the study. In this section, the researcher will review works supporting CSF theory, contingency theory, PM certification, and PM education. The researcher will point to strengths and weaknesses of the studies.

Critical Success Factors (CSF) Theory Research

While predating the development of CSF theory, Brooks (1974) provided seminal work on the critical nature of project cost and schedule control in early IT projects. Later work on CSF theory by Slevin and Pinto (1986) emphasized the significance of baselining and monitoring the project schedule, allocating financial resources, and taking corrective action as part of the Project Schedule/Plan, Monitoring and Feedback, and Trouble-Shooting success factors. Brooks' (1974) research purpose was to analyze software projects to identify recurring sources of failure. The research method used quantitative evaluation of software project secondary data from four different studies along with first-hand knowledge and data from the IBM operating system project. The research demonstrated how inaccurate estimates and poor reactions to slipping schedules negatively impacted projects.

Brooks (1974) identified five factors which contributed to project failure. Strength in the study was the use of secondary data; however, a five project sample limits the external validity in applying the results to the broader IT project manager population. As the following studies demonstrate, these early IT project management challenges persist.

As mentioned above, Slevin and Pinto (1986) developed the project implementation profile (PIP) survey instrument for assessing project leader and team progress against ten critical success factors. The purpose of the research was to outline a project implementation process conceptual model and a diagnostic tool for the project manager. The questionnaire developed used ten items to operationalize each of the ten factors. The PIP instrument was tested using a sample of 85 practitioners. High internal consistency scores resulted averaging .86 with a high of .92 and low of .76. Correlations across the ten factors were moderately high, ranging from .83 to .26 with a .59 average within each factor (Slevin & Pinto, 1986, p. 64). The researchers found a temporal relationship between the ten factors, showing factors impact was sequential versus concurrent or random. This study of the PIP had several weaknesses. The sample only examined successful projects, resulting in a nonrandom sample. The concept of critical success factors provided a foundation for follow-on studies leading to the development of critical success factors theory.

Pinto and Slevin (1987) followed up on the preliminary work on the 10 CSF with a quantitative look at critical factors in successful project implementation. This study method included a literature review and a survey of 52 graduate students to establish a project management framework and validate the PIP. The study confirmed the Slevin and Pinto (1986) ten critical success factors in the PIP that contributed to project success. The authors concluded that a temporal factor in the sequence of responses provided a thorough checklist for project managers. Based on the five earlier frameworks, the finding of empirical verification for the conceptually-based critical success factors demonstrates strength in this study.

This frequently cited Pinto and Slevin (1987) work had several weaknesses the authors failed to note. Using students, selected because they were also employed full time, was likely a flawed convenience sample. The researcher did not consider the possibility that management theories likely were included in the business curriculum creating possible response bias. Also, MBA students may lack experience and knowledge of management to comment on critical success factors. The researchers provided no data on whether or not any of the students surveyed had been project managers or had any responsibility for scope, schedule, and cost. By defining success as organizational change versus scope, schedule, and budget measures, Pinto and Slevin potentially limited the use of the results as a practical tool. Many project managers are held accountable for project efficiency versus organizational change. Follow on Pinto studies with other associates overcome some of these limitations.

Pinto and Prescott (1988) published one of the first quantitative confirmations of CSF outlined in the PIP (Slevin & Pinto, 1986). The purpose of the field study was to test the temporal nature of the critical success factors. CSF theory provided the basis for the study, noting that previous CSF frameworks had not been derived from empirical data (Pinto & Prescott, 1988, p. 6). Using a quantitative, correlation method, Pinto and Prescott sampled 408 project managers and team members across eight project categories. *T*-tests of mean responses for late versus early responses ruled out response bias. The PIP instrument was used to measure the ten CSF independent variables against the dependent variable of project success which aggregated 13 items to include budget and schedule adherence, perceived project quality and utility, client satisfaction, and the likelihood of use. The researcher tested the hypotheses that the ten CSF would significantly ($p < .05$) correlate to project success and dominant CSF would vary across the four life cycle stages: conceptual, planning, execution, and termination (Pinto & Prescott, 1988, p. 9).

To check the psychometric properties of the instrument, Pinto and Prescott (1988) examined sample reliability and validity. Cronbach alpha scores ranged from .79 to .90, well above acceptable ranges for reliability. Cronbach alpha scores over .70 are acceptable and exceeding .80 are good (Sekaran & Bougie, 2013, p. 293). Confirmatory factor analysis resulted in only one factor emerging in every case, suggesting construct validity with factor loadings from .49 to .90 and a .64 average (Pinto & Prescott, 1988, p. 11). Reliability and validity data provide the study strength.

Due to multicollinearity, the researchers used ridge regression, followed by stepwise regression to test the hypotheses. The correlations for each of the ten factors with the success measure confirmed the overall importance of each factor. The salient factors varied by stage. For example, in the conceptual phase, the two hypothesized CSFs were key to project success with an adjusted *r*-squared value of .64. In the planning stage, two CSFs explained 63% of the project success variance (Pinto & Prescott, 1988).

The researchers highlighted two study limitations. The authors cautioned that the elimination of monitoring and feedback and communications from the ridge regression analysis did not suggest the factors are unimportant. Other research suggested the importance of the two CSFs. Also, the study may not be generalizable to all projects, even though the study included a significant cross-section of projects. Large, complex projects were not part of the study. The study does provide a valid empirical evaluation of CSF theory (Pinto & Prescott, 1988).

Looking at CSF using the PIP within the research and development (R&D) project context, Pinto and Slevin (1989) conducted another quantitative, correlation study to test the temporal hypothesis that the impact of critical success factors varies across the stages of the project life cycle. A vital component of this study is that the critical success factors were expanded to include four exogenous factors beyond the project team's control: (a) project team leader competence, (b) power and politics, (c) environmental events impacting project team operations, and (d) perceived project urgency.

The research method involved stepwise regression analysis of the survey data. The regression included the 14 CSF predictor variables and the dependent variable of project success. The dependent variable of project success aggregated the 13 success measures from the PIP (Slevin & Pinto, 1986). The study confirmed the temporal nature of the impact of various CSF across the project life cycle; however, only findings for the factors of mission, client consultation, client acceptance, and technical tasks aligned to the Pinto and Prescott (1988) findings. Unlike the earlier study, this research identified personnel as a significant factor during the conceptual and termination phases. The difference in the two study findings could have been impacted by the two factors, monitoring and feedback and communications, being eliminated in the prior study (Pinto & Prescott, 1988), plus the inclusion of four new CSF (Pinto & Slevin, 1989). Of the four new factors, only urgency and environmental events correlated with project success during the conceptual and planning stages, respectively (Pinto & Slevin, 1989). The fact that project manager competence did not significantly correlate with project success points to the need for further study on the project manager's education and certification.

A strength of the study was that it addressed a limitation of the Pinto and Prescott (1988) research by sampling 159 R&D projects from a small $5,000 pilot study to a complex $2.5 billion government project (Pinto & Slevin, 1989, p. 33). The researchers provided no validity, nor reliability information resulting in a significant weakness of the study. The lack of validity and reliability data was notable because the researchers added four new critical success factors to the PIP instrument. Another study limitation involved the Pinto and Slevin taking the sample from Project Management Institute members, who may not be representative of project managers who are not members or members of other project management organizations. These factors could negatively impact the integrity of the research in the eyes of the reader of the article.

Pinto and Mantel (1990) conducted further quantitative testing of CSF theory in the study examining the causes of project failure. The study of project failure provided balance in the overall body of knowledge on CSF theory to Slevin and Pinto (1986), which only considered successful projects. As an extension of previous studies, the researchers posited that the lack of strength or absence of CSF affects project failure. The authors hypothesized that the perceived causes of failure would vary depending on the outcome measure and life cycle stage. Pinto and Mantel (1990) also considered the project context by comparing construction versus R&D projects. The hypothesis was that this contingent variable would impact the perceived cause of the failure based on project type.

The study method began with Pinto and Mantel (1990) using the PIP questionnaire for a sample of 97 Project Management Institute (PMI) members. *T*-tests indicated no early-late response bias. For this study, the researchers grouped 13 success measures into four dependent success/failure measures: (a) implementation process, (b) perceived quality, (c) client satisfaction, and (d) an aggregate project success of the first three. The method involved using "confirmatory factor analysis, employing principal components analysis" (Pinto & Mantel, 1990, p. 272). Stepwise, multivariate regression was employed to test the hypotheses.

A noted study limitation is that study critical factors only accounted for 40% of the variance in project failure causes. Other important factors, such as exogenous environmental factors, should be considered in future studies. Several CSF theory studies (Pinto & Mantel, 1990; Pinto & Prescott, 1988; Pinto & Slevin, 1989) share the weakness of sampling PMI members. If most PMI members have Project Management Professional (PMP®) certifications, do the studies adequately address the impact of project managers without the PMP® or other commercial certification? The study supported the hypotheses that cause of project failure differ depending on failure criteria employed, project type, and project life cycle stage. In the relationship between CSF and success measurement, the contextual differences impacted the development of the contingency theory of project management.

Contingency Theory Research

Contingency theory of project management grew from the CSF theory critique that one general set of success factors does not apply in all contexts. While contingency theory extends CSF theory in a natural progression of the project management body of knowledge, the CSF theory criticism seems invalid. CSF theory posits that the critical success factors vary across the context of life cycle phase (Pinto & Slevin, 1987). Contingency theory of project management significantly expands the notion that context matters in both success factors and success measures.

CSF theory studies often used regression to compare scale success factors with scale success criteria. In contingency theory studies, more analysis of variance methods are used to compare mean differences of categories of project factors against a set of success criteria (Field, 2013; Mertler & Vannatta, 2013). The independent variables are often categorical states of various components of critical success factors. Shenhar, Dvir, and associates are prolific researchers of complexity theory of project management (Dvir & Shenhar, 1992; Shenhar & Dvir, 2007a; Shenhar, Dvir, Levy, & Maltz, 2001; Shenhar et al., 2002).

Shenhar and Dvir (1996) conducted a two-dimension typology study to develop a project management theory. The intent was for the theory to assist in predicting the dependent variable of project success. In building a theoretical foundation, the authors cited critical success factors (CSF) theory, yet criticized CSF authors for identifying a supposed universal set of factors for success (p. 608). The researchers introduce contingency theory for application to project management.

The researchers combined qualitative and quantitative methods with two databases to develop typography to be rigorously, empirically tested, to meet project management theory criteria. The qualitative, case research used to build the model involved interviews of 115 people associated with 26 projects. For the quantitative test with multivariate analysis of variance (MANOVA), a survey was built and preliminarily tested on 17 projects of convenience from the 26 case projects. Then the final survey was used to collect data from a sample of 127 projects (Shenhar & Dvir, 1996).

The detail provided on validity and reliability resulted in a significant strength of the study. Shenhar and Dvir (1996) conducted Chi-squared tests of independence on all nominal variables. The researchers then calculated Cramer's measure of association. Shenhar and Dvir ran ANOVA tests in select cases to confirm consistent results. Cronbach's alpha values were calculated for internal consistency with levels exceeding 0.7, except for two scales exceeding 0.65 (Shenhar & Dvir, 1996).

The model included the dimension of scope with three levels and technological uncertainty with four levels. The researcher found budget and duration increased with the scope. Employment of risk management, systems engineering, and quality management varied with technical uncertainty, while other factors remained consistent. The findings suggest that projects have a wide range of variation. Technological uncertainty emerged as the dominant factor affecting project characteristics (Shenhar & Dvir, 1996, p. 628). A limitation of the study is in its exploratory nature. More research would be needed to refine and confirm the theory.

Follow on studies focused on contingent views of project success. Shenhar, Levy, and Dvir (1997) theorized that researchers and practitioners must measure project success beyond the traditional project efficiency measures of scope, schedule, and cost. The researchers proposed a multidimensional framework for success to include project efficiency, impact on the customer, business success and preparing for the future (p. 5). Shenhar et al. sampled 170 project managers using questionnaires based on multiple success measures. ANOVA was conducted to compare means from ongoing projects versus completed projects. The only statistically significant finding was on the success measure of future potential with an F value of 10.19 ($p < 0.005$). The study found that project managers distinguish among four dimensions of success. Beyond meeting project resource constraints of schedule and budget, project managers are concerned with meeting customer specifications (scope) and customer satisfaction. A limitation of the study is generalizability to all project managers, as the study sampled only project managers in Israel.

Shenhar et al. (2001) conducted a study to refine the multidimensional framework for assessing project success. The authors theorized that the components of project success would be assessed differently in different context per contingency theory. The researchers compared mean differences for different success factors at project initiation for four categorical independent variables of project uncertainty: (a) low-tech, (b) medium-tech, (c) high-tech, and (d) super high-tech projects. Sampling 182 project managers from 127 projects, the researchers used Pearson Correlation coefficients between the 14 measures in the study and factor analysis as the quantitative research method to see how groups of success measures clustered. ANOVA was used to compare the levels of project uncertainty. The study concluded that success dimensions would vary on time and success factor context.

Serrador and Turner (2015) recently examined the relationship between project success and project efficiency. The authors conducted a quantitative study that compared project efficiency, defined as the traditional project management success of the triple constraint with overall project success, the multifaceted view that involves stakeholder satisfaction and business outcome. The authors used an important survey instrument and surveyed over 1,300 project managers from multiple countries and across numerous fields.

The purpose of the quantitative study was to evaluate the possible relationship between project efficiency and overall project success. The methodology was a quantitative analysis using a survey instrument based on a post-positivist approach. The researchers applied a post-positivist approach in recognition that some project success factors such as stakeholder satisfaction are not purely objective. The researchers found a moderate correlation between project efficiency and overall project success (Serrador & Turner, 2015, p. 30). Aligning with other studies, the authors also concluded that project success is a broader concept than the traditional triple constraint or iron triangle of cost, schedule, and scope. "Project efficiency is an important contributor to project success;" however, "other factors contribute significantly, as well" (p. 38). The researcher also found efficiency factors of cost and schedule to have a lower correlation to project success in government and high technology than other fields.

Limitations of this study included the subjectivity associated with surveys and mono-source bias (Conway & Lance, 2010; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). The researcher suggests future research evaluating moderating factors in the relationship between project efficiency and success. While not directly stated by the authors, future research is needed to examine the moderating factors in government and high technology areas for project efficiency dependent variables.

Ahmed and bin Mohamed (2016) cited CSF theory (Pinto & Slevin, 1987) as a basis for their quantitative study to explore the relationship between top management support and a definition of project success that included the project efficiency. The research methods were MANOVA and exploratory factor analysis. The researchers used the project success assessment questionnaire developed by Shenhar, Levy, and Dvir (1997). Ahmed and bin Mohamed found a significant positive relationship between the five dimensions of top management support and project success. The strength of the study was in the detailed reporting of the statistical analysis and pointing out the limitation of using only PMI members in the study.

PM Certification Research

Starkweather and Stevenson (2011a) examined the relationship between the project management professional (PMP®) certification and project efficiency. This recent study related to CSF theory and contingency theory focused on the CSF of project leader competence (Pinto & Slevin, 1989). The purpose of the study was to investigate the relationship between the PMP® and IT project manager core competencies. Researchers attempted to find out what characteristics corporate IT executives looked for in potential IT project professionals. The authors surveyed 3,258 IT managers and executives in the United States. The researcher invited the IT executives to propose more competencies they found salient to IT project management success.

The researchers conducted the study in two phases. The study included two hypotheses tests to evaluate the value of the PMP® certification. The researchers hypnotized that the PMP® was highly valued as a core competency and PMP® certified project managers experience more project success. To test the first hypothesis, the researchers aggregated the top two scores on the Likert scale, then created percentages of high scores based on frequency for each hiring criteria. A series of *t*-tests were run on each response to see if respondents with PMP® certifications would have statistically significant differences in rating the criteria. None of the tests were statistically significant; however, the researchers did not address the possible negative impact on the statistical power of their approach. *T*-tests were also used to compare the mean success rate differences between certified and uncertified IT project managers for five different success criteria. None of the results were statistically significant. The study found the PMP® certification to be the least valued core competencies. The authors found no difference in project success rates between certified and uncertified project managers.

A critical flaw in the study is that the researchers do not address the assumptions required for the various statistical tests used. For example, the researchers ran several cross-tabulations on the data to see if the status of respondents as PMP® certified or not influenced responses. Starkweather and Stevenson (2011a) provided no information on independence or expected frequencies. Outliers and influential cases can influence the *t*-statistic; regrettably, the researchers did not address outliers in the data (Field, 2013). Using a Likert-scale, the researcher collected interval data. Unfortunately, the researcher aggregated and dichotomized the data to fit the statistical analysis approach, suboptimizing the value of the data. The researchers could have improved the study with the use of a multivariate technique. The study suggests that more research on this topic is needed.

Catanio et al. (2013) also examined the impact of project management certification on project efficiency. The researchers point out that although the number of people earning a PMP® certification has grown in recent years, the authors found no relationship between a PMP® certification and project success. Catanio et al. defined project efficiency regarding cost, schedule, and scope. The purpose of the research was the attempt to establish a link between the possession of a PMP® certification and experience of a project manager and project success regarding project efficiency. The researchers point out that IT project managers are allowed to practice the profession of IT project management without formal education and training in project management.

A quantitative research method was used in this study to compare the percentages of successful and failed projects with project managers who have and do not have a professional certification. The authors also considered the project manager's experience in the study. The researchers conducted a survey using Survey Monkey. Catanio et al. (2013) surveyed 93 IT project managers. The researchers used two independent sample means *t*-tests to determine if certified project managers were more successful than noncertified project managers for scope, schedule, and cost. A one-way ANOVA was used to test for mean differences in each experience level and certification combination. These methods would result in high risk of Type 1 errors and loss of statistical power (Field, 2013). The research would have benefited from the use of MANOVA, which would limit the risk Type 1 errors and better examine interactive effects between the independent variables of certification and experience.

The Catanio et al. (2013) study found no relationship between IT project managers with PMP® certification and reported project success against the triple constraint. The study found that both uncertified and certified IT project managers had between seven and eight years of experience. Researchers identified the self-selection of participants as a limitation of this study. The researchers suggest further studies to identify other factors and the interaction of those factors that might impact improved IT project manager performance. The study also suffers from not providing validity and reliability data for the instrument used. The flawed used of statistical methods points to a need for further study.

PM Education Research

Current studies have also focused on the project manager's education. In a related study, Karanja and Zaveri (2012) examined the educational background of IT leaders. The goal of the research was to investigate the educational backgrounds of people selected to IT leader positions.

The researchers discovered that the majority of IT leaders have a STEM (Science, Technology, Engineering, and Mathematics) undergraduate degree and a business master's degree. IT leaders tended to begin their careers as software programmers, database specialists, systems analysts, or network engineers. STEM undergraduate degrees accounted for 56% of eventual IT leaders. Karanja and Zaveri's failure to consider other factors contributing to IT leader career success led to a limitation of the study. In a study that analyzed job advertisement knowledge, skills, and abilities requirements for project managers, Ahsan, Ho, and Khan (2013) also found education to be the most oft-cited competency under the knowledge category, further emphasizing the project manager's education.

Ramazani and Jergeas (2015) examined the benefits of investing in project management education. In a qualitative case study, the authors commented on project managers employed in the Calgary gas and oil industry. The researchers concluded that educational institutions needed to add more training in project management to technical curricula. For project managers involved with complex projects, Ramazani and Jergeas suggested the following training: critical thinking for dealing with complexity, soft skills as opposed to just technical skills, and preparing project managers for the various context of actual projects (p. 46). The researchers contended that educational institutions should do more to train project managers by addressing multidimensional competencies. A limitation of the study is that it covers a specific region and industry sector. The researchers suggest more research in the area of a project manager's education.

Summary

While definitions of success vary, literature consistently values project manager's soft skills of leadership and project management as critical to project success. Most IT software development projects continue to struggle in delivering original scope on time and within budget. Gaps in the project manager's leadership and project management skills contribute to project failure. Researchers need to conduct more quantitative research on the ideal mix of education and training for the project manager to offer potential solutions to the problem. This study addressed possible combinations of a project manager's education and training by examining the interactive effects.

This review identified research gaps in this area that require further study. While researchers have conducted studies on the research problem, authors have recommended more research on the possible link between training and education for project managers and project performance. A research study using secondary data versus surveys will contribute significantly to the project management body of knowledge. The recent dissertations and peer-reviewed journal articles indicate that the topic is very relevant.

The literature might have suggested that it is better to select professional project managers with tertiary technical knowledge of IT; however, more research is needed. Information technology project managers in the U.S. Defense Department are selected based on technical or managerial expertise. A quantitative study of project performance for Defense project managers could add to the body of knowledge on software project management.

CHAPTER 3. METHODOLOGY

Purpose of the Study

The purpose of this exploratory, nonexperimental research based on the project success assessment questionnaire (PSAQ) (Ahmed & bin Mohamad, 2016; Shenhar & Dvir, 2007b), was to test the critical success factor (CSF) theory (Pinto & Slevin, 1989; Shenhar et al., 2002) that compares IT project manager's undergraduate education type and project management certification to the project efficiency for Department of Defense (DoD) information technology projects. The researcher used quantitative, comparative methods. The study included independent variable of undergraduate education type defined as a science, technology, engineering, or mathematics (STEM) undergraduate degree or nontechnical undergraduate degree (non-STEM). The researcher defined the dependent variables as scope performance, schedule performance, and cost performance per the definitions in the Project Management Institute Body of Knowledge (Project Management Institute, 2013). The number of activities or functional requirements performed on a project defined the dependent variable of scope (Belassi & Tukel, 1996).

"Objectivism is the epistemological view that things exist as meaningful entities independently of consciousness and experience, that they have truth and meaning residing in them as objects" (Crotty, 1998, p. 5). Based on the supporting post-positivism philosophical orientation, this study will use a quantitative methodology and a survey research method (Crotty, 1998). Setting forth the research using the four elements of epistemology, theoretical perspective, methodology, and method helps justify the research and "points up the theoretical assumptions that underpin it and determine the status of its findings" (Crotty, 1998, p. 6).

Research Questions and Hypotheses

The main omnibus research question, supported by null hypotheses, simultaneously asked about differences across all project management success variables. If the omnibus test found mean differences, then the researcher probed subquestions for each variable of scope, schedule, and cost where the mean difference exists (Mertler & Vannatta, 2013, p. 139).

1. To what extent does project management success in scope, schedule, and cost compare with project managers (PMs) with STEM and non-STEM education?

Hypothesis $H1_0$: There is no statistically significant difference in scope, schedule, and cost performance comparing education type of STEM and non-STEM.

(H_0: $\mu_1 = \mu_2 = \mu_3 \ldots = \mu_k$)

2. To what extent does project management success in scope, schedule, and cost compare with PMs with a commercial certification and without a commercial certification?

Hypothesis $H2_0$: There is no statistically significant difference in scope, schedule, cost performance comparing commercial PM certification and no commercial PM certification.

(H_0: $\mu_1 = \mu_2 = \mu_3 \ldots = \mu_k$)

3. To what extent do interaction between education type (STEM and non-STEM) and commercial certification compare with project management success in scope, schedule, and cost performance?

Hypothesis $H3_0$: There is no statistically significant difference in education type of STEM and non-STEM and commercial PM certification interaction effect comparing scope, schedule, and cost performance.

(H_0: $\mu_1 = \mu_2 = \mu_3 \ldots = \mu_k$)

For each mean differences discovered between any groups of independent and dependent variables, the researcher applied the following subquestions. If one or more of the mean vectors differed significantly (H_a: $\boldsymbol{\mu}_n \neq \boldsymbol{\mu}_k$), then the alternative hypotheses would have been tested, as appropriate (Mertler & Vannatta, 2013; Sekaran & Bougie, 2013).

Scope:

1.1 To what extent does scope performance compare with PMs with STEM and non-STEM education?

Hypothesis $H1_{A1}$: There is a statistically significant difference in scope performance comparing education type of STEM and non-STEM.

2.1 To what extent does scope performance compare with PMs with a commercial certification and without a commercial certification?

Hypothesis $H2_{A1}$: There is a statistically significant difference in scope performance comparing commercial PM certification and no commercial PM certification.

3.1 To what extent does interaction between education type (STEM and non-STEM) and commercial certification compare with scope performance?

Hypothesis $H3_{A1}$: There is a statistically significant difference in education type of STEM and non-STEM and commercial PM certification interaction effect on scope performance.

Schedule:

1.2 To what extent does schedule performance compare with PMs with STEM and Non-STEM education?

Hypothesis $H1_{A2}$: There is a statistically significant difference in schedule performance comparing education type of STEM and non-STEM.

2.2 To what extent does schedule performance compare with PMs with a commercial certification and without a commercial certification?

Hypothesis $H2_{A2}$: There is a statistically significant difference in schedule performance comparing commercial PM certification and no commercial PM certification.

3.2 To what extent does interaction between education type (STEM and non-STEM) and commercial certification compare with schedule performance?

Hypothesis $H3_{A2}$: There is a statistically significant difference in education type of STEM and non-STEM and commercial PM certification interaction effect on schedule performance.

Cost:

1.3 To what extent does cost performance compare with PMs with STEM and Non-STEM education?

Hypothesis $H1_{A3}$: There is a statistically significant difference in cost performance comparing education type of STEM and non-STEM.

2.3 To what extent does cost performance compare with PMs with a commercial certification and without a commercial certification?

Hypothesis $H2_{A3}$: There is a statistically significant difference in cost performance comparing commercial PM certification and no commercial PM certification.

3.3 To what extent does interaction between education type (STEM and non-STEM) and commercial certification compare with cost performance?

Hypothesis $H3_{A3}$: There is a statistically significant difference in education type of STEM and non-STEM and commercial PM certification interaction effect on cost performance.

Research Design

This quantitative, nonexperimental, comparative research, based on an Internet-based PSAQ (Ahmed & bin Mohamad, 2016; Hagen & Park, 2013; Shenhar & Dvir, 2007b), tested components of critical success factors theory (Pinto & Slevin, 1987; Pinto & Slevin, 1989) by comparing IT project manager undergraduate education type and certification to the project scope, schedule, and cost performance for DoD IT projects. Serrador and Turner (2015) used a quantitative comparative study to examine differences between industry categories for predicting project success. Shenhar et al., (1997) used a comparative study to examine the mean differences for completed projects and projects in process for project success measurements to include project efficiency.

The researcher defined the independent variable of undergraduate education type as a science, technology, engineering, or mathematics (STEM) undergraduate degree or non-technical undergraduate degree (non-STEM) based on the U.S. Department of Education STEM definition (U.S. Department of Education, 2012). The researcher defined the dependent variables of scope, schedule and cost performance per the definition in the Project Management Institute Body of Knowledge (Project Management Institute, 2013).

The researcher based this study on the PSAQ (Shenhar & Dvir, 2007b). The Shenhar, Dvir, and Levy (1997) study created and validated the instrument used to collect the data. More recent studies have further validated the use of the project success assessment questionnaire (Ahmed & bin Mohamad, 2016; Hagen & Park, 2013; Shenhar et al., 2001). The addition of demographic questions on the project manager's type of undergraduate education and commercial project management certification assisted the researcher in addressing a gap in previous studies. Dr. Shenhar and Dr. Dvir provided permission to use the survey instrument.

The researcher eliminated any respondent from the sample who entered the survey site but failed to answer any questions. The researcher eliminated from the sample IT project managers who failed to respond to questions about an undergraduate degree and certification in the survey. IT project manager respondents were eliminated from the sample for not responding to project efficiency. The researcher used the remaining survey data in the analysis and hypotheses testing.

Target Population and Sample

The researcher limited the population of project managers for the study to DoD IT project managers. For the study survey, the terms project managers and program managers were used interchangeably because the DoD defines the term program manager as an equivalent to the term project manager (Kendall et al., 2015). DoD program/project managers manage development projects and programs for everything from ships to aircraft and missiles to information systems. DoD IT program/project managers are a subset of the general DoD project management population. DoD IT project managers manage hundreds of IT projects. While the researcher is a member of the DoD program management community, the researcher's current role is in learning and development versus actually managing programs. The researcher works for the Defense Acquisition University that has a statutory requirement to conduct academic research (Defense Acquisition University Structure Act, 1990).

Population

As of October 2018, there were 24,534 program/project managers and information technology members in the Defense Acquisition Workforce, each with varying levels of education and certification (DAU, 2018). General demographics for the DoD project management and information technology breaks down as follows:

- 74% male, 26% female
- 77% white, 11% black, 5% Asian, 2% multi, 5% other/unspecified
- 80% civilian, 20% military
- Average age: 46

Sample

The sampling design was a probability sampling. The researcher collected data using an approved survey instrument via the Defense Acquisition University (DAU) Opinio web-based survey tool. The sample included DoD IT project managers.

DoD IT project managers are a subset of the larger project management population. The researcher acquired the sample from a sample frame of 8895 members of the project management and information technology population. The researcher's organization, DAU, maintains an email list of IT PMs who possessed a DoD level III certification. Defense acquisition workforce members must earn a DoD level III certification before leading a DoD IT project or program.

Limiting the sample frame to Level III certified workforce member had several benefits. The limited sample frame reduced statistical model error related to varying levels of DoD certification training. Also, the DoD level III certification requires a minimum of four years' experience (DAU, 2018). Prior studies indicated that experience positively correlated to project success (Frey, 2013; Müller & Turner, 2010; Ropponen & Lyytinen, 2000; Standish Group, 2013). By restricting the sample frame to those with at least four years of experience, the researcher reduced error in the model resulting from inexperience.

Additionally, the 8,895-person sample frame used for recruiting participants was below the 10,000-limit for surveying DoD personnel. The DoD Information Collection approval limited the number of DoD personnel whom the researcher could recruit. Using a sample frame creates a source of sample error (Vogt, 2007, p. 80); however, the researcher used the sample frame to balance DoD survey limitations and the need to achieve the minimum sample size.

Power Analysis

The estimated minimum sample size was 98. The estimate was calculated using GPower 3.1. The researcher based estimate in GPower 3.1 on two binary IVs (predictors) resulting in four groups, and three DVs (response variables). Cohen (1988) established a rule of thumb for evaluating effect sizes as .2 for small, .5 for medium, and .8 for large (as cited in Mertler & Vannatta, 2013, p. 11). Chen (1999) found a 0.13 Pillai's trace to be significant in a critical success factors study of the banking industry. In this sample estimate, the researcher used a Pillai’s trace value of .1 to be conservative. Of the four test statistics used to evaluate group differences, Pillai’s trace is more robust in instances of unequal sample sizes among groups and violations of assumptions (Mertler & Vannatta, 2013, p. 125). The previous studies using the project success assessment questionnaire did not experience a violation of assumptions for the survey collected interval (scale) variables (Ahmed & bin Mohamad, 2016; Hagen & Park, 2013; Shenhar et al., 1997; Shenhar et al., 2001). The recommended sample size also exceeds the recommended minimum sample size of 64 for two-tailed hypotheses in a quantitative comparative study (Onwuegbuzie & Collins, 2007, p. 288).

Procedures

The method for the collection of data was a random sample. In this section, the researcher will describe the processes involved in random sampling to include how participants were selected. Additionally, the researcher will describe the procedure for protecting participant and their rights. Finally, the researcher will describe the process for data collection and data analysis.

The unit of analysis was IT project manager, representing a case in the statistical analysis. The survey measured the project manager education type and project management certification. The survey also measured the project manager's perception of project scope, schedule, and cost performance.

Participant Selection

The participants were recruited via email sent from the Defense Acquisition University, the organization sponsoring the researcher. The researcher developed a recruitment email, which informed and invited recipients who managed a DoD IT project to participate. The participants' email addresses were obtained from the sample frame of the DAU list of Level III certified DoD IT project managers. The DAU communications team sent the recruitment email to each of the 8895 Defense Acquisition Workforce Level III certified IT program managers ensuring an equal opportunity to respond to the survey, thus ensuring a random sample (Vogt, 2007, p. 78).

The researcher used the entire sample of IT project manager respondents after eliminating respondents who did not complete the survey after reading the informed consent. The researcher also excluded respondents because the respondents recognized the questions did not apply to them answering not applicable (N/A) to every question on project management success. IT project managers entered the DAU Opinio survey site, after receiving the recruitment email and reading the informed consent form. The survey informed consent form provided participants with the opportunity to contact the researcher with questions about the study via phone or email. Some participants contacted the researcher via phone and email. Questions from participants included verification of their eligibility, how to obtain DoD approval to conduct a survey, and interest in access to the published dissertation. The researcher accepted respondents into the sample who chose to complete the survey after reading the informed consent. This approach provided a sufficient minimum sample of more than 98 IT project managers.

Protection of Participants

The researcher protected the participants in the study in several ways. The recruitment email was digitally signed using DoD certificates. This ensured participant knew the email was from a trusted DoD source. The survey site was within the DoD .mil domain, instilling further confidence in participants that the survey was safe and DoD approved. When respondents entered the site, the landing page contained the informed consent message. The informed consent message advised the participants that the survey was anonymous and no personally identifiable information would be collected in the survey. Demographic data included only undergraduate degree type, gender, project size, and commercial PM certification identification. The questions were multiple choice, generic categories designed to limit severely respondent identification risk.

Data Collection

After reading the informed consent, participants completed the electronic survey by answering the thirty-two questions online. Participants completed the questions in under ten minutes based on a test run by DAU faculty before the survey went live. Participants also provided unsolicited feedback to the researcher that the survey took less than ten minutes to complete. Survey data was collected and stored on DAU servers. The researcher exported survey data from the Opinio tool to a Microsoft Excel spreadsheet file. The researcher downloaded the file to the researcher’s password-protected laptop. Next, the researcher imported the Excel file into the IBM SPSS software for data analysis. Data stored and in motion was encrypted. The researcher will destroy all data per the DoD Instruction 1100.13 and Capella IRB requirements.

Data Analysis

Data analysis involved several steps. First, the researcher imported the data from an Excel file to SPSS version 24 for the data analysis. Second, the researcher ensured the variables were categorized appropriately in the SPSS variable tab as nominal or scale for independent and dependent variables, respectively. The researcher then conducted correlation tests using Pearson's *r* and calculated Cronbach α to verify the instrument reliability and validity data from previous research. After that, the researcher produced descriptive statistics and conducted exploratory data analysis to check for missing data and outliers. Next, the researcher did hypothesis testing using factorial multifactor analysis of variance (MANOVA). Finally, a post hoc test was conducted based on the result of the MANOVA.

Descriptive statistics. The researcher produced descriptive statistics. Descriptive statistics included sample size, missing data, mean, standard deviation, skewness, kurtosis, and Q-Q plots. The researcher then conducted an exploratory data analysis on each of the three scale dependent variables (DVs), and two nominal independent variables (IVs) to address missing values, eliminating cases with missing data for IVs the sample. Outliers were not an issue, as the survey measured data on a 5-point Likert scale.

Hypothesis Testing. After that, the researcher screened and statistically tested the assumptions of normality, linearity, homoscedasticity, and multicollinearity using the DVs. Next, the researcher conducted a factorial Multifactor Analysis of Variance (MANOVA) using Pillai's Trace as it is robust to violations of normality provided the violation was due to skewness or kurtosis versus outliers (Field, 2013).

Post Hoc Analysis. If the MANOVA showed any significant relationships between the variables, the researcher would have conducted an ANOVA for the variables showing a significant relationship. Since SPSS version 24 cannot test for multivariate normality, the possibility of normality violation existed. The researcher conducted a non-parametric Mann-Whitney test, not dependent on MANOVA assumption of normality, to confirm the results of the MANOVA.

Instrument

In this section, the researcher will describe the instrument used in the study to collect data. The researcher used the Project Assessment Questionnaire (Ahmed & bin Mohamad, 2016; Hagen & Park, 2013; Shenhar & Dvir, 2007b) as the instrument. The researcher administered the survey online by loading the instrument to the DAU Opinio survey tool.

Project Success Assessment Questionnaire (PSAQ)

The PSAQ instrument collects data on project manager's perception of project management success construct of project efficiency which included scope, schedule, and cost performance. The questionnaire collects data on four other measures of project success. With the PSAQ Internet-based survey, the researcher collected additional demographic data on the project manager's undergraduate education type, commercial project management certification, gender, and confirmation that the project manager managed a DoD IT project.

The original instrument with a 4-point Likert scale was first used to collect data in the Shenhar, Dvir, and Levy (1997) study. With the approval email to use the instrument, Dr. Dvir provided the latest version of the instrument, translated from Hebrew, updated to a 5-point Likert scale with a middle score added between the categories of Agree and Disagree. More recent studies include the term neutral to the middle score on the 5-point scale and further validated the instrument (Ahmed & bin Mohamad, 2016; Hagan & Park, 2013). This study used the 5-point scale version of the instrument per the approval emails from Dr. Dvir and Dr. Shenhar.

Validity. Construct validity demonstrates that the instrument measures what "one intends it to measure" (Vogt, 2007, p. 120). The construct measured in this study was project management success or project efficiency, which includes the variables of scope, schedule, and cost. Researchers can measure validity using the factor loading in an exploratory factor analysis or correlational analysis (Sekaran & Bougie, 2013, p. 227). Ahmed and bin Mohamad (2016) computed project efficiency factor loadings of 0.633 for scope, 0.725 for schedule, and 0.809 for cost. The factor loading cutoff value was set at 0.40 (Roberts, Priest, & Turner, 2006 as cited in Ahmed & bin Mohamad, 2016). Shenhar et al. (2001) established factor loadings of 0.694 for scope defined as functional performance, 0.872 for schedule, and 0.834 for the cost. Correlation coefficients were calculated between the three factors as follows: scope and schedule Pearson r 0.277 significant at $p<0.01$; scope and cost Pearson r 0.310 significant at $p<0.001$; and schedule and cost Pearson r 0.604 significant at $p<0.001$ (Shenhar et al., 2001, p. 722). In this study, coefficients were calculated with Pearson r 0.418, 0.523, 0.765 significant a $p<0.01$ (2-tailed), for scope-schedule, scope-cost, and schedule-cost, respectively, as shown in Table 1.

Reliability. Reliability refers to whether "an instrument can be interpreted consistently across different situations" (Field, 2013, p. 12). Researchers have used various items in the instrument across time demonstrating the instrument lacks bias (Ahmed & bin Mohamad, 2016; Hagan & Park, 2013; Shenhar et al., 1997). Inter-item consistency reliability can be measured for multipoint-scaled items using Cronbach α (Sekaran & Bougie, 2013). Hagen and Park reported a Cronbach's α score of 0.906 for organizational outcomes using the PSAQ project efficiency construct. Ahmed and bin Mohamad reported Cronbach's Alpha of 0.759 for the

PSAQ project efficiency construct. This study computed a Cronbach's Alpha of 0.803 for the three dependent variables that comprise the construct of project efficiency.

Table 1. *Pearson r Validity Data*

Dependent Variables		Project on Time	Project on Budget	Minor Scope Change
Project on Time	Pearson Correlation	1	.765**	.418**
	Sig. (2-tailed)		.000	.000
	N	297	291	289
Project on Budget	Pearson Correlation	.765**	1	.523**
	Sig. (2-tailed)	.000		.000
	N	291	292	285
Minor Scope Change	Pearson Correlation	.418**	.523**	1
	Sig. (2-tailed)	.000	.000	
	N	289	285	291

*** Correlation is significant at the 0.01 level (2-tailed).*

Ethical Considerations

The population for this study is adult, U.S. Department of Defense government IT project managers. The most significant risk in this study is the possible compromise of personally identifiable information (PII). Since the project survey instrument did not collect PII and the survey was anonymous, the risk is assessed as low. The researcher mitigated the risk of PII compromise by including an informed consent statement at the beginning of the Internet survey. The educational degree types did not reflect the educational institution. The researcher did not administer the survey until the Capella IRB approved the study. The researcher obtained DoD Information collection process approval reflected in the approval number, RCS# DD-A&S-2675. The survey collected no PII.

The *Belmont Report* resulted in the Ethical Principles and Guidelines for the Protection of Human Subjects of Research. The *Belmont Report* outlines three ethical principles: respect for persons, beneficence, and justice (USD HHS, 1979). The risk mitigation plan proposed respects the target population of project managers in this study by protecting their PII. The study will benefit the entire project management community to include the subjects involved in the research by adding to the project management body of knowledge in a way that will assist the individual project manager in career planning for education and certification. The benefit gained from the study benefits all project managers equally by contributing to the general body of knowledge, therefore adhering to the principle of justice.

The results of this study only provided one data point that builds on the knowledge gained from previous work. As such, researchers and practitioners should only view the study with similar studies in the field. A risk arises in the interpretation of findings when this study is viewed alone. The researcher must protect PII as the published results could contribute to ongoing project management legislative and policy discussions.

Summary

This exploratory, non-experimental, quantitative, comparative research using the PSAQ (Shenhar & Dvir, 2007b; Shenhar et al., 2001), used factorial MANOVA to compare the independent variables of IT project manager's undergraduate education type and project management certification to the project efficiency for DoD IT projects. The project efficiency construct is measured using the dependent variables of scope, schedule, and cost. The researcher documented validity and reliability measures for the PSAQ instrument. The researcher also protected participants in the study per established ethical standards. The following chapter reports on the results of the study using the methods outlined in this chapter.

CHAPTER 4. RESULTS

Background

This chapter will present the results of the analysis of data. The analysis will begin with a description of the sample to include sample size, eliminated cases, and descriptive statistics. The survey results from the DAU Opinio tool were analyzed with SPSS version 24 to produce descriptive statistics and test for assumptions.

The next section will discuss the results of answering the main omnibus research questions with associated hypotheses:

1. To what extent does project management success in scope, schedule, and cost compare with project managers (PMs) with STEM and non-STEM education?

Hypothesis $H1_0$: There is no statistically significant difference in scope, schedule, and cost performance comparing education type of STEM and non-STEM.

2. To what extent does project management success in scope, schedule, and cost compare with PMs with a commercial certification and without a commercial certification?

Hypothesis $H2_0$: There is no statistically significant difference in scope, schedule, cost performance comparing commercial PM certification and no commercial PM certification.

3. To what extent do interaction between education type (STEM and non-STEM) and commercial certification compare with project management success in scope, schedule, and cost performance?

Hypothesis $H3_0$: There is no statistically significant difference in education type of STEM and non-STEM and commercial PM certification interaction effect comparing scope, schedule, and cost performance.

(H_0: $\mu_1 = \mu_2 = \mu_3 \ldots = \mu_k$)

If one or more of the mean vectors differ significantly (H_a: $\boldsymbol{\mu}_n \neq \boldsymbol{\mu}_k$), then the researcher will test the alternative hypotheses, as appropriate (Mertler & Vannatta, 2013; Sekaran & Bougie, 2013). After the researcher tests the hypotheses, a post hoc test will be conducted to confirm the results. MANOVA testing will be used to test hypotheses. The Mann-Whitney non-parametric test will be conducted to validate the MANOVA results against concerns over the assumptions. Finally, the results will be summarized.

Description of the Sample

The sample was collected using an Internet-based DAU Opinio survey tool. The survey was open for two weeks to ensure the study reached the minimum sample size. Responding to the recruitment email sent to the DoD IT PM population, 384 volunteer participants logged into the DAU Opinio survey web page. After reading the informed consent, 70 did not complete any portion of the survey recognizing the survey did not apply to them. Five respondents marked not applicable to each answer, so the researcher eliminated the cases from the study. The sample included data from the two independent variables (IVs) and three dependent variables (DVs) representing two constructs listed in Table 2.

Table 2. *Variable Information*

Constructs	Variables	Level of Measurement	Operational Definition
Construct 1 Project Manager Competence (Stevenson & Starkweather, 2010)	Undergraduate Education Type (IV)	Nominal (Vogt, 2007; Sekaran & Bougie, 2013)	STEM vs. Non-STEM degree (Survey question 30; Hypotheses H1 & H3)
	Project Management Certification (IV)	Nominal (Vogt, 2007; Sekaran & Bougie, 2013)	Commercial PM certification (Survey question 29; Hypotheses, H2, & H3)
Construct 2 Project Efficiency (Mir & Pinnington, 2013; Serrador & Turner, 2015)	Scope performance (DV)	Interval (Vogt, 2007; Sekaran & Bougie, 2013)	Scope Assessment (Survey question 3; Hypotheses H1, H2 & H3)
	Schedule performance (DV)	Interval (Vogt, 2007; Sekaran & Bougie, 2013)	Schedule Assessment (Survey question 1; Hypotheses H1, H2 & H3)
	Cost performance (DV)	Interval (Vogt, 2007; Sekaran & Bougie, 2013)	Cost Assessment (Survey question 2; Hypotheses H1, H2 & H3)

Missing Data and Outliers

The remaining data had 15 missing responses randomly scattered throughout the data set covering cost, schedule, scope, commercial certification, and education representing only 5% of the data shown in Table 3. The cases with missing data were eliminated using the pairwise method (Mertler & Vannatta, 2013, p. 38). Case 161031 did not answer having a commercial PM certification; a negative response was entered based on the respondent not providing any specific commercial PM certification information in the free text block. The final sample size of 284 more than doubled the minimum sample size.

Table 3. *Sample Cases and Missing Data*

	Valid		Missing		Total	
Dependent Variables	N	Percent	N	Percent	N	Percent
Project on Time	284	95.0%	15	5.0%	299	100.0%
Project on Budget	284	95.0%	15	5.0%	299	100.0%
Minor Scope Change	284	95.0%	15	5.0%	299	100.0%

Outliers were not an issue, as the survey measured dependent variables on a 5-point Likert scale. Boxplots in Figure 3 show no outliers for the dependent variables (Scope, Schedule, and Cost).

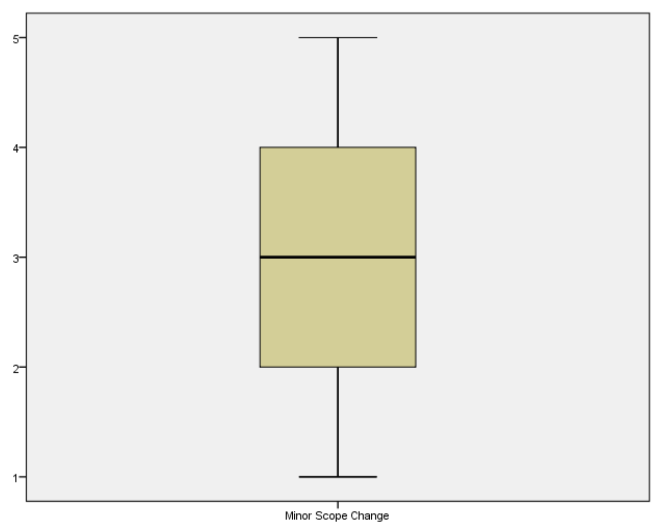
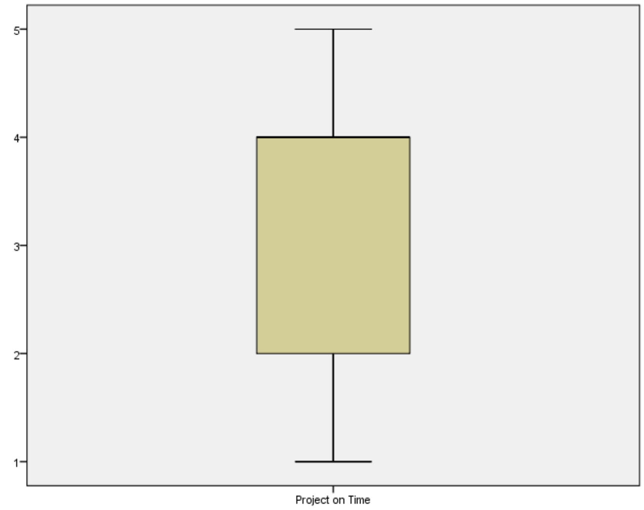


Figure 2. Boxplots for Scope, Schedule, and Cost



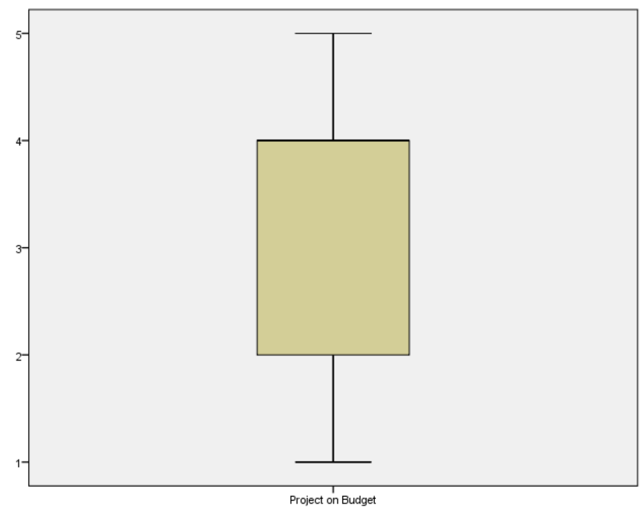


Figure 2. Boxplots for Scope, Schedule, and Cost Continued

Sample Power

The sample had power (1-β) of 0.99 with a type I error α of 0.05 established using GPower 3.1, as outlined in Figure 4. The result aligned with the *a priori* power analysis in Figure 2 that reports $F(6, 186) = 2.1476$, $p < .001$with power (1-β) of 0.99 and a type I error α of 0.05.

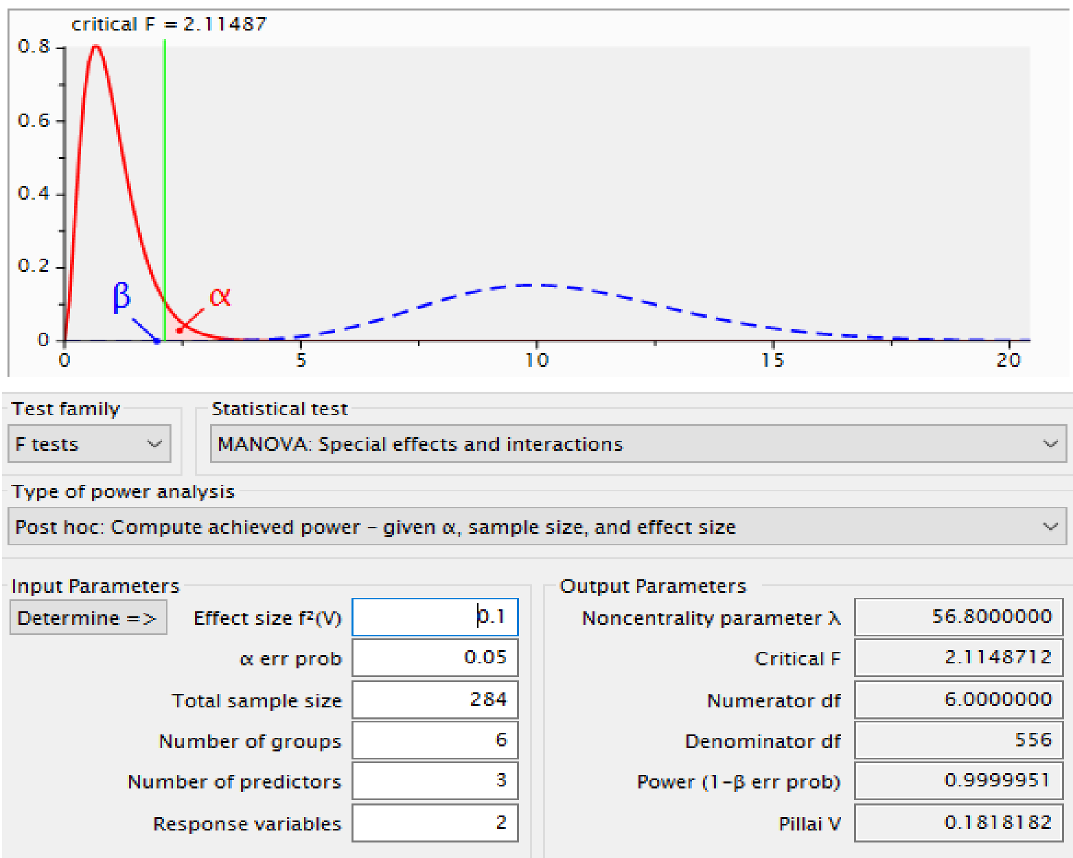


Figure 3. GPower 3.1 MANOVA Power Calculation

Descriptive Statistics

Sample gender demographic was 75.2% male and 24.8% female. The sample demographic closely matched the population demographics of 74% male and 26% female, which indicates the sample is representative of the population. IT project managers responding to the survey based responses on both large and small IT project with 63.4% of projects having a contract value below $100 million and 36.6% having a contract value at or above $100 million. The sample had 232 (77.6%) respondents without a commercial PM certification and 67 (22.4%) with a commercial PM certification. Those claiming a commercial PM certification were asked to specify which PM certification. The respondents with a PM certification possessed the following types:

- 52 PMP®,
- four Lean Six Sigma,
- two ITIL® Foundation Basic,
- two Certified Scrum Masters, and
- the others held various PM certifications.

In the sample, 154 (51.5%) participants had an undergraduate STEM degree, and 145 (48.5%) did not possess a STEM degree. Table 4 outlines the descriptive statistics for the sample.

Table 4. *Unadjusted Means for Schedule, Cost, and Scope by Categories*

Dependent Variable	Coml PM Certification	STEM Degree	Mean	Std. Deviation	N
Project on Time	No	No	3.29	1.343	110
		Yes	3.48	1.240	110
		Total	3.39	1.293	220
	Yes	No	3.16	1.313	25
		Yes	2.95	1.450	39
		Total	3.03	1.391	64
	Total	No	3.27	1.334	135
		Yes	3.34	1.314	149
		Total	3.31	1.322	284

Table 4. *Unadjusted Means for Schedule, Cost, and Scope by Categories Continued*

Dependent Variable	Coml PM Certification	STEM Degree	Mean	Std. Deviation	N
Project on Budget	No	No	3.35	1.282	110
		Yes	3.75	1.085	110
		Total	3.55	1.202	220
	Yes	No	3.24	1.200	25
		Yes	3.10	1.447	39
		Total	3.16	1.348	64
	Total	No	3.33	1.264	135
		Yes	3.58	1.220	149
		Total	3.46	1.245	284
Minor Scope Change	No	No	3.05	1.210	110
		Yes	3.15	1.221	110
		Total	3.10	1.214	220
	Yes	No	2.96	1.172	25
		Yes	2.92	1.265	39
		Total	2.94	1.220	64
	Total	No	3.04	1.200	135
		Yes	3.09	1.232	149
		Total	3.07	1.215	284

Tests for Normality, Linearity, and Homoscedasticity

The researcher conducted tests for the assumptions of normality, linearity, and homoscedasticity using the five variables, Scope (Minor Scope Change), Schedule (Project on Time), Cost (Project on Budget), PMCert (Coml PM Certification), and STEMDegree (STEM Degree). The results follow.

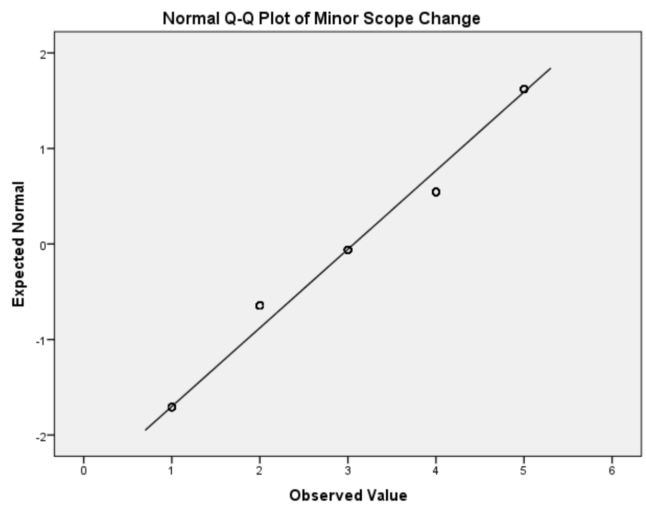
Normality (Examine Skewness, Kurtosis, and Kolmogorov-Smirnov). For the Scope (Minor Scope Change) variable, skewness was -0.078, -0.040, -0.072, and -0.071 for no PMCert, yes PMCert, no STEMDegree, and yes STEMDegree, respectively. For the Schedule (Project on

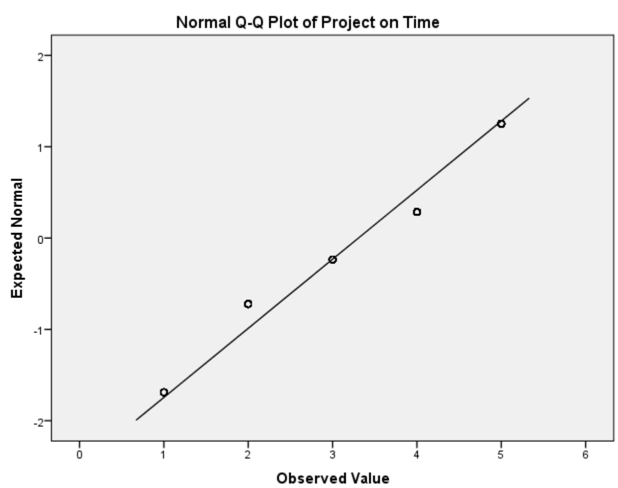
Time) variable, skewness was -0.341, 0.016, -0.234, and -0.294 for no PMCert, yes PMCert, no STEMDegree, and yes STEMDegree, respectively. As well, the Cost (Project on Budget), skewness was -0.504, 0.093, -0.293, and -0.537 for the above four categories, respectively. Skewness scores for the three DVs and four IV categories are between 1.0 and -1.0 indicating normal distribution (Mertler & Vannatta, 2013, p. 45). While overall skewness scores are near the normal distribution, kurtosis scores are not consistently normal ranging from -0.837 to -1.466. Table 6 shows the K-S tests with a non-normal result of $p < .001$ for each group. Field (2013) states "that if you have a large sample size then tests like K-S will lead you to conclude that even very minor deviations from normality are 'significant'" (p. 191).

Table 5. *K-S Normality Test*

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Dependent Variable	Statistic	df	Sig.	Statistic	df	Sig.
Project on Time	.267	284	.000	.855	284	.000
Project on Budget	.258	284	.000	.870	284	.000
Minor Scope Change	.261	284	.000	.860	284	.000

Q-Q plots and histograms for each DV show a near normal distribution in Figures 5 and 6, respectively. Also, MANOVA is robust regarding normality with sufficient cell sample sizes and provided the non-normality is not from outliers. With unequal sample sizes, only a few DVs, and a sample size of about 20 in the smallest cell, MANOVA is robust to violations of normality (Mertler & Vannatta, 2013, p. 124). The smallest cell in this sample is 25 per Table 5.





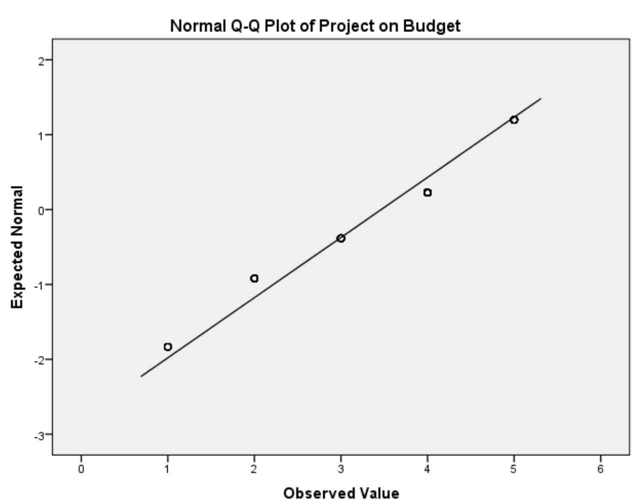


Figure 4. Q-Q Plots for Dependent Variables

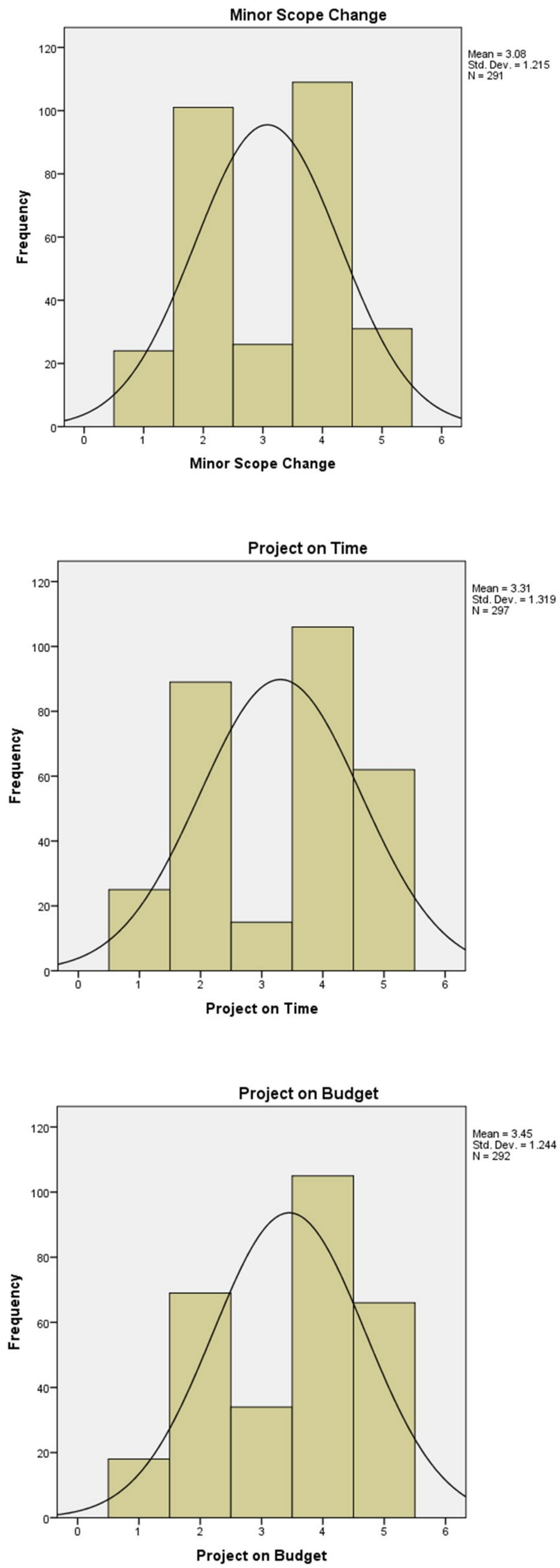


Figure 5. Histograms with Normal Plots for Dependent Variables

Linearity. For MANOVA, the researcher tested linearity between the DVs with Pearson *r* correlation coefficients. Pearson *r* was 0.418, 0.523, 0.765 significant a $p<0.01$ (2-tailed), for scope-schedule, scope-cost, and schedule-cost, respectively, as shown in Table 1. Overall the linear relationships were moderate.

Homoscedasticity. The researcher conducted a MANOVA homogeneity test with PMCert and STEMDegree as the IVs and Scope, Schedule, and Cost as DVs. Table 6 shows Box's Test of Equality of Covariance. With $F(18, 36864) = 0.904$, $p = .574$, equal variance can be assumed; therefore, the Wilks' Lambda will be used as the test statistic.

Table 6. *Box's Test of Equality of Covariance Matrices*[a]

Box's M	16.781
F	.904
df1	18
df2	36863.991
Sig.	.574

Note: Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.
[a]*Design: Intercept + PMCert + STEMDegree + PMCert * STEMDegree*

Hypothesis Testing

Factorial, two-way, MANOVA was used to test the null hypothesis that there is no statistically significant difference in scope, schedule, and cost performance comparing education type of STEM and non-STEM. MANOVA results indicate that Commercial PM Certification [Wilks' Lambda = .983, $F(3, 278) = 1.569$, p = .197, $\eta2 = .017$] do not significantly affect the combined DVs of scope, schedule, and cost. STEM undergraduate degree [Wilks' Lambda = .994, $F(3, 278) = .513$, p = .674, $\eta2 = .006$] do not significantly affect the combined DVs of scope, schedule, and cost. Interaction between PM certification and STEM Degree [Wilks' Lambda = .991, *F*(3, 278) = .846, p = .470, η2 = .009] do not significantly affect the combined DVs of scope, schedule, and cost. The researcher could not reject the null hypotheses. Table 7 shows the results of the multivariate tests.

Table 7. *Test Results from MANOVA*[a]

Effect	Test	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Wilks' Lambda	.137	583.324[b]	3.000	278.000	.000	.863
PMCert	Wilks' Lambda	.983	1.569[b]	3.000	278.000	.197	.017
STEMDegree	Wilks' Lambda	.994	.513[b]	3.000	278.000	.674	.006
PMCert * STEMDegree	Wilks' Lambda	.991	.846[b]	3.000	278.000	.470	.009

[a]*Design: Intercept + PMCert + STEMDegree + PMCert * STEMDegree*
[b]*Exact statistic*

To further address concerns of violations of the assumption of multivariate normality, the non-parametric Mann-Whitney post hoc test was conducted on the main effects. MANOVA provides the capability to test interactive effects; Mann-Whitney does not. While robust parametric tests such as MANOVA are preferable to non-parametric tests in testing hypotheses, non-parametric tests overcome problems with the normalcy of the distribution (Field, 2013). Non-parametric tests also overcome objections to the use of Likert scale survey data as interval data (Robertson, 2012) by ranking the data. Researchers can calculate the Effect size, *r*, by dividing the *z* score by the square root of the sample size (N) (Field, 2013).

The results in Tables 8 and 9 align with the MANOVA results that the null hypothesis must be accepted in each area, except for commercial PM Certification showing a significant relationship with cost in Table 11. Scope performance for IT PMs with STEM Degrees ($\bar{x}$ = 144.31) did not differ significantly from IT PMs without STEM Degrees ($\bar{x}$ = 140.50), U = 10,327.50, z = .412, p = .681, r = .024. Schedule performance for IT PMs with STEM Degrees ($\bar{x}$ = 144.62) did not differ significantly from IT PMs without STEM Degrees ($\bar{x}$ = 140.16), U = 10,373.00, z = .476, p = .634, r = .028. Cost performance for IT PMs with STEM Degrees ($\bar{x}$ = 150.03) did not differ significantly from IT PMs without STEM Degrees ($\bar{x}$ = 134.19), U = 11,180.00, z = 1.687, p = .092, r = .100.

Table 8. *Mann-Whitney Results for STEM Degree*

Null Hypothesis	Test	Sig.	Decision
The distribution of Project on Time is the same across categories of STEM Degree.	Independent-Samples Mann-Whitney U Test	.865	Retain the null hypothesis.
The distribution of Project on Budget is the same across categories of STEM Degree.	Independent-Samples Mann-Whitney U Test	.089	Retain the null hypothesis.
The distribution of Minor Scope Change is the same across categories of STEM Degree.	Independent-Samples Mann-Whitney U Test	.722	Retain the null hypothesis.

Note: Asymptotic significances are displayed. The significance level is .05.

Scope performance for IT PMs with commercial PM certifications ($\bar{x}$ = 134.20) did not differ significantly from IT PMs without commercial PM certifications ($\bar{x}$ = 144.91), U = 6,509.00, z = -.968, p = .333, r = .057. Schedule performance for IT PMs with commercial PM certifications ($\bar{x}$ = 126.84) did not differ significantly from IT PMs without commercial PM certifications ($\bar{x}$ = 147.05), U = 6,038.00, z = -1.808, p = .071, r = .107. Cost performance for IT PMs with commercial PM certifications ($\bar{x}$ = 124.54) did differ significantly from IT PMs without commercial PM certifications ($\bar{x}$ = 1470.72), U = 5,890.50, z = -2.065, p = .039, r = .123 as shown in Figure 7. While significant for cost performance, the effect size was small.

Table 9. *Mann-Whitney Results for Commercial PM Certification*

Null Hypothesis	Test	Sig.	Decision
The distribution of Project on Budget is the same across categories of Coml PM Certification.	Independent-Samples Mann-Whitney U Test	.039	Reject the null hypothesis.
The distribution of Minor Scope Change is the same across categories of Coml PM Certification.	Independent-Samples Mann-Whitney U Test	.333	Retain the null hypothesis.
The distribution of Project on Time is the same across categories of Coml PM Certification.	Independent-Samples Mann-Whitney U Test	.071	Retain the null hypothesis.

Note: Asymptotic significances are displayed. The significance level is .05.

Table 10. Detailed *Mann-Whitney Results for Commercial PM Certification*

Nomenclature	Result
Total N	284
Mann-Whitney U	5890.500
Wilcoxon W	7970.500
Test Statistic	5890.500
Standard Error	556.618
Standardized Test Statistic	-2.065
Asymptotic Sig. (2-sided test)	.039

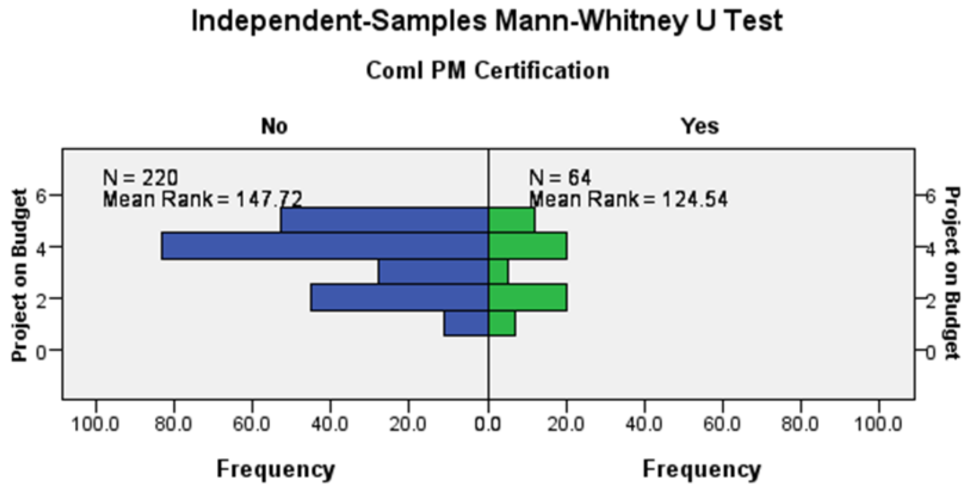


Figure 6. Detailed Mann-Whitney Results for PM Certification and Cost

Summary

This research was conducted to comprehend to what extent project management success in scope, schedule, and cost compare with project managers (PMs) with STEM and non-STEM education, PMs with a commercial certification and without a commercial certification, and to what extent interaction between education type (STEM and non-STEM) and commercial certification compare with project management success. The researcher did this by testing the omnibus null hypotheses that there is no statistically significant difference in scope, schedule, and cost performance comparing education type of STEM and non-STEM, commercial PM certification and no commercial PM certification, and education type of STEM and non-STEM and commercial PM certification interaction effect. The researcher collected the data using the DAU Opinio survey tool with 284 complete responses. SPSS version 24 was used to analyze the descriptive and inferential statistics. MANOVA was used to test the hypotheses and a post hoc, non-parametric Mann-Whitney test was conducted on the main effects to examine potential bias from a slight violation of normality by attempting to confirm the MANOVA results.

Three null hypotheses were tested using MANOVA. The results of the MANOVA, shown in Table 8, were that the researcher did not reject the three null hypotheses. The researcher conducted a Mann-Whitney post hoc on the main effects of hypotheses 1 and 2. Per the Mann-Whitney test of hypothesis, $H1_0$ showed no statistically significant difference in scope, schedule, and cost performance comparing education type of STEM and non-STEM. The Mann-Whitney test of hypothesis $H2_0$ demonstrated no statistically significant difference in scope and schedule performance comparing commercial PM certification and no commercial PM certification.

In the Mann-Whitney post hoc test, cost performance did show a statistically significant difference comparing commercial PM certification and no commercial PM certification. The difference would result in accepting the Hypothesis $H2_{A3}$ that there is a statistically significant difference in cost performance comparing commercial PM certification and no commercial PM certification.

The researcher will further examined the results in Chapter 5. The researcher will discuss the potentially conflicting results between the MANOVA test and Mann-Whitney post hoc test. Then the researcher will make recommendations for additional research.

CHAPTER 5. DISCUSSION, IMPLICATIONS, RECOMMENDATIONS

This quantitative research study expanded on the existing research on the relationship between IT PM commercial project management certifications, predominately PMP®, and project management success; and limited research on PM undergraduate technical education and project management success. No previous research was found examined the interactive effects of IT PM commercial certification and undergraduate STEM education and project management success. This quantitative, non-experimental, exploratory study aimed to add to the body of knowledge on the relationship between the constructs of project manager competence and project efficiency. Project efficiency was determined using the PSAQ developed by Shenhar and Dvir (2007b), and project manager competence was evaluated using demographic questions on training certification and education. The PSAQ is a well-established instrument with published reliability and validity information.

The sample was collected using an Internet-based DAU Opinio survey tool. The survey had 32 questions: 28 from the PSAQ instrument and four demographic questions. The researcher obtained the sample from the sample frame of a DAU list of the population of DoD Level III certified members of the IT PM community. The researcher administered the survey via an electronically signed email that contained a link to the Internet site with the DAU Opinio survey tool.

Responding to the recruitment email sent to the DoD IT PM population, 384 volunteer participants logged into the DAU Opinio survey web page. After reading the informed consent, 70 did not complete any or some portion of the survey recognizing the survey did not apply to them. Thirty more respondents failed to complete other parts of the instrument and were eliminated, leaving a sample of 284. The remainder of this chapter will include a summary of the results, discussion of the findings, conclusions, limitations, implications for practice, recommendations for further study, and the conclusion.

Summary of the Results

The business problem is the failure of project managers to deliver on scope, schedule, and cost, resulting in a high rate of IT project failure. The research problem statement is how a program manager's education type and training, as evidenced in project management related certifications, relates to project scope, schedule and cost performance on DoD IT projects. The researcher expressed the research problem in the following three omnibus research questions:

1. To what extent does project management success in scope, schedule, and cost compare with project managers (PMs) with STEM and non-STEM education?

Hypothesis $H1_0$: There is no statistically significant difference in scope, schedule, and cost performance comparing education type of STEM and non-STEM.

2. To what extent does project management success in scope, schedule, and cost compare with PMs with a commercial certification and without a commercial certification?

Hypothesis $H2_0$: There is no statistically significant difference in scope, schedule, cost performance comparing commercial PM certification and no commercial PM certification.

3. To what extent do interaction between education type (STEM and non-STEM) and commercial certification compare with project management success in scope, schedule, and cost performance?

Hypothesis $H3_0$: There is no statistically significant difference in education type of STEM and non-STEM and commercial PM certification interaction effect comparing scope, schedule, and cost performance.

(H_0: $\mu_1 = \mu_2 = \mu_3 \ldots = \mu_k$)

If one or more of the mean vectors differ significantly (H_a: $\boldsymbol{\mu}_n \neq \boldsymbol{\mu}_k$), then the alternative hypotheses will be tested, as appropriate (Mertler & Vannatta, 2013; Sekaran & Bougie, 2013).

The study will contribute to further understanding of the project manager's education and certification impact on project efficiency, thus expanding the project management body of knowledge on critical success factors (Darrell et al., 2010; Smith et al., 2011; Starkweather & Stevenson, 2011b; Sudhakar, 2013; Warren, 2014). A study of the project manager's education and certification gaps may lead to better selection criteria, education, and certification for IT project managers (Darrell et al., 2010; Whitney & Daniels, 2013). The critical success factor of project manager competence (Belassi & Tukel, 1996; Pinto & Slevin, 1989) expands on the original personnel and technical skills CSFs (Pinto & Slevin, 1987; Pinto & Slevin, 1988; Pinto & Slevin, 1989). The target audience for this study is IT project managers on DoD information technology projects.

The study has additional significance within DoD. The U.S. Congress and the Office of the Secretary of Defense for Acquisition and Sustainment are considering legislation and policy related to STEM education and commercial PM certification requirements for DoD PMs. The recent 2016 Program Management Improvement Accountability Act requires commercial PM certification for federal agencies with a partial exception for DoD.

We know that the leading project management professional training certification, PMP®, has not correlated to project efficiency in limited studies (Abu-rumman, 2014; Catanio et al., 2013; Nazeer & Marnewick, 2018; Robertson, 2015; Starkweather & Stevenson, 2011b). We do not know that IT project managers with a technical education positively impact project efficiency due to mixed results in the literature (Agrawal & Thite, 2006; Darrell et al., 2010; Dulaimi, 2005;

Kappelman et al., 2007; Karanja & Zaveri, 2012; Rehman et al., 2011; Smith et al., 2011). We do not know the possible interaction effects of education and certification on project efficiency.

The survey results were analyzed using factorial MANOVA and the non-parametric Mann-Whitney post hoc test. MANOVA tested all three null hypotheses to include the interactive effects of STEM education and commercial PM certification. The non-parametric Mann-Whitney post hoc test was used to confirm the MANOVA results for research questions 1 and 2 to address possible concerns of slight violations of the normality assumption due to kurtosis and concerns that researcher should view Likert scale data as rank data versus interval data.

MANOVA tests of hypothesis resulted in accepting all three null hypotheses that no relationship existed between STEM undergraduate education, commercial PM certification, nor interactive effects of the two with project efficiency of scope, schedule, and cost. The Post Hoc Mann-Whitney test of hypothesis for research questions 1 and 2 confirmed acceptance of Hypothesis $H1_0$ that no statistically significant difference exists in scope, schedule, and cost performance comparing education type of STEM and non-STEM. The Mann-Whitney test confirmed Hypothesis $H2_0$ that no statistically significant difference exists in scope and schedule performance comparing commercial PM certification and no commercial PM certification. The Mann-Whitney test did find a statistically significant difference in cost performance comparing commercial PM certification and no commercial PM certification.

Discussion of the Results

The confirmation of the null hypothesis $H1_0$ that no relationship exists between IT PM undergraduate STEM degree and project efficiency was unexpected. The research showed mixed results for the impact of technical training and education on project efficiency. Dulaimi

(2005) suggests that project managers with a technical background may pay too much attention to the technical aspects of the project and neglect critical soft skill requirements. Other studies found project management soft skills more pertinent to project success than technical skills (Agrawal & Thite, 2006; Darrell et al., 2010; Kappelman et al., 2007). Alternatively, Ropponen and Lyytinen (2000) identified a relationship between a project manager's level of education in computing and the ability to manage project efficiency risk.

The expected result for hypothesis $H2_0$ that no relationship exists between an IT PM possessing a commercial PM certification and project efficiency was a failure to reject the null hypothesis. This result aligned with previous quantitative studies that failed to discover a relationship between a PM earning a commercial certification and improved project efficiency (Abu-rumman, 2014; Catanio et al., 2013; Robertson, 2015; Starkweather & Stevenson, 2011). In a recent study, Nazeer and Marnewick (2018) revealed that project management certification does not influence project efficiency in research of South African IT projects.

For the main effects, a non-parametric Mann-Whitney was conducted to address potential bias over a slightly non-normal distribution related to kurtosis. MANOVA is robust to non-normal distributions, provided those violations are not a result of outliers (Field, 2013). The Mann-Whitney tests are not dependent on MANOVA assumptions and overcome concerns over using Likert scale data as interval data (Robertson, 2015), converting data to rank data. Similarly, Müller, Geraldi, and Turner (2012) used the Mann-Whitney test as a post hoc test to an Analysis of Variance in addressing concerns over low group size.

The Mann-Whitney test confirmed the MANOVA results for both main effect hypotheses, $H1_0$ and $H2_0$, for each area except one. In the Mann-Whitney test, cost performance did show a statistically significant difference comparing commercial PM certification and no commercial PM certification. The result showing the cost performance mean for IT PMs with commercial PM certifications ($\bar{x}$ = 124.54) differed significantly from IT PMs without commercial PM certifications ($\bar{x}$ = 1470.72), U = 5,890.50, z = -2.065, p = .039, r = .123 is misleading when considering the size of the sample (N=284). This result indicates that project managers with a commercial PM certification had worse cost performance; however, the test becomes significant at p<.05, very close to the cutoff point. Additionally, the effect size r = .123 is small. With the large sample size for this study, the statistical power (1-β) is 0.99; the test becomes more powerful in detecting relationships. Powerful test errors are more likely to be false positives (Vogt, 2007, p. 142), particularly with the significance is marginal with a small effect (Field, 2013; Mertler & Vannatta, 2013; Vogt, 2007). For this reason, the Mann-Whitney result does not invalidate the MANOVA result that $H1_0$ and $H2_0$ should be accepted. The Mann-Whitney test could not examine the interactive effects of hypothesis $H3_0$.

Previous studies have not examined the interactive effects of combining a STEM education with a commercial project management certification. The study found no statistically significant difference in education type of STEM and non-STEM and commercial PM certification interaction effect comparing scope, schedule, and cost performance. The MANOVA test examined each of the four combinations of undergraduate education type of STEM and non-STEM with or without a commercial PM certification. No interactive combination shows significant mean vector variance for cost, schedule, or performance.

Conclusions Based on the Results

For the first research question, the study found no significant difference in project management success in scope, schedule, and cost for PMs with STEM and non-STEM undergraduate education. While the research is mixed, the expected result of $H1_0$ was to reject the null hypothesis. Several studies in the literature emphasized the importance of technical skill for project management success (Brill et al., 2006; Dubois et al., 2015; Niederman et al., 2016; Oak & Laghate, 2016). Due to the findings in this study and the mixed results in previous research, hiring managers and project sponsors should remain open to hiring IT PMs with both STEM and non-STEM degrees. IT PMs should pursue balanced education and training between hard technical skills and project management soft skills. Whitney and Daniels (2013) found that IT project failure is more linked to soft skills failure than technical issues, valuing project leadership soft skills over education and technical expertise. Ropponen and Lyytinen (2000) identified a positive relationship between a project manager's increased technical training and the ability to manage cost and schedule project risk. In a study of engineering student experiencing project management training, Ballesteros-Sanchez, Ortiz-Marcos, and Rodrigues-Rivero (2017) did not find a significant correlation between soft and hard skills for engineering students during the training experience as project managers. Several studies examine the value of adding project management training for engineers managing projects (Ballesteros-Sanchez et al., 2017; Cicmil & Gaggiotti, 2018; Darrell et al., 2010; Dulaimi, 2005). The results of this study suggest a reexamination of viewing a technical degree as an assumed prerequisite to assignment and training as an IT project manager.

As expected, the study found no link between a commercial PM certification and project efficiency resulting in accepting hypothesis $H2_0$. The study confirms the findings of previous quantitative studies (Abu-rumman, 2014; Catanio et al., 2013; Nazeer & Marnewick, 2018; Quan & Cha, 2010; Robertson, 2015; Starkweather & Stevenson, 2011b). Blomquist, Farashah, and Thomas (2018) found that voluntary project management certifications benefit potential employees looking to impress prospective employers than improving project efficiency. Other qualitative studies suggest earning a commercial project management certification helps the career progression of an IT PM by demonstrating dedication to the trade (Armstrong, 2015; Baird & Riggins, 2012; Dubois et al., 2015; Nicholas & Hidding, 2010; Rivera-Ruiz & Ferrer-Moreno, 2015). This study adds to the growing body of evidence that commercial PM certifications do not impact project efficiency.

Limitations

IT PMs manage IT projects in the public and private sector around the globe; however, this study focused on public sector IT PMs in the U.S. Department of Defense. External validity needed to generalize the finding to the general IT PM population in various countries for both the public and private sector is limited. Other limitations of this study included the ordinary subjectivity associated with surveys and mono-source bias (Conway & Lance, 2010; Podsakoff et al., 2003). The use of Likert scale survey data for parametric statistical analysis requiring interval or ratio data, while widely accepted, remains controversial (Field, 2013; Robertson, 2015; Vogt, 2007).

The study population was DoD IT PMs who had completed Level III Defense Acquisition Workforce certification. For DoD IT PMs, the Defense certification is a prerequisite for selection as an IT PM on a Defense IT project. In examining the relationship of commercial PM certification and project efficiency, the DoD certified population removed possible error with differing levels of DoD certification training; however, this potentially resulted in evaluating the incremental impact of a commercial PM certification over having a DoD certification. The relationship could limit the external validity of the study.

Finally, the study did not directly examine the experience of the DoD IT PM population. Catanio, Armstrong, and Tucker (2013) did not find a significant relationship between IT PM experience and project efficiency; however, several other studies found a connection between PM experience and project efficiency (Frey, 2013; Müller & Turner, 2010; Ropponen & Lyytinen, 2000; Standish Group, 2013). This possible limitation is mitigated by examining DoD certified IT PMs. DoD Level III certification requires a minimum of four years' experience in the field (DAU, 2018).

Implications for Practice

This study suggests that organizations should recruit project managers with either a STEM or non-STEM degree. Growing evidence shows the need to balance technical and leadership soft skills in project managers for project management success (Cicmil & Gaggiotti, 2018). Requiring a technical education as a prerequisite to becoming a project manager, as suggested by Pandya (2014), may not yield better project outcomes. The study found no significant difference comparing a project manager's education type (STEM vs. non-STEM) and project efficiency. While current research suggested education and training balance technical and non-technical skills (Ballesteros-Sanchez et al., 2017; Cicmil & Gaggiotti, 2018; Niederman et al., 2016), researchers found the non-technical, project management skills more critical (Briner, Geddes, & Hastings, 1990; Kappelman et al., 2007; Serrador & Turner, 2015; Toor & Ogunlana, 2010) At a minimum, organization should reconsider setting the lesser important technical background as a prerequisite for managing an IT project.

This research contributes to the body of knowledge on the relationship of technical, STEM education to IT project efficiency. Research on the impact of technological education on the project manager's performance provided mixed results. This research suggests a reexamination of the practice selecting project managers based on a STEM degree, then providing project management training (Cicmil & Gaggiotti, 2018; Pandya, 2014; Ropponen &

Lyytinen, 2000;). Findings from this research, combined with previous studies, could assist organizations in selecting and training project managers, leading to improved project outcomes (Müller & Turner, 2010; Mir & Pinnington, 2013; Serrador & Turner, 2015).

This study recommends that organizations seeking to improve IT project efficiency should not depend on having their project managers attain commercial PM certification, as the benefits balance tilts more toward the individual's career than IT project efficiency. PM certifications validate general knowledge in the field of project management. Industry and organizational specific project management training on the temporal and contextual application of CSF is required to improve IT project outcomes (Pinto & Prescott, 1988; Pinto & Slevin, 1989; Shenhar et al., 1997). This study contributes to the project management body of knowledge by adding to the growing research refuting the positive impact of commercial PM certification on IT project outcomes (Abu-rumman, 2014; Blomquist et al., 2018; Catanio et al., 2013; Nazeer & Marnewick, 2018; Quan & Cha, 2010; Robertson, 2015; Starkweather & Stevenson, 2011b).

Voluntary commercial PM certifications do have value for the individual PM interested in career advancement. Project managers demonstrate a commitment to the project management field by voluntarily pursuing and achieving a PM certification (Baird & Riggins, 2012; Dubois et al., 2015; Rivera-Ruiz & Ferrer-Moreno, 2015). Successful project managers continue "to improve themselves over the course of their careers" (Marion et al., 2014, p. 60). Compulsory commercial PM certification eliminates the benefit to the organization of identifying potentially successful IT PMs who pursue certification. Organizations should support the voluntary pursuit of commercial PM certifications by project manager candidates versus requiring commercial certification. Commercial PM certification has value in identifying the project manager's dedication to the guild; however, PM certification provides insufficient evidence of the PM training required to improve project management success.

Recent legislation requires federal agencies to adopt commercial project management certification for the federal project managers (Program Management Improvement Accountability Act, 2016). While the legislation exempted DoD from some components of the legislation, the results of this study could inform the discussion about the merits of commercial project management certifications for DoD IT project managers. DoD leaders should refrain from enacting policy making commercial PM certification mandatory until more studies expand on this exploratory research.

This study contributed initial work to the knowledge gap of the interactive effects of IT PM education and training on project management outcomes. The study found no relationship between the interactive effects of STEM education and commercial PM certification. Catanio et al. (2013), in research on the relationship between PM certification, experience, and project efficiency, noted the need to study PM competence factor combinations to help measure the effectiveness of IT PMs. This exploratory study suggests organizational executives and chief information officers sponsor more research on the interactive effects of IT PM education and training in order to achieve the appropriate balance of soft and hard skills' education and training for the IT PM workforce.

Knowledge of IT PM education and training certification impact on DoD IT project outcomes contributes to the ongoing dialogue regarding legislation and policy for PM education and training (Defense Acquisition University Structure Act, 1990; Program Management Improvement Accountability Act, 2016). Recent research recommends changing current IT PM education and training certification to adopt a new approach that balances hard and soft skills' competencies for IT project managers, in order to improve project efficiency (Nazeer & Marnewick, 2018). Additionally, this research contributed to the body of knowledge on appropriate critical success factor of project manager competence, project schedule/plan, technical tasks, and personnel (Pinto & Slevin, 1987; Pinto & Slevin, 1989) for selecting and training IT project managers (Ahsan et al., 2013; Mazur et al., 2014). OSD acquisition executives could benefit from sponsoring continued academic research on IT PM education and training to inform future legislation and policy.

Recommendations for Further Research

This study began the exploration of interactive effects of PM competence critical success factors. While significant research exists on the various critical success factors contributing to PM competence, the project management community needs more research on the interactive effects of those factors on project success. Research needs to be expanded across several PM competence critical success factors in multiple contexts to include various industries, plus both public and private sector projects. The researcher recommends examination of the interactive effects of technical, hard skills training and leadership, soft skills training as a specific focus for future exploration of PM competence.

The researcher recommends further research on DoD IT PM competencies' relationship to project efficiency using secondary data to overcome limitations associated with survey data. The DoD collects significant data on IT program and project performance and associated PM education, training, and experience (Kendall et al., 2015). Granting DoD researchers access to the available data would expand the statistical methods available for analysis thus improving study validity.

In very recent research, Nazeer and Marnewick (2018) suggested more research on the approach to training and certification of IT PMs. Blomquist, Farashah, and Thomas (2018) suggested more research on the organizational impact of IT PM education and certification. This research aligns to the need for future research outlined in these recent studies (Garel, 2013).

Conclusion

A consistent, long-standing problem has been the failure of many IT projects to deliver on scope, schedule, and cost (Bloch et al., 2012; Brooks, 1974; Standish Group, 2013; Standish Group, 2015). As the IT PM is ultimately responsible for the project management success of the project, it is appropriate to study the critical success factors contributing to IT PM competence.

This exploratory, quantitative study examined the independent and interactive relationship between STEM education and commercial PM certification and project efficiency represented by scope, schedule, and cost. The study data was gathered using an Internet-based DAU Opinio survey tool administered by the researcher; survey results were analyzed using SPSS version 24. Of the 384 respondents who logged into the Opinio survey site, 284 completed the survey, which well exceeded the 98 sample minimum. The Cronbach alpha for the three dependent scale variables in the research was 0.803 on the PSAQ questionnaire indicating reliable results.

The study focused on three omnibus research questions, represented by three hypotheses, tested using MANOA. Hypothesis $H1_0$ showed no statistically significant difference in scope, schedule, and cost performance comparing education type of STEM and non-STEM. Hypothesis $H2_0$ specified no statistically significant difference in scope, schedule, cost performance comparing commercial PM certification and no commercial PM certification. Hypothesis $H3_0$ stated no statistically significant difference existed in education type (STEM and non-STEM) and commercial PM certification interactive effect comparing scope, schedule, and cost performance (H_0: $\boldsymbol{\mu}_1 = \boldsymbol{\mu}_2 = \boldsymbol{\mu}_3 \ldots = \boldsymbol{\mu}_k$). The study found no statistically significant relationship between IT PM STEM education and commercial PM certification and project efficiency to include the interactive effects of STEM education and PM certification on project efficiency, thus accepting all three null hypotheses.

Several research opportunities arose based on the study findings. A follow-up study of DoD IT PM education and training certification relationship to project efficiency using DoD secondary data would add great validity to this exploratory study. More studies on the interactive effects of various IT PM competencies are needed. Also, the researcher recommends additional research on the overall approach to education and training requirements for IT PMs.

REFERENCES

Abu-rumman, A. (2014). Prince or pauper? Does project management certification really matter? *PM World Journal, 3*(4), 1-7.

Adolph, S., Kruchten, P., & Hall, W. (2012). Reconciling perspectives: A grounded theory of how people manage the process of software development. *Journal of Systems and Software*, *85*(6), 1269-1286.

Agrawal, N., & Thite, M. (2006). Nature and importance of soft skills in software project leaders. *Asia Pacific Management Review, 11*(2), 93-102.

Ahimbisibwe, A., Cavana, R. Y., & Daellenbach, U. (2015). A contingency fit model of critical success factors for software development projects. *Journal of Enterprise Information Management, 28*(1), 7-33.

Ahmed, R., & bin Mohamad, N. A. (2016). Exploring the relationship between multi-dimensional top management support and project success: An international study. *Engineering Management Journal, 28*(1), 54-67.

Ahsan, K., Ho, M., & Khan, S. (2013). Recruiting project managers: A comparative analysis of competencies and recruitment signals from job advertisements. *Project Management Journal*, *44*(5), 36-54.

Aramo-Immonen, H., Koskinen, K. U., & Porkka, P. L. (2011). The significance of formal training in project-based companies. *International Journal of Managing Projects in Business*, *4*(2), 257-273.

Aronin, B., Bailey, J., Byun, J., Davis, G., & Wolfe, C. (2011). Expeditionary combat support system: Root cause analysis. *Institute for Defense Analysis*. Retrieved from http://www.acq.osd.mil/parca/docs/2011-ida-rca-ecss-p-4732.pdf

Armstrong, A. (2015). *The value of project management certification in achieving project success -- A qualitative study* (Doctoral Dissertation). Retrieved from ProQuest Dissertations & Theses Global. (1708991227).

Atkinson, R., Crawford, L., & Ward, S. (2006). Fundamental uncertainties in projects and the scope of project management. *International Journal of Project Management*, *24*(8), 687-698. doi: 10.1016/j.ijproman.2006.09.011

Avots, I. (1969). Why does project management fail? *California Management Review (Pre-1986), 12*(000001), 77-82.

Baird, A., & Riggins, F. J. (2012). Planning and sprinting: Use of a hybrid project management methodology within a CIS capstone course. *Journal of Information Systems Education*, *23*(3), 243-257.

Ballesteros-Sanchez, L., Ortiz-Marcos, I., & Rodrigues-Rivero, R. (2017). Project management training: An integrative approach for strengthening the soft skills of engineering students. *International Journal of Engineering Education, 33*(6), 1912-1926.

Barki, H., Rivard, S., & Talbot, J. (1993). Toward an assessment of software development risk. *Journal of Management Information Systems*, *10*(2), 203-225.

Batra, D., Xia, W., VanderMeer, D., & Dutta, K. (2010). Balancing agile and structured development approaches to successfully manage large distributed software projects: A case study from the cruise line industry. *Communications of the Association for Information Systems*, *27*(21), 379-394.

Beck, K., Beedle, M., van Bennekum, A., Cockbum, A., Cunningham, W., Fowler, M., … Thomas, D. (2001). *Agile manifesto.* Retrieved from http://agilemanifesto.org

Bernier, C., Dubé, L., & Roy, V. (2012). An agile method, a contractual relationship, and distance: A triad of challenging conditions for a successful system development project. *Journal of IT Case and Application Research*, *14*(4), 30-56.

Belassi, W., & Tukel, O. I. (1996). A new framework for determining critical success/failure factors in projects. *International Journal of Project Management, 14*(3), 141-152.

Bloch, M., Blumberg, S., & Laartz, J. (2012). Delivering large-scale IT projects on time, on budget, and on value. *McKinsey Quarterly-October*, 1-6.

Blomquist, T., Farashah, A. D., & Thomas, J. (2018). Feeling good, being good and looking good: Motivations for, and benefits from, project management certification. *International Journal of Project Management, 36*(3), 498-511. doi: 10.1016/j.ijproman.2017.11.006

Blomquist, T., & Thomas, J. (2004). Project manager's perceptions of the motivation for, and benefits, of certification. *IRNOP VI Conference, Turku, Finland*.

Bredillet, C. (2010). Blowing hot and cold on project management. *Project Management Journal, 41*(3), 4-20. doi: 10.1002/pmj.20179

Brill, J. M., Bishop, M. J., & Walker, A. E. (2006). The competencies and characteristics required of an effective project manager: A web-based Delphi study. *Educational technology research and development*, *54*(2), 115-140.

Brooks, F., Jr. (1974). The mythical man month. *Datamation. 20*(12), 44-52.

Bullen, C. V., & Rockart, J. F. (1981). A primer on critical success factors. Cambridge, MA: Center for Information Systems Research. doi: 10.1.1.465.3321

Carvalho, M. D., & Rabechini, R., Jr. (2015). Impact of risk management on project performance: The importance of soft skills. *International Journal of Production Research*, *53*(2), 321-340. doi:10.1080/00207543.2014.919423

Catanio, J., Armstrong, G., & Tucker, J. (2013). The effects of project management certification on the triple constraint. *International Journal of Information Technology Project Management (IJITPM), 4*(4), 93-111. doi:10.4018/ijitpm.2013100106

Chen, T. Y. (1999). Critical success factors for various strategies in the banking industry. *International Journal of Bank Marketing*, *17*(2), 83-92.

Cicmil, S. & Gaggiotti, H. (2018). Responsible forms of project management education: Theoretical plurality and reflective pedagogies. *International Journal of Project Management 36*(1), 208-218. doi: 10.1016/j.ijproman.2017.07.005

Cicmil, S., Williams, T., Thomas, J., & Hodgson, D. (2006). Rethinking project management: Researching the actuality of projects. *International Journal of Project Management*, *24*(8), 675-686.

Coleman, R. (2014). *The relationship between project managers' competence, professional experience, and education on career success: A correlation study*. Available from ProQuest Dissertations & Theses Global. (1629445103).

Conway, J. M., & Lance, C. E. (2010). What reviewers should expect from authors regarding common method bias in organizational research. *Journal of Business and Psychology, 25*(3), 325-334. doi: 10.1007/s10869-010-9181-6

Cooke-Davies, T. (2002). The "real" success factors on projects. *International Journal of Project Management*, *20*(3), 185-190.

Crotty, M. (1998). *The foundations of social research: Meaning and perspective in the research process*. London: Sage Publications.

Cserhati, G., & Szabo, L. (2014). The relationship between success criteria and success factors in organisational event projects. *International Journal of Project Management*, *32*(4), 613-624.

Daniel, D. (1961). Management information crisis. *Harvard Business Review,* 111-121.

Darrell, V., Baccarini, D., & Love, P. (2010). Demystifying the folklore of the accidental project manager in the public sector. *Project Management Journal, 41*(5), 56-63. doi: 10.1002/pmj.20164

Defense Acquisition University (2018). Information technology and program management. *Defense Acquisition University Defense Functional Area Gateways.* Retrieved from https://www.dau.mil/training/career-development

Defense Acquisition University Structure Act of 1990, 10 U.S.C. § 1746 (1990). Retrieved from https://www.gpo.gov/fdsys/pkg/USCODE-2006-title10/pdf/USCODE-2006-title10-subtitleA-partII-chap87-subchapIV-sec1746.pdf

Dubois, M., Hanlon, J., Koch, J., Nyatuga, B., Kerr, N. (2015). Leadership styles of effective project managers: Techniques and traits to lead high performance teams. *Journal of Economic Development, Management, IT, Finance and Marketing, 7*(1), 30-46.

Dubey, S. J. (2011). Key success factors in software development projects. *SSRN Electronic Journal,* 1-10. doi: 10.2139/ssrn.1952935

Dulaimi, M. (2005). The influence of academic and formal training on the project manager's behavior. *Journal of Construction Research. 6*(1), 179-193.

Dvir, D., & Shenhar, A. (1992). Measuring the success of technology-based strategic business units. *Engineering Management Journal*, *4*(4), 33-38.

Emam, K., & Koru, A. (2008). A replicated survey of IT software project failures. *IEEE Software, 25*(5), 84-90.

Ewusi-Mensah, K. (1997). Critical issues in abandoned information system development projects. *Communications of the ACM*, *40*(9), 74-80.

Field, A. (2013). *Discovering statistics using IBM SPSS statistics* (4th ed.). Thousand Oaks, CA: Sage.

Frey, C. (2013). *Perception of success in information technology projects from the perspective of the project manager*. Available from ProQuest Dissertations & Theses Global. (1431540451)

Garel, G. (2013). A history of project management models: From pre-models to the standard models. *International Journal of Project Management, 31*(5), 663-669. doi: 10.1016/j.ijproman.2012.12.011

Hagen, M., & Park, S. (2013). Ambiguity acceptance as a function of project management: A new critical success factor. *Project Management Journal*, *44*(2), 52-66.

Hanisch, B., & Wald, A. (2012). A bibliometric view on the use of contingency theory in project management research. *Project Management Journal*, *43*(3), 4-23. doi: 10.1002/pmj.21267

Jethani, K. (2013). Software metrics for effective project management. *International Journal of System Assurance Engineering and Management*, *4*(4), 335-340.

Kappelman, L., McKeeman, R., & Zhang, L. (2007). Early warning signs of IT project failure: The dominant dozen. *Information Systems Management, 23*(4), 31-36.

Karanja, E., & Zaveri, J. (2012). IT leaders: Who are they and where did they come from? *Journal of Information Systems Education. 23*(2). 143-163.

Kendall, F., Gilmore, J., & Halvorsen, T. (2015). Operation of the defense acquisition system. *Department of Defense Instruction 5000.02*.

Kiridena, S., & Sense, A. (2017). Profiling project complexity: Insights from complexity science and project management literature. *Project Management Journal*, *47*(6), 56-74.

Kloppenborg, T. J., & Opfer, W. A. (2002). The current state of project management research: Trends, interpretations, and predictions. *Project Management Journal*, *33*(2), 5-17.

Marion, J. W., Richardson, T. M., & Earnhardt, M. P. (2014). Project manager insights: An analysis of career progression. *Organisational Project Management*, *1*(1), 53-73.

Mazur, A., Pisarski, A., Chang, A., & Ashkanasy, N. M. (2014). Rating defence major project success: The role of personal attributes and stakeholder relationships. *International Journal of Project Management*, *32*(6), 944-957.

Mertler, C. & Vannatta, R. (2013). *Advanced and multivariate statistical methods* (5th ed.). New York, NY: Routledge.

Mir, F. A., & Pinnington, A. H. (2014). Exploring the value of project management: Linking project management performance and project success. *International Journal of Project Management, 32*(2), 202-217. doi: 10.1016/j.ijproman.2013.05.012

Müller, R., Geraldi, J., & Turner, J. R. (2012). Relationships between leadership and success in different types of project complexities. *IEEE Transactions on Engineering Management*, *59*(1), 77–90. doi: 10.1109/tem.2011.2114350

Müller, R., & Jugdev, K. (2012). Critical success factors in projects. *International Journal of Managing Projects in Business, 5*(4), 757-775. doi: 10.1108/17538371211269040

Müller, R. & Turner, J. R. (2010). *Project-oriented leadership.* Burlington, VT: Gower Publishing Limited.

Nazeer, J. & Marnewick, C. (2018). Investing in project management certification: Do organisations get their money's worth? *Information Technology and Management, 19*(1), 51-74.

Nicholas, J., & Hidding, G. (2010). Management principles associated with IT project success. *International Journal of Management & Information Systems (Online)*, *14*(5), 147-156.

Niederman, F., Ferratt, T. W., & Trauth, E. M. (2016). On the co-evolution of information technology and information systems personnel. *ACM SIGMIS Database*, *47*(1), 29-50.

Oak, V. J., & Laghate, K. (2016). Analysis of project management issues in information technology industry: An overview of literature. *International Journal of System Assurance Engineering and Management*, *7*(4), 418-426.

Ojiako, U., Johansen, E., & Greenwood, D. (2008). A qualitative re-construction of project measurement criteria. *Industrial Management & Data Systems*, 108(3), 405-417. doi: 10.1108/02635570810858796

Onwuegbuzie, A., & Collins, K. (2007). A typology of mixed methods sampling designs in social science research. *The Qualitative Report, 12*(2), 281-316.

Pandya, K. (2014). The key competencies of project leader beyond the essential technical capabilities. *IUP Journal of Knowledge Management, 12*(4), 39-48.

Pant, I., & Baroudi, B. (2008). Project management education: The human skills imperative. *International Journal of Project Management*, *26*(2), 124-128.

Pinto, J. K., & Mantel, S. J. J. (1990). The causes of project failure. *IEEE Transactions on Engineering Management, 37*(4), 269-277.

Pinto, J. K., & Prescott, J. E. (1988). Variations in critical success factors over the stages in the project life cycle. *Journal of Management, 14*(1), 5-18.

Pinto, J. K., & Slevin, D. P. (1987). The critical factors in successful project implementation. *IEEE Transactions on Engineering Management, 34*(1), 22-28.

Pinto, J. K., & Slevin, D. P. (1988). Critical success factors across the project life cycle. *Project Management Journal, 19*(3), 67-75.

Pinto, J. K., & Slevin, D. P. (1989). Critical success factors in R&D projects. *Research-technology management*, *32*(1), 31-35.

Podsakoff, P. M., MacKenzie, S. B., Lee, J., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, *88*(5), 879-903. doi: 10.1037/0021-9010.88.5.879

Pollack, J. (2007). The changing paradigms of project management. *International Journal of Project Management*, *25*(3), 266-274. doi: 10.1016/j.ijproman.2006.08.002

Program Management Improvement Accountability Act of 2016, 31 U.S.C. § 503. (2016). Retrieved from https://www.congress.gov/bill/114th-congress/senate-bill/1550

Project Management Institute. (2013). *A guide to the project management body of knowledge*. (5th Ed.) Newtown Square, PA: Project Management Institute.

Quan, J., & Cha, H. (2010). IT certifications, outsourcing and information systems personnel turnover. *Information Technology & People, 23*(4), 330-351. doi: 10.1108/09593841011087798

Ramazani, J., & Jergeas, G. (2015). Project managers and the journey from good to great: The benefits of investment in project management training and education. *International Journal of Project Management, 33*(1), 41–52.

Rehman, A. U., Khan, A. M., & Khan, R. A. (2011). Measuring training effectiveness: A case study of public sector project management in Pakistan. *Journal of Diversity Management (JDM)*, *6*(1), 39-48.

Rezvani, A., Chang, A., Wiewiora, A., Ashkanasy, N. M., Jordan, P. J., & Zolin, R. (2016). Manager emotional intelligence and project success: The mediating role of job satisfaction and trust. *International Journal of Project Management*, *34*(7), 1112-1122.

Rivera-Ruiz, I., & Ferrer-Moreno, E. (2015). The relationship between strategic leadership, human IT infrastructure, project management, project success, and firm performance. *International Journal of Information, Business and Management, 7*(2). 77-84.

Rockart, J. F. (1979). Chief executives define their own data needs. *Harvard Business Review, 57*(2), 81-93.

Robertson, J. [Judy]. (2012). Likert-type scales, statistical methods, and effect sizes. *Communications of the ACM*, *55*(5), 6-7. doi:10.1145/2160718.2160721

Robertson, J. [Jenifer]. (2015). *The relationship between project management professional certification and project health*. Available from ProQuest Dissertations & Theses Global. (1729577955)

Ropponen, J., & Lyytinen, K. (2000). Components of software development risk: How to address them? A project manager survey. *IEEE Transactions on Software Engineering, 26*(2), 98-112. doi: 10.1109/32.841112

Savolainen, P., Ahonen, J. J., & Richardson, I. (2012). Software development project success and failure from the supplier's perspective: A systematic literature review. *International Journal of Project Management*, *30*(4), 458-469.

Saynisch, M. (2010). Beyond frontiers of traditional project management: An approach to evolutionary, self-organizational principles and the complexity theory—results of the research program. *Project Management Journal*, *41*(2), 21-37. doi: 10.1002/pmj.20159

Sekaran, U., & Bougie, R. (2013). *Research methods for business: A skill-building approach* (6th Ed.) Chichester, England: Wiley.

Serrador, P., & Turner, R. (2015). The relationship between project success and project efficiency. *Project Management Journal, 46*(1), 30-39. doi: 10.1002/pmj.21468

Sewchurran, K., Smith, D., & Roode, D. (2010). Toward a regional ontology for information systems project management. *International Journal of Managing Projects in Business. 3*(4), 681-692. doi: 10.1108/17538371011076118

Shackman, G. (2015). Accreditation, certification, credentialing: Does it help? *New Directions for Evaluation*, *2015*(145), 103-113. doi: 10.1002/ev.20114

Shenhar, A. J. & Dvir, D. (1996). Toward a typological theory of project management. *Research Policy, 25*(4), 607-632.

Shenhar, A. J., & Dvir, D. (2007a). Project management research—The challenge and opportunity. *Project Management Journal*, *38*(2), 93-99.

Shenhar, A. J. & Dvir, D. (2007b). *Reinventing project management: The diamond approach to successful growth and innovation*. Boston, Massachusetts: Harvard Business School Press Books.

Shenhar, A. J., Dvir, D., Levy, O., & Maltz, A. C. (2001). Project success: A multidimensional strategic concept. *Long range planning*, *34*(6), 699-725.

Shenhar, A. J., Levy, O. & Dvir, D. (1997). Mapping the dimensions of project success. *Project Management Journal, 28* (2), 5-13.

Shenhar, A., Tishler, A., Dvir, D., Lipovetsky, S. & Lechler, T. (2002). Refining the search for project success factors: A multivariate, typological approach. *R&D Management, 32*(2), 111-126.

Slevin, D. P., & Pinto, J. K. (1986). The project implementation profile. *Project Management Journal*, *17*(4), 57-70.

Smith, D., Bruyns, M, & Evan, S. (2011). A project manager's optimism and stress management and IT project success. *International Journal of Managing Projects in Business, 4*(1), 10-27. doi: 10.1108/17538371111096863

Smyth, H., & Morris, P. (2007). An epistemological evaluation of research into projects and their management: Methodological issues. *International Journal of Project Management, 25*(4), 423-436. doi: 10.1016/j.ijproman.2007.01.006

Söderlund, J. (2011). Pluralism in project management: Navigating the crossroads of specialization and fragmentation. *International Journal of Management Reviews*, *13*(2), 153-176. doi: 10.1111/j.1468-2370.2010.00290.x

Standish Group International, Inc. (2013). Chaos manifesto 2013. Retrieved from http://www.versionone.com/ assets/img/files/ChaosManifesto2013.pdf

Standish Group. (2015). 2015 CHAOS report. Retrieved from https://www.standishgroup.com/store/services/chaos-report-2015-blue-pm2go-membership.html

Starkweather, J. A., & Stevenson, D. H. (2011a). IT hiring criteria vs. valued IT competencies. In *Managing IT Human Resources: Considerations for Organizations and Personnel* (pp. 66-81). IGI Global. doi: 10.4018/978-1-60960-535-3.ch006

Starkweather, J., & Stevenson, D. (2011b). PMP® certification as a core competency: Necessary but not sufficient. *Project Management Journal, 42*(1), 31-41. doi: 10.1002/pmj.20174

Stevenson, D. H., & Starkweather, J. A. (2010). PM critical competency index: IT execs prefer soft skills. *International Journal of Project Management*, *28*(7), 663-671.

Sudhakar, G. P. (2013). A review of critical success factors for offshore software development projects. *Organizacija, 46*(6), 282-296. doi: 10.2478/orga-2013-0026

Svejvig, P., & Andersen, P. (2015). Rethinking project management: A structured literature review with a critical look at the brave new world. *International Journal of Project Management, 33*(2), 278-291.

Tesch, D., Kloppenborg, T., & Stemmer, J. (2003). Project management learning: What the literature has to say. *Project Management Journal*, *34*(4), 33-39.

Toor, S., & Ogunlana, S. (2010). Beyond the "iron triangle": Stakeholder perception of key performance indicators (KPIs) for large-scale public sector development projects. *International Journal of Project Management, 28*(3), 228-236.

Udechukwu, O., Chipulu, M., Marshall, A., Ashleigh, M. J., & Williams, T. (2015). Project management learning: A comparative study between engineering students' experiences in

South Africa and the United Kingdom. *Project Management Journal*, *46*(4), 47-62. doi:10.1002/pmj.21510

U.S. Department of Education. (2012). STEM in postsecondary education. *National Center for Education Statistics.* Retrieved from https://nces.ed.gov/pubs2013/2013152.pdf

U.S. Department of Health & Human Services (1979). Belmont report: Ethical principles and guidelines for the protection of human subjects of research. Retrieved from http://www.hhs.gov/ohrp/humansubjects/guidance/belmont.html#xjusth

Vogt, W. P. (2007). *Quantitative research methods for professionals*. Allyn & Bacon.

Warren, A. (2014). Critical success factors for IT project management: A case study of a UK MOD IT project. *Paper presented at the European Conference on Research Methodology for Business and Management Studies.* 425-432.

Whitney, K. M., & Daniels, C. B. (2013). The root cause of failure in complex IT projects: Complexity itself. *Procedia Computer Science*, *20*, 325-330.