This article examines the relationship between Department of Defense information technology (IT) program managers (PMs), their technical education, commercial project management certification, and project management success—also known as project efficiency—for IT PMs. The researcher asked, “To what extent does project management success in scope, schedule, and cost compare among PMs, specifically their technical education, commercial project management certification, and interaction effects between education type and commercial PM certification?” A gap in research exists on whether IT PMs with a technical education positively or negatively impact project outcomes. The IT PM community needs more studies on the extent to which commercial PM certifications affect project efficiency. The researcher 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. A Mann-Whitney post hoc test confirmed the MANOVA results. Both tests concluded that no relationship exists between undergraduate technical degree, commercial PM certification, and project management success.

DOI: https://doi.org/10.22594/dau.20-856.28.02
Keywords: Information Technology, Project Management, PM Certification, IT PM Education, Project Success.
Information technology (IT) project managers (PMs) lead IT project teams and are ultimately accountable for the overwhelming number of IT project failures. Typically, IT PMs fail to deliver on scope, schedule, and cost, which threatens the organization’s competitive advantage. IT project failures are well documented in literature, and modern agile software development practices have failed to stem the tide. According to the CHAOS reports of The Standish Group (2013, 2015), nearly two-thirds of IT projects fail to deliver on initial scope, schedule, and cost. The problem becomes more pronounced on large IT projects versus smaller efforts where agile approaches have demonstrated success. Bloch et al. (2012, pp. 1–6) found that large IT projects—those over $15 million—fail more than half of the time. IT project failure is hindering the ability of organizations to capitalize on IT innovation and limits the realization of the technological benefit. Failure of large projects can threaten the viability of a company. 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 (DoD, 2015). One DoD MAIS IT project, USAF Expeditionary Combat Support System Program, failed to deliver any capability with $1.1 billion lost (Aronin et al., 2011). The United Kingdom Social Security Department and Post Office Counters, Ltd., launched a software project (£1 billion or approximately $1.6 billion) to change how post offices would operate and how benefit recipients would receive payments. Four years later, the project was abandoned based on a projected 3-year schedule delay and 30% budget overrun (Budzier & Flyvbjerg, 2012). IT PM competence contributes to project success (Pinto & Slevin, 1987; Ramazani & Jergeas, 2015). Organizational leaders need to select and develop better IT PMs to improve outcomes.

IT project failures are well documented in literature, and modern agile software development practices have failed to stem the tide.

In the public sector, PMs 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. These technical skills by which IT professionals are selected as PMs 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). PMs 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) also suggested that PMs 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 development of personnel and strategic managerial perspective as contributing to IT project success. Researchers suggest a combination of technical hard skills and project leadership soft skills to build the PM competence required for project success (Ballesteros-Sanchez et al., 2017; Ramazani & Jergeas, 2015).

This research compared project efficiency to the PM’s undergraduate education type and commercial project management certification, for U.S. Department of Defense (DoD) IT projects. The research examined the possible relationship to project outcomes of combinations of technical and nontechnical education and project management training certification. Undergraduate degree and commercial project management certification are used as constructs to represent PM competency. Using education degrees and PM certifications to represent PM competency is consistent with existing research (Ahsan et al., 2013; Ballesteros-Sanchez et al., 2017). Understanding the relationship between project efficiency and PMs’ education and training on U.S. DoD IT projects will provide valuable information to the greater IT PM community.

**Literature Review**

To alter the trend of high failure in IT development projects, IT community members recognize the need for better leadership and project management training to supplement IT technical education. IT project success rates will not continue to grow to acceptable rates without PMs who combine project management and leadership competence with technical competence. IT PM competency and project efficiency have been widely addressed in project management academic literature.
Theoretical Orientation

The contingency theory of project management provides the underpinning for this research. Contingency theory expands on the earlier theory of critical success factors (CSF) by emphasizing project differences. CSF project management theory posits that project success can be achieved by following a set of project management best practices. The seminal work of Pinto and Slevin (1987) codified the literature on CSF theory. Pinto, Slevin, and associates provided the preponderance of oft-cited work on project management (Pinto & Mantel, 1990; Pinto & Prescott, 1988; Pinto & Slevin, 1989; Slevin & Pinto, 1986). The work of Pinto, Slevin, and associates closely links to the Project Management Body of Knowledge (PMBoK) (Project Management Institute, 2013), the most recognized publication on project management in the United States.

Context matters. Building on CSF theory, contingency theory of project management asserts that the application of success factors varies with the project context. Differing project environments, such as government IT projects, require different application of project management practices. Shenhar, Dvir, and associates led contingency project management research (Dvir & Shenhar, 1992; Shenhar & Dvir, 1996; Shenhar et al., 2002). Shenhar and Dvir (1996) developed a model contingent on project types with expanded independent and dependent variables from CSF-based studies. According to contingency theory, projects exhibit consistent relationships among factors and measurements within a given project context versus a general set of universal factors (Söderlund, 2011). Other contingency theory-based studies expanded success factors, criteria, and project typology (Ahimbisibwee et al., 2015; Cserhati & Szabo, 2014; Mazur et al., 2014). Contingency theory provides the foundation for examining the relationship between project success and PM education and training, within the specific context of DoD IT projects.
PM Education and Training Background

Trepidation around the influence of the PM’s education and training on IT project performance has been an ongoing concern addressed in the literature. Chua (2009) identified three internal project risk factors contributing to IT project failure: people, process, and technical. The PM competencies contributing to project outcomes include hard technical skills, leadership soft skills, and application of project management skills (also considered soft skills). In his seminal work, Brooks (1974) states that the software PM’s lack of knowledge leads to overoptimistic estimates that in turn significantly contribute to project failure. Similarly, Flyvbjerg (2013, pp. 321–344) distinguishes between causes and root causes in explaining project underperformance, identifying the root cause as PM ignorance of project risk, also considered optimism. Research identified PM competency as critical to project success (Pinto & Slevin, 1989; Shenhar et al., 2002). Technical knowledge is needed to understand the scope for the product or service. Soft skills are those leadership and project management skills required to motivate the team and influence stakeholders.

IT project success rates will not continue to grow to acceptable rates without PMs who combine project management and leadership competence with technical competence.

Researchers continue to seek the right balance of technical and project management training in educational institutions and training agencies (Ballesteros-Sanchez et al., 2017; Pandya, 2014). Udechukwu et al. (2015) identified the importance of a holistic curriculum combining both engineering and project management content. Ramazani and Jergeas (2015) suggested that educational institutions and training agencies should consider both project management and technical skills versus maintaining “just technical skills” (p. 51). Niederman et al. (2016) identified the need to achieve “the right balance of technical and nontechnical skills within an education program” for management positions (p. 45). Ramazani and Jergeas (2015) recommended that universities and training activities include both project management and technical skills.

Project management literature has identified the need for technical competence in education and training. Some researchers have suggested technical competence as a prerequisite for selection as a PM. While significant research points to project management and leadership skills as more important to project success, practitioners cannot ignore technical factors. PMs require technical expertise to keep pace with changing technology.
Agrawal and Thite (2006) cited the need to keep up with the latest technology and continuous learning about challenges experienced by software project leaders. Some project management 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).

Technical skills that IT professionals selected as PMs possess differ from the soft skills required to manage the project. Project managers selected based on technical expertise too often do not possess the leadership and management skills required for successful team supervision (Agrawal & Thite, 2006; Darrell et al., 2010). Dulaimi (2005) suggests that IT PMs with engineering backgrounds focus too much on the technical details. IT professionals list project management and leadership skills as more critical to IT project success than software engineering technical knowledge (Agrawal & Thite, 2006). Orchestrating the entire project demands a significantly different skill set than providing technical leadership. Lack of project management skills contributes to IT project failure (Carvalho & Rabechini, 2015; Catanio et al., 2013; Rivera-Ruiz & Ferrer-Moreno, 2015).

While these studies recommend combining technical and soft skill education based on independent evaluation, the studies do not examine the interactive effects of technical education and soft skills training on project outcomes. McLeod and MacDonell (2011) note that “many factor-based studies implicitly assume” that individual factors in software projects are independent, when this is not the case in practice (p. 46). This study addressed that gap in the literature by examining the interactive effects of education and training.
PM Certification Impact on Project Outcomes

With the exponential growth in Project Management Professional (PMP) certifications 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 1,000 in 1993 to 412,503 in 2010 (Catanio et al., 2013). Other IT project management certifications, such as PRINCE2, ITIL Foundation, Scrum Alliance’s Scrum Master, and SAFe credentials have also thrived (Catanio et al., 2013; Cicmil & Gaggiotti, 2018). Contingency theory suggests that one certification might be more appropriate for a specific type of IT project; however, research has not supported a link between certifications and improved project outcomes. Several studies reviewed just the PMP (Robertson, 2015; Starkweather & Stevenson, 2011), while others addressed multiple certifications (Abu-rumman, 2014; Nazeer & Marnewick, 2018; Shackman, 2015) or did not specify the certification type (Catanio et al., 2013).

The academic literature does not support a relationship between project management certifications and a project manager’s success in scope, schedule, and cost. 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 PMs and uncertified PMs in a quantitative study. For PMs with a PMP, Abu-rumman (2014) found “limited evidence to suggest it has any significant impact on the relative success or failure of projects” (p. 5). Findings by Starkweather and Stevenson (2011) indicated no difference in project success rates between PMP-certified PMs and uncertified PMs. Robertson (2015), in a study using secondary data from 1,444 RGS consulting firm projects, found PMP certification correlated with poorer
project outcomes. Shackman (2015) found “insufficient evidence to indicate whether accreditation, certification, and credentialing will improve program outcomes” (p. 110). More research is required to confirm or refute the findings. The extent to which the combined PM’s education and PM certification predict project efficiency has not been sufficiently studied. The researcher found no evidence of the possible interactive effects of the IT PM’s education and certification on project efficiency.

Qualitative studies show the importance of certifications for selecting PMs, PM career enhancement, and perceptions of success. In a study of PMs seeking voluntary project management certifications “collected 10 years apart (2004 and 2014),” Blomquist et al. (2018) found that voluntary project management certifications’ benefit is more aligned with looking good to prospective employers than being good at project management (p. 498). Other qualitative studies suggest earning a commercial project management certification helps the career progression of an IT PM by demonstrating dedication to the guild (Armstrong, 2015; Dubois et al., 2015; Rivera-Ruiz & Ferrer-Moreno, 2015).

**Summary**

The PM must guide the project team and influence stakeholders to create the collaborative synergy for success. PMs must also manage the trifecta of project success metrics: scope, schedule, and cost. While definitions of success vary, literature consistently values the PM’s soft skills of leadership and project management as critical to project success. Gaps in the PM’s competence contribute to project failure. This study addressed possible combinations of a PM’s education and training to examine the interactive effects.
Methodology

The study involved an exploratory, comparative model to examine the statistical relationship among variables without specifying the direction of the influence. The research, based on a survey using the project success assessment questionnaire (PSAQ) (Shenhar & Dvir, 2007), compared the project efficiency for DoD IT projects to the IT project manager’s undergraduate education type and project management certification. The PSAQ instrument collected data on the PM’s perception of project success using the construct of project efficiency, which included scope, schedule, and cost. The addition of demographic questions on the PM’s type of undergraduate education and commercial project management certification assisted the researcher in comparing combinations of education and training certification. No known study has examined the interaction effect of PMs’ education and certification on project efficiency, nor has any study compared education type for PMs. An exploratory study is more appropriate because the findings may not be generalizable to the entire community of PMs (Sekaran & Bougie, 2013, p. 97).

Data Collection Methods and Procedures

The method for the collection of data was a random sample using a web-based survey tool. The researcher limited the population of PMs for the study to DoD IT PMs. For this study, the terms project manager and program manager were used interchangeably because the DoD defines the term program manager as an equivalent to project manager (DoD, 2015). DoD IT PMs are a subset of the general DoD PM population. As of October 2018, 24,534 PMs and IT acquisition professionals were members of the Defense Acquisition Workforce, each with various levels of education and certification (Defense Acquisition University [DAU], 2018). General demographics for the DoD project management and information technology population break 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

“The extent to which the combined PM’s education and PM certification predict project efficiency has not been sufficiently studied.”
The researcher acquired the sample from a sample frame of 8,895 members of the project management and IT population. The sample acquired came from a DAU email list of the IT and PM career field members who possessed a DoD level III certification as the sample frame. (Note. Defense Acquisition Workforce members must earn a DoD level III certification before leading a DoD IT project.) Limiting the sample frame had several benefits. The limited sample frame reduced statistical model error related to various levels of DoD certification training. Also, the DoD level III certification for PM and IT requires a minimum of 4 years’ experience (DAU, 2018). By restricting the sample frame to those with at least 4 years of experience, the researcher reduced error in the model resulting from inexperience. Prior studies indicated that experience positively correlated to project success (Müller & Turner, 2010; Ropponen & Lyytinen, 2000; The Standish Group, 2013). Additionally, the 8,895-person sample frame used for recruiting participants was below the 10,000 limit for surveying DoD personnel. 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.

The researcher developed a recruitment email, which invited recipients who managed a DoD IT project to participate. The email was sent to each of the 8,895 Defense Acquisition Workforce level III certified IT PMs, 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 PM respondents after eliminating respondents who did not complete the survey after reading the informed consent. Demographic data included only undergraduate degree type, gender, project size, and commercial PM certification identification. The questions were multiple choice using generic categories designed to limit respondent identification risk.
**Variables**

The study included the independent variables of undergraduate education type defined as a science, technology, engineering, and mathematics (STEM) undergraduate degree or nontechnical undergraduate degree (non-STEM) (U.S. Department of Education, 2012) and commercial project management certifications. The researcher defined the dependent variables as scope performance, schedule performance, and cost performance per the definitions in the PMBoK (Project Management Institute, 2013). The dependent construct is project efficiency based on the dependent variables of cost, schedule, and scope from survey data (Figure 1).

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

**Research Questions**

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.

1. To what extent does project management success in scope, schedule, and cost compare among PMs with STEM and non-STEM education?
Hypothesis H1: 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 among PMs with a commercial certification and without a commercial certification?

Hypothesis H2: There is no statistically significant difference in scope, schedule, and 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: 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 difference 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 (\( H_a: \mu_n \neq \mu_k \)), then the alternative hypotheses would have been tested, as appropriate (Sekaran & Bougie, 2013).

**Power Analysis**

The estimated minimum sample size was 98. The estimate was calculated using GPower 3.1. The researcher based an estimate in GPower 3.1 on two binary IVs (predictors), resulting in four groups and three DVs (response variables). The GPower 3.1 analysis resulted in \( F(6, 186) = 2.1476, \)
with power (1-\(\beta\)) of 0.99 and a type I error \(\alpha\) of 0.05. 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 0.1 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 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).

**Human Subjects Protection**

The population for this study is adult, DoD government IT PMs. 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 obtained DoD information collection process approval reflected in the approval number, RCS# DD-A&S-2675.

The benefit gained from the study benefits all PMs equally by contributing to the general body of knowledge, therefore adhering to the ethical principle of justice. The results of this study provided only one data point that builds on the knowledge gained from previous work. As such, researchers and practitioners should view this study only in conjunction with similar studies in the field. A risk arises in the interpretation of findings when this study is viewed alone. The entire body of research should contribute to ongoing project management legislative and policy discussions.

**Results and Discussion**

The researcher undertook this study to investigate the potential relationship between project success and IT PM education and training. Factorial MANOVA and the nonparametric Mann-Whitney post hoc test were used to analyze the data in SPSS data analysis software. Discussion of the results of the analysis follows.

**Sample**

The sample was collected using an Internet-based survey tool. The survey was open for 2 weeks to ensure the study reached the minimum sample size. Responding to the recruitment email, 384 volunteer participants logged on to the survey web page. After reading the informed consent, 70 did not complete any portion of the survey after recognizing the survey did not apply to them. Five respondents marked not applicable to each answer, so the
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 1.

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Variables</th>
<th>Level of Measurement</th>
<th>Operational Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construct 1: Project Manager</td>
<td>Undergraduate Education Type (IV)</td>
<td>Nominal</td>
<td>STEM vs. Non-STEM degree</td>
</tr>
<tr>
<td>Competence</td>
<td>Project Management Certification (IV)</td>
<td>Nominal</td>
<td>Commercial PM Certification</td>
</tr>
<tr>
<td>Construct 2: Project Efficiency</td>
<td>Scope (DV)</td>
<td>Interval</td>
<td>Scope Assessment</td>
</tr>
<tr>
<td></td>
<td>Schedule (DV)</td>
<td>Interval</td>
<td>Schedule Assessment</td>
</tr>
<tr>
<td></td>
<td>Cost (DV)</td>
<td>Interval</td>
<td>Cost Assessment</td>
</tr>
</tbody>
</table>

While the sample size is more than double the minimum required, the survey response rate of approximately 4% is well below the recommended minimum response rate of 50% (Kittleson, 1997) or average online survey response rate of 33% (Nulty, 2008). The low response rate could introduce nonresponse bias resulting in a sample that is not representative of the population (Sekaran & Bougie, 2013). Field (2013) suggested bootstrapping, a method of resampling, as a method to check for potential nonresponse bias. Based on the assumption that late respondents are very similar to nonrespondents (Creswell, 2014), resampling using bootstrapping identifies the bias if the resampled means do not equate to the original sample means. Bootstrapping, with a 95% bias corrected and accelerated confidence interval using 1,000 resamples, resulted in bootstrapping means of 3.30, 3.46, and 3.06 for schedule, cost, and scope, respectively. The bootstrapping results nearly matched the sample means of 3.31, 3.46, and 3.07, respectively. The bootstrapping result combined with the male-female demographic match between the population and sample indicates a representative, random sample, which significantly reduced nonresponse bias risk.

**Missing Data**

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 2. The cases with missing data were eliminated using the pairwise method. The final sample size of 284 more than doubled the minimum sample size.
TABLE 2. SAMPLE CASES AND MISSING DATA

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Valid N</th>
<th>Percent</th>
<th>Missing N</th>
<th>Percent</th>
<th>Total N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project on Time</td>
<td>284</td>
<td>95.0%</td>
<td>15</td>
<td>5.0%</td>
<td>299</td>
<td>100.0%</td>
</tr>
<tr>
<td>Project on a Budget</td>
<td>284</td>
<td>95.0%</td>
<td>15</td>
<td>5.0%</td>
<td>299</td>
<td>100.0%</td>
</tr>
<tr>
<td>Minor Scope Change</td>
<td>284</td>
<td>95.0%</td>
<td>15</td>
<td>5.0%</td>
<td>299</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Sample Power

The sample had power \((1-\beta)\) of 0.99 with a type I error \(\alpha\) of 0.05 established using GPower 3.1, as outlined in Figure 2. The result aligned with the a priori power analysis in this study that reported \(F(6, 186) = 2.1476, p < .001\) with power \((1-\beta)\) of 0.99 and a type I error \(\alpha\) of 0.05.

FIGURE 2. G-POWER 3.1 MANOVA POWER CALCULATION

Descriptive Statistics

The 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 PMs responded to the survey-based responses on both large and small IT projects, 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 of certifications:

- 52 PMP
- 4 Lean Six Sigma
- 2 ITIL Foundation Basic
- 2 Certified Scrum Masters
- various PM certifications held by others

In the sample, 154 (51.5%) participants had an undergraduate STEM degree, and 145 (48.5%) did not possess a STEM degree. Table 3 outlines the descriptive statistics for the sample.

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Compl PM Certification</th>
<th>STEM Degree</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project on Time</td>
<td>No</td>
<td>No</td>
<td>3.29</td>
<td>1.343</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>3.48</td>
<td>1.240</td>
<td></td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3.39</td>
<td>1.293</td>
<td></td>
<td>220</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>3.16</td>
<td>1.313</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>2.95</td>
<td>1.450</td>
<td></td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3.03</td>
<td>1.391</td>
<td></td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>3.27</td>
<td>1.334</td>
<td></td>
<td>135</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>3.34</td>
<td>1.314</td>
<td></td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3.31</td>
<td>1.322</td>
<td></td>
<td>284</td>
</tr>
<tr>
<td>Project on a Budget</td>
<td>No</td>
<td>No</td>
<td>3.35</td>
<td>1.282</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>3.75</td>
<td>1.085</td>
<td></td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3.55</td>
<td>1.202</td>
<td></td>
<td>220</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>3.24</td>
<td>1.200</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>3.10</td>
<td>1.447</td>
<td></td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3.16</td>
<td>1.348</td>
<td></td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>3.33</td>
<td>1.264</td>
<td></td>
<td>135</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>3.58</td>
<td>1.220</td>
<td></td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3.46</td>
<td>1.245</td>
<td></td>
<td>284</td>
</tr>
</tbody>
</table>
TABLE 3. UNADJUSTED MEANS FOR SCHEDULE, COST, AND SCOPE BY CATEGORIES (CONTINUED)

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Compl PM Certification</th>
<th>STEM Degree</th>
<th>Mean</th>
<th>Std Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Scope Change No</td>
<td>No</td>
<td>3.05</td>
<td>1.210</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>3.15</td>
<td>1.221</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3.10</td>
<td>1.214</td>
<td>220</td>
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<tr>
<td></td>
<td>No</td>
<td>2.96</td>
<td>1.172</td>
<td>25</td>
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<tr>
<td></td>
<td>Yes</td>
<td>2.92</td>
<td>1.265</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2.94</td>
<td>1.220</td>
<td>64</td>
<td></td>
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<tr>
<td></td>
<td>No</td>
<td>3.04</td>
<td>1.200</td>
<td>135</td>
<td></td>
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<tr>
<td></td>
<td>Yes</td>
<td>3.09</td>
<td>1.232</td>
<td>149</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3.07</td>
<td>1.215</td>
<td>284</td>
<td></td>
</tr>
</tbody>
</table>

Reliability and Validity

The PSAQ is a well-established instrument with published reliability and validity information. Hagen and Park (2013) reported a Cronbach’s α score of 0.906 for organizational outcomes using the PSAQ project efficiency construct. Ahmed and bin Mohamad (2016) 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 constitute the construct of project efficiency. In this study, correlation coefficients were calculated with Pearson $r$ 0.418, 0.523, 0.765 significant at $p < 0.01$ (2-tailed), for scope-schedule, scope-cost, and schedule-cost, respectively, as shown in Table 4.

TABLE 4. PEARSON $R$ VALIDITY DATA

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Project on Time</th>
<th>Project on Budget</th>
<th>Minor Scope Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project on Time</td>
<td>Pearson Correlation 1</td>
<td>0.765**</td>
<td>0.418**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$N$</td>
<td>297</td>
<td>291</td>
</tr>
<tr>
<td>Project on a Budget</td>
<td>Pearson Correlation 0.765**</td>
<td>1</td>
<td>0.523**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>$N$</td>
<td>291</td>
<td>292</td>
</tr>
<tr>
<td>Minor Scope Change</td>
<td>Pearson Correlation 0.418**</td>
<td>0.523**</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>$N$</td>
<td>289</td>
<td>285</td>
</tr>
</tbody>
</table>

Note. **Correlation is significant at the 0.01 level (2-tailed).
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). For the Scope 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 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, cost skewness was -0.504, 0.093, -0.293, and -0.537 for the four categories, respectively. While overall skewness scores are near the normal distribution, kurtosis scores are not consistently normal, ranging from -0.837 to -1.466. Table 5 shows the Kolmogorov–Smirnov, or K-S tests with a nonnormal 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>
<thead>
<tr>
<th>TABLE 5. K-S NORMALITY TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable</td>
</tr>
<tr>
<td>Project on Time</td>
</tr>
<tr>
<td>Project on a Budget</td>
</tr>
<tr>
<td>Minor Scope Change</td>
</tr>
</tbody>
</table>

MANOVA is robust regarding normality with sufficient cell sample sizes and provided the nonnormality 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.

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 4. Overall, the linear relationships were moderate.

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

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Box’s M</td>
<td>16.781</td>
</tr>
<tr>
<td>F</td>
<td>0.904</td>
</tr>
<tr>
<td>df1</td>
<td>18</td>
</tr>
<tr>
<td>df2</td>
<td>36,863.991</td>
</tr>
<tr>
<td>Sig.</td>
<td>0.574</td>
</tr>
</tbody>
</table>

**Note.** Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

*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 when comparing education type of STEM and non-STEM. Results indicate that Commercial PM Certification [Wilks’ Lambda = .983, $F(3, 278) = 1.569, p = .197, \eta^2 = .017$] do not significantly affect the combined DVs of scope, schedule, and cost. STEM undergraduate degree [Wilks’ Lambda = .994, $F(3, 278) = .513, p = .674, \eta^2 = .006$] does not significantly affect the combined DVs of scope, schedule, and cost. Interaction between PM certification and STEM Degree [Wilks’ Lambda = .991, $F(3, 278) = .846, p = .470, \eta^2 = .009$] does not significantly affect the combined DVs of scope, schedule, and cost. The researcher could not reject the null hypotheses.

To further address concerns of violations of the assumption of multivariate normality, the nonparametric 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 nonparametric tests in testing hypotheses, nonparametric tests overcome problems with the normalcy of the distribution (Field, 2013). Nonparametric tests also overcome objections to the use of Likert scale survey data as interval data (Robertson, 2012) by ranking the data. The results align with the MANOVA results that the null hypothesis must be accepted in each area, except for Coml PM Certification showing a significant relationship with cost in Figure 3.

Scope 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 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 for IT PMs with STEM Degrees ($\bar{x} = 150.03$) did not differ significantly from IT PMs without STEM Degrees ($\bar{x} = 134.19$), $U = 11,180.00, z = 1.687, p = .092, r = .100$. Scope performance for IT PMs with Coml PM Certification ($\bar{x} = 134.20$) did not differ significantly from IT PMs without
Compl PM Certification (\(\bar{x} = 144.91\)), \(U = 6,509.00, z = -0.968, p = .333, r = .057\). Schedule for IT PMs with Compl PM Certification (\(\bar{x} = 126.84\)) did not differ significantly from IT PMs without Compl PM Certification (\(\bar{x} = 147.05\)), \(U = 6,038.00, z = -1.808, p = .071, r = .107\). Cost performance for IT PMs with Compl PM Certification (\(\bar{x} = 124.54\)) did differ significantly from IT PMs without Compl PM Certification (\(\bar{x} = 1470.72\)), \(U = 5,890.50, z = -2.065, p = .039, r = .123\), as shown in Figure 3.

The cost mean significant difference between IT PMs with and without Compl PM Certification (\(p = .039\)) is misleading when considering the size of the sample \((N = 284)\). The test becomes significant at \(p < .05\). The result is very close to the cutoff point. Additionally, the effect size, \(r = .123\), is small. For this reason, the Mann-Whitney result does not invalidate the MANOVA result.

**Conclusions, Limitations, Implications, and Recommendations**

This quantitative research study expanded on the existing research regarding the relationship between commercial project management certification and project success; and limited research on PM undergraduate technical education and project management success. 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. While the legislation exempted DoD from parts of the legislation, the results of this study could inform the discussion about the merits of commercial project management certifications for DoD IT PMs.

**Conclusions Based on the Results**

For the first research question, the study found no significant difference in project efficiency success between PMs with STEM and non-STEM undergraduate education. The literature results in this area are mixed. This study suggests that organizations should recruit PMs with either a STEM or non-STEM degree. Requiring a technical education as a prerequisite to becoming a project manager, as suggested by Pandya (2014), may not yield better project outcomes. 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). IT PMs should pursue balanced education and training between hard technical skills and project management soft skills. Growing evidence shows the need to balance technical and project leadership soft skills (Ballesteros-Sanchez et al., 2017; Cicmil & Gaggiotti, 2018; Darrell et al., 2010). The results of this study suggest a reexamination of a technical degree as a prerequisite to assignment as an IT PM. Contingency theory posits that a deeper examination of specific degrees and specific certifications in follow-on studies may reveal educational benefits for specific IT project types.

As expected, the study found no link between a commercial PM certification and project efficiency. 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, 2011). This study adds to the growing body of evidence that commercial PM certifications do not impact 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; Blomquist et al., 2018; Dubois et al., 2015; Rivera-Ruiz & Ferrer-Moreno, 2015).

This study recommends that organizations seeking to improve IT project outcomes should not require their PMs to attain commercial PM certification, as the benefits balance tilts more toward the individual's career than IT
project efficiency. Voluntary commercial PM certifications do have value for the individual PM interested in career advancement. 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 PM candidates versus requiring commercial certification. Industry and organization-specific project management training on contextual application of critical success factors is required to improve IT project outcomes (Pinto & Prescott, 1988; Pinto & Slevin, 1989; Shenhar et al., 1997).

Limitations

Some limitations exist for this study. First, the population of DoD IT PMs is significantly smaller than the overall population of PMs; therefore, the study may have limited applicability to the greater project management community. Second, if the study showed a relationship between PMs’ education and training and project performance, a relationship does not guarantee causation. IT PMs manage IT projects in the public and private sector around the globe; however, this study focused on public sector IT PMs in DoD. 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). The survey measured respondents’ perception of cost, schedule, and scope variance versus secondary data. 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).

This study recommends that organizations seeking to improve IT project outcomes should not require their PMs to attain commercial PM certification, as the benefits balance more toward the individual’s career than IT project efficiency.
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. Perry (2017) found that PMs who held certifications in addition to a PMP had better project outcomes than PMs with only a PMP. This study did not support the Perry (2017) finding that multiple certifications improved project outcomes. The relationship could limit the external validity of the study.

Internal validity is threatened by potential nonresponse bias. While bootstrapping and sample gender demographics reduce the threat of nonresponse bias, such bias must be recognized. Nonresponse bias threat would hold greater importance if the study found a statistically significant relationship. Follow-on research using secondary data will overcome risks associated with survey results.

This study focused on explicit knowledge gained through training and education without fully examining tacit knowledge gained through experience. Wateridge (1997) suggested that 60% of project management skill can be learned on the job, but formal training is required. Hao and Swierczek (2010) suggested that more training and certification is required to build PM skills. Other studies have found tacit knowledge gained through experience relates to positive project outcomes (Coleman, 2014; Sauer et al., 2007).
Implications for Practice
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. Further study using secondary data will provide researchers the opportunity to do a deeper examination of educational differences by subdividing STEM and non-STEM education into more specific areas of undergraduate study. DoD leaders should exercise caution in enacting policy designating commercial PM certification as mandatory until more studies expand on this exploratory research. This study provided initial work to reduce the knowledge gap concerning the interactive effects of IT PM education and training.

Knowledge of IT PM competencies’ 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 (Nazeer & Marnewick, 2018). Additionally, this research contributed to the body of knowledge on appropriate factors for selecting and training IT PMs (Ahsan et al., 2013; Mazur et al., 2014).

Recommendations for Further Research
This study began the exploration of interactive effects of PM competence critical success factors. While significant research exists on the critical success factors that contribute to PM competence, the interactive effects of the factors require more research. Research needs to be expanded across several PM competence factors in multiple contexts including various industries, in both public and private sectors. Udechukwu et al. (2015) and Pandya (2014) noted that in addition to technical education, management skills training was necessary for PMs. Niederman et al. (2016)
identified a trend in adding nontechnical skills training to information systems curricula. These studies did evaluate the impact of the combined training on project outcomes.

Defense acquisition executives could benefit from sponsoring continued academic research on IT PM education and training to inform future legislation and policy. The researcher recommends further research on DoD IT PM competencies’ relationship to project efficiency using secondary data to overcome limitations associated with survey data. A follow-up study of the DoD IT PM education and training certification relationship to project efficiency using DoD secondary data would add validity to this exploratory study. The DoD collects significant data on IT program-and-project performance and associated PM education, training, and experience (DoD, 2015). Granting DoD researchers access to the available data would expand the statistical methods available for analysis, thus improving study validity. Also, the researcher recommends additional research on the overall approach to education and training requirements for IT PMs.

This is an exploratory study based on the survey respondents’ perceptions of cost, schedule, and scope. Follow-on studies could overcome this limitation associated with surveys by using secondary data from DoD projects. Using secondary data from DoD projects would increase the sample size sufficiently to allow for the examination of different PM certifications and specific degrees beyond STEM and non-STEM. Such an examination could support or refute the contingency theory claim that context matters for project success factors.
References


Appendix

PROJECT SUCCESS ASSESSMENT QUESTIONNAIRE (PSAQ)

This survey captures project manager (PM) perceptions of project success to include scope, schedule, and cost. The PSAQ developed by Shenhar and Dvir (2007) contains 28 questions using a 5-point Likert scale. The instrument displayed consistent reliability and validity in several studies (Ahmed & bin Mohamad, 2016; Hagen & Park, 2013; Shenhar & Dvir, 2007). Respondents were asked to answer these questions based on the most recent Department of Defense (DoD) IT program/project managed. The researcher added demographic questions to create independent variable groups for the study. The final demographic question confirms that the survey respondent worked on DoD IT projects.

Demographic questions:

1. Several commercial project management certifications have been earned by project managers and program managers to include:
   - Certified Associate in Project Management (CAPM@)
   - Project Management Professional (PMP@)
   - Master Project Manager (MPM@)
   - Certified Project Manager (CPM)
   - other commercial PM certifications

   Do you possess a commercial project management certification?
   [ ] Yes (Please specify)________________________
   [ ] No

2. The U.S. Department of Education defines a science, technology, engineering, and mathematics (STEM) undergraduate degree as included in the following areas of study:
   - mathematics
   - physical sciences
   - biological/life sciences
   - computer and information sciences
   - engineering/technologies
Do you possess a STEM undergraduate degree?

☐ Yes (Please specify) ________________________________

☐ No

3. What is your gender?

☐ Male

☐ Female

4. What was the largest IT project or program you managed?

☐ DoD IT program or project with project value under $100 million

☐ DoD IT program or project with project value at or over $100 million

☐ Have not managed a DoD IT program or project
Dr. William J. Parker

joined the Defense Acquisition University faculty after serving 23 years in the U.S. Marine Corps and working in the defense industry. He currently serves as Executive Program Management faculty. Dr. Parker holds a bachelor’s degree in Economics from Pennsylvania State University, an MBA from Old Dominion University, and a PhD in Information Technology from Capella University. He earned a Project Management Professional (PMP) certification and a certified scrum master certification from the Scrum Alliance. Dr. Parker also completed a postgraduate Executive Data Science certificate program from Johns Hopkins University.

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