

Author: Swant, Ryan T.

Title: *Engineering, Procurement, and Collaborative Curricula in Wisconsin Technical Colleges*

The accompanying research report is submitted to the **University of Wisconsin-Stout, Graduate School** in partial completion of the requirements for the

Graduate Degree/ Major: MS Degree/ Career and Technical Education

Research Advisor: Matthew Simoneau, Ed.D.

Submission Term/Year: Spring 2018

Number of Pages: 57

Style Manual Used: American Psychological Association, 6th edition

I have adhered to the Graduate School Research Guide and have proofread my work.

I understand that this research report must be officially approved by the Graduate School.

Additionally, by signing and submitting this form, I (the author(s) or copyright owner) grant the University of Wisconsin-Stout the non-exclusive right to reproduce, translate, and/or distribute this submission (including abstract) worldwide in print and electronic format and in any medium, including but not limited to audio or video. If my research includes proprietary information, an agreement has been made between myself, the company, and the University to submit a thesis that meets course-specific learning outcomes and CAN be published. There will be no exceptions to this permission.

I attest that the research report is my original work (that any copyrightable materials have been used with the permission of the original authors), and as such, it is automatically protected by the laws, rules, and regulations of the U.S. Copyright Office.

My research advisor has approved the content and quality of this paper.

STUDENT:

NAME: Ryan Swant

DATE: 5/10/2018

ADVISOR: (Committee Chair if MS Plan A or Thesis or Field Project/Problem):

NAME: Matt Simoneau

DATE: 5/10/2018

This section for MS Plan A Thesis or EdS Thesis/Field Project papers only

Committee members (other than your advisor who is listed in the section above)

1. CMTE MEMBER'S NAME: **DATE:**

2. CMTE MEMBER'S NAME: **DATE:**

3. CMTE MEMBER'S NAME: **DATE:**

This section to be completed by the Graduate School

This final research report has been approved by the Graduate School.

Director, Office of Graduate Studies:

DATE:

Swant, Ryan T. *Engineering, Procurement, and Collaborative Curricula in Wisconsin Technical Colleges*

Abstract

Considering recent trends in construction project delivery methods, this descriptive study investigated the adequacy of engineering, procurement, and collaborative curricula in Wisconsin Technical College System construction programs. The subjects included technical college graduates and their supervisors. The researcher developed a list of skills needed on integrated projects and collected quantitative data using closed-item questionnaires. The data was analyzed using descriptive statistics and response-frequency methods.

The research revealed several important conclusions. First, respondents were more likely to use traditional delivery strategies than collaborative strategies. Second, no standard model exists for integrated project delivery, though certain organizations are leaders in relevant publications. Third, subjects were more likely to be satisfied with collaborative skill training than they were with engineering and procurement skill training. Finally, supervisors had more favorable perceptions of graduate skill levels than graduates did.

The researcher recommended that program faculty consult with advisory boards, review existing task analyses, and monitor future professional publications about project delivery strategies. Additionally, the researcher recommended that supervisors should discuss actual and expected performance with their employees. Finally, the researcher recommended a repeat study using a different graduating class, geographic area, or institution.

Acknowledgments

I gratefully acknowledge Dr. Matt Simoneau for supporting me during my graduate work at the University of Wisconsin-Stout. As my instructor, you taught and inspired me. As my research advisor, you helped me to know when to sharpen my pencil and when to put it down.

I would also like to thank my program advisor, Dr. Deanna Schultz. Somehow you kept me on track even when there were many states between us.

I thank the teachers, classmates, supervisors, co-workers, roommates, and friends who offered support during my graduate studies.

Most of all, I thank my family. Without your love and encouragement this achievement would not have been possible.

Table of Contents

Abstract.....	2
Chapter I: Introduction.....	8
Statement of the Problem.....	11
Purpose of the Study	11
Assumptions of the Study	11
Definition of Terms.....	12
Limitations of the Study.....	13
Chapter II: Literature Review	14
General Engineering Skills	14
Civil Engineering Skills	17
Mechanical Engineering Skills	18
Electrical Engineering Skills.....	19
Procurement Skills	20
Collaborative Skills.....	20
Summary	21
Chapter III: Methodology	23
Description of the Study	23
Subject Selection and Description	24
Instrumentation	24
Validity	25
Reliability.....	26
Engagement.....	26

Data Collection Procedures.....	27
Data Analysis	28
Limitations	28
Summary.....	29
Chapter IV: Results.....	30
Demographics	30
Target Market.....	30
Delivery Strategy	30
Geographic Area.....	31
Institution	31
Research Objective One Results.....	31
Engineering Skills.....	31
Procurement Skills	31
Collaborative Skills.....	32
Research Objective Two Results	32
Research Objective Three Results	32
Table 1: Prominence of Delivery Strategies	33
Results from Questionnaire Item One: Ability to Recognize Design Problems... 33	
Results from Questionnaire Item Two: Ability to Solve Design Problems..... 34	
Results from Questionnaire Item Three: Knowledge of Material Design	34
Results from Questionnaire Item 4: Knowledge of Sustainability Practices	34
Results from Questionnaire Item Five: Knowledge of Design Principles..... 34	
Results from Questionnaire Item Six: Ability to Manage Suppliers	34

Results from Questionnaire Item Seven: Ability to Manage Customer Relationships.....	35
Results from Questionnaire Item Eight: Ability to Manage Procurement Risks..	35
Results from Questionnaire Item Nine: Knowledge of Logistics Practices	35
Results from Questionnaire Item Ten: Knowledge of Warehousing Practices	35
Results from Questionnaire Item Eleven: Ability to Commit to Team Goals.....	35
Results from Questionnaire Item Twelve: Ability to Make Value-Based Decisions	35
Results from Questionnaire Item Thirteen: Ability to Communicate Openly	36
Results from Questionnaire Item Fourteen: Ability to Act Respectfully	36
Results from Questionnaire Item Fifteen: Knowledge of Contract Law	36
Table 2: Questionnaire Response Frequency.....	36
Figure 1: Combined Satisfaction Levels for Each Skill Group	37
Figure 2: Comparison of Satisfaction Levels for Each Skill Group	38
Chapter V: Discussion	39
Restatement of the Problem	39
Restatement of the Limitations of the Study.....	39
Methodology.....	40
Conclusions for Research Objective One	40
Conclusions for Research Objective Two.....	41
Conclusions for Research Objective Three.....	41
Recommendations Related to the Study	42
Recommendations for Future Research	42

References.....	44
Appendix A: WTCS A.A.S. Construction Management Programs.....	48
Appendix B: Supervisor Questionnaire	52
Appendix C: Graduate Questionnaire.....	54
Appendix D: Telephone Scripts.....	56
Appendix E: Email Template.....	57

Chapter I: Introduction

Construction contracts have evolved significantly in the last fifty years. In the 1960s, bid-build contracts were the most popular model used in the United States (Moynihan & Harsh, 2016). Bid-build contracts involve two distinct agreements. First, the project owner enlists an engineer to design and procure the engineered components of the project. Next, the owner awards a separate contract to a construction firm. Bid-build contracts are simple to manage and well-understood in the industry, but they limit the ability of project teams to reduce the cost and schedule of a project.

Design-build contracts became popular in the early 2000s (Moynihan & Harsh, 2016). The design-build philosophy involves a single contract between the owner and a design-build team that collaborates to design and construct a project. This contract structure allows design and construction phases to overlap which compresses the schedule and reduces the overall cost. Design-build contracts also promote collaboration and discourage conflict. For example, builders who contribute knowledge during the design phase will likely encounter fewer design obstacles during construction.

Project teams seeking even more collaboration have chosen a contracting strategy known as integrated project delivery (IPD). IPD contracts encourage teams to share information, processes, and talent (Beck, 2012). Newer and less defined than bid-build and design-build strategies, IPD projects typically exhibit three characteristics (Post & Leonidas, 2010). First, IPD participants sign one multiparty contract (Moynihan & Harsh, 2016). Second, all parties help with the planning and coordination efforts (Ellis, 2016). Third, key stakeholders are involved earlier in the project than they are on design-build and bid-build projects (El Asmar, Hanna, & Loh, 2013).

The IPD strategy has gained support due to its several advantages over traditional contract models. El Asmar et al. (2013) performed quantitative analysis of thirty-five projects in the Midwest and California to determine whether IPD projects performed better than non-IPD projects. The results indicated that IPD strategies lead to improvements in schedule, quality, communication, and change management. IPD contracts can also improve team efficiency and engagement on large, complex, or risky projects (Beck, 2012). Moynihan and Harsh (2016) reported that multiparty IPD contracts lead to increased collaboration. Finally, Ellis (2016) indicated that IPD projects produce less waste than those using traditional bid-build and design-build approaches. While skeptics argue that IPD contracts introduce unnecessary financial and legal risks, they also acknowledge the advantages of a collaborative and integrated project team (Post & Leonidas, 2010).

Integrated delivery strategies place project team members in non-traditional roles. Construction professionals can expect to assist with project design functions. They may also be responsible for procuring project materials that were historically purchased by an engineer. Most importantly, they are expected to collaborate with owners and engineers in new and significant ways. As a result, construction professionals must now prepare for involvement in engineering, procurement, and collaborative tasks. Thus, this shift of responsibilities has implications for the educational programs that prepare post-secondary students for construction careers. Construction education programs must be evaluated to ensure that students emerge with the engineering, procurement, and collaborative skills needed to succeed on integrated projects. This study was designed to contribute to the evaluation of construction education programs in Wisconsin.

Wisconsin colleges offer multiple degree programs that vary in duration and content. Bachelor of Science (B.S.) degree programs consist of four years of general, technical, and professional courses; Associate of Applied Science (A.A.S.) degree programs consist of two years of general and technical courses; and technical diploma and certificate programs teach hands-on, occupational skills in less than two years (Wisconsin Technical College System [WTCS], 2018a). The following list represents a sample of construction degree programs offered in Wisconsin:

- A.A.S. Construction Management – Northeast Wisconsin Technical College,
- A.A.S. Construction Management Technology – Fox Valley Technical College,
- B.S. Construction – University of Wisconsin-Stout,
- B.S. Construction Management – Milwaukee School of Engineering,
- Construction Project Supervision Certificate – Fox Valley Technical College, and
- Construction & Remodeling Technical Diploma – Madison Area Technical College.

These degree programs vary in cost. Technical college degrees – certificates, technical diplomas, and A.A.S. degrees – are more affordable than B.S. degrees (WTCS, 2018b).

Wisconsin's most comprehensive technical construction programs are the Construction Management Technology (CMT) A.A.S. program at Fox Valley Technical College (FVTC) and the Construction Management (CM) A.A.S. program at Northeast Wisconsin Technical College (NWTC). Both programs prepare students for supervisory roles in residential, commercial, and industrial construction (see Appendix A for course listings). Course descriptions refer to engineering, procurement, and collaborative content: engineering topics include drafting techniques, material strength calculations, and sustainability in design; material procurement skills may be addressed through construction material units; and collaborative topics include

teambuilding, resolving conflict, and diversity in vocational settings. However, program descriptions and course listings alone are not sufficient to establish whether students emerge with the skills required to succeed on integrated projects. Further assessment is needed to determine the adequacy of engineering, collaborative, and procurement skill training provided in these programs.

Statement of the Problem

It is unclear whether Wisconsin Technical College System (WTCS) construction management programs adequately prepare students with the engineering, procurement, and collaborative skills needed on integrated projects. If the programs do not properly train students, graduate employability may be compromised.

Purpose of the Study

The purpose of this research was to investigate the adequacy of engineering, procurement, and collaborative curricula in WTCS construction management programs. The research was guided by the following objectives:

1. Identify engineering, procurement, and collaborative skills needed in the construction industry.
2. Measure the extent to which Wisconsin builders expect graduates that are prepared with engineering, procurement, and collaborative skills.
3. Measure the extent to which WTCS construction management students are prepared to succeed on integrated projects.

Assumptions of the Study

The assumptions of this study were as follows:

1. WTCS construction management programs do not adequately prepare students to succeed on integrated projects.
2. A list of skills can be developed to represent integrated project requirements;
3. Wisconsin building contractors engage in integrated projects.
4. Wisconsin builders employ WTCS graduates.

Definition of Terms

The following definitions have been provided for clarification.

Bid-build. This is a project delivery strategy wherein the engineer and building contractor each enter into separate contracts with the project owner. The term bid-build is used interchangeably with the term design-bid-build.

Building contractor. This is the firm employed to construct a project. The term building contractor is used interchangeably in this research with the term builder.

Construction professional. This term refers to an employee of a building contractor.

Design-build. This is a project delivery strategy wherein the engineer and building contractor exist as a single entity that is contracted by a project owner.

Engineer. This term refers to the firm employed by an owner to design a project.

Engineer-procure-construct. This is a project delivery strategy wherein a single entity or partnership performs engineering, procurement, and construction.

Integrated project delivery (IPD). This is a collaborative delivery strategy wherein multiple parties work under a single contract (Moynihan & Harsh, 2016).

Purchasing agent. In this study, the term purchasing agent refers to a professional that performs procurement tasks for construction projects.

Limitations of the Study

The following limitations apply to this study:

1. The sample of supervisors who were subjects in this research may not be representative of supervisors in other companies or markets.
2. The sample of graduates who were subjects in this research may not be representative of graduates from other WTCS construction programs.
3. Convenience sampling was used in this study and may limit the extent to which the results can be generalized.
4. The sample size of six subjects may not adequately represent the population.
5. The researcher developed the questionnaires used in this study. They were not tested for validity or reliability.
6. The researcher obtained responses using several collection strategies which resulted in a unique experience for each respondent. This may have introduced interaction bias (Gall et al., 2003).
7. Respondent identity became known to the researcher when follow-up contact was required. This lack of anonymity could be a source of bias.

Chapter II: Literature Review

The purpose of this research was to investigate the adequacy of engineering, procurement, and collaborative curricula in WTCS construction management programs. The research was guided by the following objectives: (1) Identify engineering, procurement, and collaborative skills needed in the construction industry; (2) Measure the extent to which Wisconsin builders expect graduates that are prepared with engineering, procurement, and collaborative skills; and (3) Measure the extent to which WTCS construction management students are prepared to succeed on integrated projects. This chapter provides a summary of existing literature that identifies engineering, procurement, and collaborative skills.

General Engineering Skills

Tatum (2011) identified core engineering knowledge required for success in the construction industry. First, engineers need technical skills such as the ability understand specifications, plans, and constructability concepts. Engineers with these skills should be able to analyze relationships among construction resources and construction processes like the one between soil composition and the effectiveness of soil compaction methods. Engineers should recognize these variables and specify appropriate compaction methods in the design.

Second, engineers must be familiar with construction material characteristics including performance, availability, substitutions, and cost (Tatum, 2011). Engineers with this knowledge would likely be able to establish design parameters, evaluate construction methods, and select appropriate building materials. For example, skilled engineers should be able to design structural connections using bolts that are durable, readily available, and cost-effective.

Third, Tatum (2011) indicated that engineers should be able to select construction resources including temporary materials, tools, and equipment used for lifting, transporting, or

joining construction materials. To make these selections, engineers must understand temporary material characteristics like the strength of lumber used for concrete formwork construction and construction equipment capabilities like the lifting capacity of a crane used to hoist steel beams.

Finally, engineers must recognize the potential of their designs to affect field operations (Tatum, 2011). This awareness promotes favorable acceptance criteria, reduces risk, and may improve productivity. For example, a design that included unreasonable weld acceptance criteria would likely reduce a building contractor's welding efficiency and lead to increases in the cost of a project.

Harper and Hazleton (2014) reported additional engineering skill requirements such as proficiency with building information modeling (BIM) computer programs. Engineers use BIM programs to create navigable, three-dimensional jobsite models which enhance procurement, planning, and construction processes. In turn, construction supervisors may use BIM models to communicate project features such as the layout of fire hydrants relative to nearby roads and buildings.

Harper and Hazleton (2014) also reported that engineers should incorporate sustainability into their designs in order to conserve resources and reduce waste. Sustainability is often associated with the Leadership in Energy and Environmental Design (LEED) certification for engineers (U.S. Green Building Council, 2018). The LEED program recognizes achievement in sustainable design which promotes public health and environmental stewardship. In addition, project owners recognize that LEED certified projects result in operating efficiencies and, subsequently, long-term cost benefits. Engineers who understand sustainability concepts are more likely to select energy-efficient lighting, mechanical, and plumbing materials (Harper & Hazleton, 2014).

Similarly, engineers must be aware of lean construction principles which lower project cost, reduce waste, improve productivity, and increase customer satisfaction (Harper & Hazleton, 2014). Structural steel fabricators demonstrate lean principles by using a nesting process to cut complimentary beam lengths from a single piece of stock material. The nesting process allows the fabricator to plan the placement of cuts according to the relationships between the required beam lengths and nominal manufacturing lengths. For example, the fabricator may cut a thirty-foot beam and a nine-foot beam from a stock length of forty feet, generating only one foot of waste material. Engineers aware of similar lean construction principles are more likely to produce responsible designs.

Finally, engineers need communication, coordination, and cooperation skills to succeed on construction projects (Harper & Hazleton, 2014). The importance of these skills is highlighted by considering the variation in objectives held by project team members. A project owner may focus on the construction schedule, the engineer may place more value on quality control, and the building contractor may attend to productivity. While seemingly different, these three objectives relate to one another. In other words, schedule goals are met when production goals are met, and neither schedule nor production goals will be achieved if quality issues result in rework. Team members with communication, coordination, and cooperation skills can unite a project team by explaining the relationships between varying objectives.

In summary, the literature review revealed that engineers should be able to:

- read construction specifications and plans;
- understand constructability concepts;
- understand material characteristics;
- select appropriate materials, tools, and equipment;

- recognize the influence that project design has on field operations;
- use BIM programs proficiently;
- understand sustainability and lean construction concepts; and
- communicate, coordinate, and cooperate with team members.

Civil Engineering Skills

Civil engineers design roads, buildings, airports, tunnels, dams, bridges, water systems, and sewage systems (US Bureau of Labor Statistics [BLS], 2015). According to the American Society of Civil Engineers (ASCE), civil engineers should possess foundational, technical, and professional skills. Foundational skills include understanding mathematics, humanities, natural sciences, and social sciences. These skills provide a basis for developing the technical and professional skills required to be a civil engineer (Body of Knowledge Committee of the Committee on Academic Prerequisites for Professional Practice [BKCCAPPP], 2008). For example, an engineer would not be able to calculate the load-bearing capacity of a concrete foundation without first knowing the mathematical formulas used in the calculation.

ASCE reported a broad list of technical skills needed by civil engineers (BKCCAPPP, 2008). First, civil engineers should understand material science and mechanics. A civil engineer needs this knowledge to perform design calculations such as defining the loading conditions under which a steel-framed roof may fail. Similarly, civil engineers must be able to perform experiments, recognize field problems, and solve field problems (BKCCAPPP, 2008). These capabilities provide a framework for solving jobsite design conflicts. For example, if an embedded steel anchor conflicts with an embedded drain pipe and requires relocation, the engineer needs to understand the structural implications of moving the anchorage point.

Finally, civil engineers need a variety of professional skills related to leadership, communication, ethical responsibility, business administration, and public policy (BKCCAPPP, 2008). In practice, these skills cultivate a moral code and they encourage its enforcement. Engineers who feel responsible for public safety are more likely to design structures in accordance with recognized quality standards. If the interests of clients, builders, or other engineers obstruct efforts to adhere to these standards, engineers need communication, leadership, and business skills to stand firm in their convictions so that the standards will be met.

In summary, civil engineers should be able to:

- understand mathematics, humanities, natural sciences, and social sciences;
- understand material science and mechanics;
- perform experiments, recognize field problems, and solve field problems;
- lead, communicate, and uphold ethical responsibility; and
- understand business administration and public policy.

Mechanical Engineering Skills

Mechanical engineers design tools, sensors, engines, machines, and other devices (BLS, 2015). According to the University of Wisconsin-Madison, mechanical engineers should possess both general and technical skills (Board of Regents of the University of Wisconsin System, 2018). Like civil engineers, mechanical engineers need communication skills and competence in mathematics and science in order to support technical skill development. The technical skills identified by UW-Madison also resemble civil engineering skills. For example, mechanical engineers must design and conduct experiments, interpret and analyze data, identify and solve engineering problems, and understand the impact of engineering solutions.

In summary, mechanical engineers should be able to:

- communicate effectively;
- understand mathematics and science;
- design and conduct experiments;
- interpret and analyze data;
- identify and solve engineering problems; and
- understand the impact of engineering solutions.

Electrical Engineering Skills

Electrical engineers design electric motors, power generation equipment, radar systems, navigation systems, and communication systems (BLS, 2015). Similar to civil and mechanical engineers, electrical engineers require core competencies in science, calculus, and statistics (ABET, 2018). Additionally, the National Center for O*NET Development (O*NET) (2017a) reported that electrical engineers should demonstrate knowledge of computers, electronics, and software. These skills are needed when electrical engineers use BIM and other technology to design electrical components and systems. Finally, electrical engineers must understand technical concepts related to electrical science, digital logic, electromagnetic fields, and semiconductor devices (Cheville & Bunting, 2011). Electrical engineers may apply this knowledge when designing electrical lighting, power, and control systems for a project.

In summary, electrical engineers should be able to:

- understand science, calculus, and statistics;
- use computers, electronics, and software; and
- understand electrical science, digital logic, electromagnetic fields, and semiconductor devices.

Procurement Skills

Procurement skills are used by purchasing agents who procure materials for construction projects. O*NET (2017b) indicated that purchasing agents should be competent in assembling requisitions and purchase orders, administering contracts, soliciting bids, selecting suppliers, and negotiating. With these competencies, purchasing agents can secure materials that are affordable, available when needed, and compliant with project specifications. Construction purchasing agents must also know how to implement internal quality management systems, develop quality personnel, measure supplier performance, and manage risk (AlMaian, Needy, Walsh, & Alves, 2015). Purchasing agents can use these skills to prevent project delays and reduce safety risks that would have resulted from late or substandard materials. Finally, the American Production and Inventory Control Society (APICS) (2011) identified procurement skills such as managing logistics, distribution, and warehousing processes. These processes must function smoothly to ensure that the movement, storage, and delivery of materials will support the needs of construction crews.

In summary, purchasing agents should be able to:

- assemble requisitions and purchase orders;
- administer contracts, solicit bids, select suppliers, and negotiate;
- implement internal quality management systems, develop quality personnel, measure supplier performance, and manage risk; and
- manage logistics, distribution, and warehousing processes.

Collaborative Skills

Kuchera (2015) cited the presence of collaborative skills as one of the most important factors for success on integrated projects. The American Institute of Architects (AIA) and the

AIA California Council (2007) reported that integrated project team members should communicate openly, commit to team goals, and develop trust and respect. Successful teams also share knowledge, make value-based decisions, and make team decisions (Daswani, Poindexter, & Reed, 2015).

Knight (2008) suggested that the most important elements of successful integrated projects are team selection and effective leadership. The team leader must encourage trust, accountability, and respect for each member's contributions. Reed (2017), however, warned potential collaborators of the legal risks that result from the non-traditional roles introduced through integrated strategies. This cautionary message suggests that integrated project team members may also need to understand contract law.

In summary, integrated project team members should:

- communicate openly and commit to team goals;
- develop trust, respect, and accountability;
- share knowledge, make value-based decisions, and make team decisions;
- show respect for each member's contributions; and
- understand contract law.

Summary

The literature review revealed a variety of engineering, procurement, and collaborative skills. Many of the engineering skills were technical in nature such as interpreting, analyzing, designing, and solving. Procurement skills like assembling, reviewing, complying, and administering were also predominantly technical. However, both engineering and procurement literature specified a significant subset of collaborative skills needed to navigate relationships with project participants. Integrated projects require collaborative skills such as team decision-

making, commitment to team goals, and knowledge sharing, and they may also benefit from members who are versed in legal issues. The skills identified in this literature review became the basis for the data collection instrument described in Chapter III.

Chapter III: Methodology

The purpose of this research was to investigate the adequacy of engineering, procurement, and collaborative curricula in WTCS construction management programs. The research was guided by the following objectives: (1) Identify engineering, procurement, and collaborative skills needed in the construction industry; (2) Measure the extent to which Wisconsin builders expect graduates that are prepared with engineering, procurement, and collaborative skills; and (3) Measure the extent to which WTCS construction management students are prepared to succeed on integrated projects. This chapter will describe the methods used to obtain and analyze data.

Description of the Study

This study was completed in two phases. First, the researcher performed a literature review to identify engineering, procurement, and collaborative skills needed on integrated construction projects. Second, the researcher collected skill-related data from WTCS graduates and their supervisors. When choosing between qualitative and quantitative data collection, Patton (2002) suggested asking what type of data will illuminate the research objectives. Qualitative methods produce more detailed data that is less generalizable. Quantitative methods support statistical analysis of broader sets of data and produce generalizable results. In this study, the researcher determined that a quantitative method would produce data that was more meaningful with respect to the research objectives.

Researchers obtain quantitative data through causal-comparative, correlational, experimental, and descriptive methods (Gall et al., 2003). The researcher selected a descriptive method because this type of research produces statistics that (a) illustrate characteristics of a sample, and (b) may be useful to educators and policy makers (Gall et al., 2003). Specifically,

the researcher designed a descriptive study to illuminate the adequacy of engineering, procurement, and collaborative skill training in WTCS programs.

Subject Selection and Description

The population for this research included Construction Management Technology (CMT) and Construction Management (CM) program graduates and their supervisors. The researcher used convenience sampling to select a sample from the graduating classes of 2016 from FVTC and NWTC. Some researchers believe that inferential statistics are meaningless when derived from convenience samples. Gall et al. (2003) reported that convenience samples are used in more than ninety-five percent of social science research and are appropriate if the population and sample descriptions are carefully considered. The criteria for convenience samples is that they suit the purpose of a study and they are convenient for some other reason such as a common location. The sample in this study was selected for two reasons that align with the definition of a convenience sample. First, the researcher believed that recent program graduates and their supervisors were two credible sources to evaluate WTCS skill training. Second, the sample was convenient to locate through graduate reports from FVTC and NWTC.

Instrumentation

According to Gall et al. (2003), descriptive research relies heavily on instrumentation and often requires development of a unique instrument to collect the kind of data that the researcher intends to gather. For this study, the researcher developed closed-item questionnaires to collect demographic information and to measure graduate and supervisor satisfaction with skill training. Copies of the questionnaires are included in Appendices B and C.

To obtain the best quality data, the researcher addressed challenges related to the following factors: (1) validity, or the extent to which an item measures what the researcher

intended (Bott, 1996); (2) reliability, or the extent to which an item yields consistent results (Bott, 1996); and (3) respondent engagement, or the effort that respondents are willing to expend in order to provide meaningful responses. The following paragraphs explain the relevance of each factor to this study.

Validity. Validity is compromised when respondents interpret items differently than the researcher intended. The risk of interpretation error is particularly relevant in this study where technical language may not translate consistently across companies, markets, and geographic boundaries. The researcher considered an interview methodology that would provide opportunities for clarification if required. However, interviews introduce difficulties in standardizing the experience for each respondent (Gall et al., 2003). Carefully designed questionnaires limit interaction bias and increase validity by minimizing interpretation errors.

Gall et al. (2003) offered several questionnaire design guidelines which the researcher adopted to encourage accurate interpretation. These include limiting the use of complex terms, organizing items in a logical sequence, avoiding imprecise terms such as *most* or *usually*, stating items briefly, and avoiding negatively stated items and leading items. In addition to these practices, the researcher offered a *no opinion* response choice for skills that respondents considered irrelevant or unfamiliar. The researcher assumed that if a respondent was not familiar with a term, the term was unlikely to be relevant in the respondent's work and therefore was not a valid construct to measure for that respondent.

Validity is also compromised when respondents answer disingenuously or insincerely. Such answers may result when respondents distrust a researcher or feel that anonymity will be relinquished. Gall et al. (2003) reported that trust is particularly important when respondents are divulging negative information about themselves. To address potential trust issues, the

researcher acknowledged the lack of anonymity in the data collection process and assured subjects that direct identifiers would be removed in the analysis and reporting phases of the research. Additionally, the researcher selected item phrasing that emphasized the adequacy of training rather than individual competence.

Reliability. Questionnaires are said to have reliability issues if phrasing conventions would cause the same person to answer differently on separate occasions. Gall et al. (2003) indicated that using a Likert scale improves reliability when measuring opinions, perceptions, and attitudes. They also recommend phrasing items carefully, using at least ten items, and offering a *no opinion* response choice. The researcher used these strategies to encourage consistent interpretation and to clarify data analysis.

Engagement. Qualitative interviews were considered for this study. However, it is the researcher's opinion that the urgency present on construction projects would make it difficult to engage construction professionals for a sufficient time to produce meaningful responses. Instead, the researcher chose a quantitative, closed-item format to improve the quality of responses. Additionally, Gall et al. (2003) offered several organization, length, and phrasing guidelines that encourage the development of interesting questionnaire items. Many of these were incorporated into the design of questionnaires.

Considering the above factors, the researcher designed closed-item questionnaires based on the following principles: (1) researchers promote valid and reliable data by standardizing each respondent's experience; and (2) well-designed questionnaires are engaging and they encourage objective responses that are efficient for respondents and researchers alike (Gall et al., 2003). The University of Wisconsin-Stout Institutional Review Board for the Protection of Human Subjects in Research evaluated the questionnaires and deemed this study exempt from further

review. However, researchers are still ethically bound to follow principles of respect, beneficence, and justice (E. Buchanan, personal correspondence, February 12, 2018). Thus, the researcher advised respondents of their implied consent to participate and of the voluntary nature of the questionnaire.

Data Collection Procedures

The researcher identified potential participants by contacting seven employers that were listed in FVTC and NWTC graduate reports. The researcher contacted the human resources (HR) manager at each company by phone and then by email. The purpose of the initial contact was to introduce the researcher, explain the purpose and significance of the study, and obtain contact information for two subjects from each company – a recent graduate and a supervisor. During the initial phone conversations, the researcher followed a script to replicate the process as nearly as possible. The researcher also standardized the emails that were sent to each company. Copies of the introductory script and email template have been included in Appendices D and E.

If HR managers did not respond to the initial contact attempts, the researcher placed additional calls and sent additional emails. Two potential subjects were eliminated from the study when one HR manager did not respond to multiple contact attempts. Six more potential subjects were eliminated when HR managers from three companies declined to share employee contact information. In total, the introductions resulted in contact information for one supervisor and one graduate from each of three companies. These six subjects comprised the sample for the research.

The researcher provided, via email, an anonymous link that led each respondent to the questionnaire on the Qualtrics survey website. When no responses were returned, the researcher sent reminder emails. This effort resulted in one response. The researcher sent a second

reminder, and no additional responses were returned. Next, the researcher sent direct emails to each subject with the questionnaire items embedded in the body of the email, and two more responses were returned. The researcher obtained a fourth response by calling a subject and verbally administering the questionnaire. The two remaining subjects did not respond. Of the six subjects, four completed the questionnaire.

Data Analysis

The data was analyzed using three methods. First, the researcher calculated response frequency and descriptive statistics for each questionnaire item. Second, the researcher calculated overall average scores for engineering items, procurement items, and collaborative items. Third, the researcher calculated the average supervisor and average graduate scores for engineering items, procurement items, and collaborative items.

Gall et al. (2003) stated that some researchers believe statistical inferences are meaningless when made from studies that do not use random sampling. However, they suggested that it is appropriate to make statistical inferences from convenience samples if the sample and population have been carefully conceptualized. They also advised exercising caution in generalizing results to a population, based on a single study. When making inferences, readers should consider similarities of this sample to populations of interest and recognize that further research is likely required to validate findings.

Limitations

The following limitations apply to this study:

1. The sample of supervisors who were subjects in this research may not be representative of supervisors in other companies or markets.

2. The sample of graduates who were subjects in this research may not be representative of graduates from other WTCS construction programs.
3. Convenience sampling was used in this study and may limit the extent to which the results can be generalized.
4. The sample size of six subjects may not adequately represent the population.
5. The researcher developed the questionnaires used in this study. They were not tested for validity or reliability.
6. The researcher obtained responses using several collection strategies which resulted in a unique experience for each respondent. This may have introduced interaction bias (Gall et al., 2003).
7. Respondent identity became known to the researcher when follow-up contact was required. This lack of anonymity could be a source of bias.

Summary

The purpose of this research was to investigate the adequacy of engineering, procurement, and collaborative curricula in WTCS construction management programs. The researcher chose a descriptive study aimed at developing statistical information pertinent to educators and policy makers. The study involved two phases. First, the researcher reviewed existing literature to identify skill requirements. Next the researcher distributed quantitative questionnaires to collect skill-related data from the population sample. Results of the questionnaires are discussed in Chapter IV.

Chapter IV: Results

The purpose of this research was to investigate the adequacy of engineering, procurement, and collaborative curricula in WTCS construction management programs. The research was guided by the following objectives: (1) Identify engineering, procurement, and collaborative skills needed in the construction industry; (2) Measure the extent to which Wisconsin builders expect graduates that are prepared with engineering, procurement, and collaborative skills; and (3) Measure the extent to which WTCS construction management students are prepared to succeed on integrated projects. To investigate these objectives, the researcher administered questionnaires to WTCS graduates and their supervisors. This chapter describes the results from the questionnaires.

Demographics

The demographics section of the questionnaires requested that respondents identify target markets, delivery strategies, and geographic areas. Additionally, graduates were asked to identify whether they attended FVTC or NWTC. For all demographic items, respondents were to select *yes*, *no*, or *unsure*. Respondents were not limited to one “best-fit” choice but rather could select all applicable markets, strategies, areas, and institutions.

Target market. One respondent (25%) indicated involvement in residential construction, three respondents (75%) indicated commercial construction, two respondents (50%) indicated industrial construction, four respondents (100%) indicated retail construction, three respondents (75%) indicated infrastructure construction, and two respondents (50%) indicated other construction markets.

Delivery strategy. Three respondents (75%) indicated use of the bid-build strategy, two respondents (50%) indicated the design-build strategy, three respondents (75%) indicated the

construction manager strategy, zero respondents (0%) indicated the engineer-procure-construct strategy, and one respondent (25%) indicated using the IPD strategy.

Geographic area. Three respondents (75%) indicated serving eastern Wisconsin and four respondents (100%) indicated serving other geographic areas.

Institution. All four respondents (100%) indicated that graduates attended FVTC and zero respondents (0%) indicated that graduates attended NWTC.

Research Objective One Results

The researcher developed objective one in order to identify engineering, procurement, and collaborative skills needed in the construction industry. To accomplish objective one, the researcher reviewed existing literature that identified skills needed on integrated projects. As indicated in the following sections, the researcher identified fifteen of these skills that emphasize the spirit of integrated projects.

Engineering skills. The following list of engineering skills was selected for use on the questionnaire:

- ability to recognize design problems,
- ability to solve design problems,
- knowledge of material design concepts,
- knowledge of sustainability concepts, and
- knowledge of design principles.

Procurement skills. The following list of procurement skills was selected for use on the questionnaire:

- ability to manage suppliers,
- ability to manage customer relationships,

- ability to manage procurement risks,
- knowledge of logistics practices, and
- knowledge of warehousing practices.

Collaborative skills. The following list of collaborative skills was selected for use on the questionnaire:

- ability to commit to team goals,
- ability to make value-based decisions,
- ability to communicate openly,
- ability to show respect, and
- knowledge of contract law.

Research Objective Two Results

The researcher developed objective two in order to measure the extent to which Wisconsin builders expect graduates that are prepared with engineering, procurement, and collaborative skills. To accomplish objective two, the researcher designed a questionnaire item requesting that respondents identify the project delivery strategy used by their respective companies. Respondents were not limited to one “best-fit” choice, but rather could select all applicable strategies. Table 1 lists the percentage of respondents choosing each strategy.

Research Objective Three Results

The researcher developed objective three in order to measure the extent to which WTCS construction management students are prepared to succeed on integrated projects. To accomplish objective three, the researcher requested that respondents report satisfaction levels with training in each of the fifteen skills identified in the literature review. Response choices for each questionnaire item were presented in the form of a five-point Likert scale with the

Table 1

Prominence of Delivery Strategies

Strategy	Yes	No	Unsure
Design-bid-build	75%	25%	0%
Bid-build	75%	25%	0%
Design-build	50%	50%	0%
Construction manager	75%	0%	25%
Engineer-procure-construct	0%	75%	25%
Integrated project delivery	25%	50%	25%

following options: (1) extremely dissatisfied; (2) dissatisfied; (3) neutral; (4) satisfied; and (5) extremely satisfied. The researcher also included a *no opinion* option for instances when respondents did not understand a skill or did not consider the skill relevant. Most responses ranged from neutral to extremely satisfied, and none of the respondents selected *no opinion* for any item.

The data was analyzed using three methods. First, the researcher calculated response frequencies and average response scores for each item. Second, the researcher calculated the average score for the five engineering items, the average score for the five procurement items, and the average score for the five collaborative items. Third, the researcher compared supervisor response averages with graduate response averages for engineering items, procurement items, and collaborative items. The following paragraphs contain details from the first analysis method.

Results from questionnaire item one: Ability to recognize design problems. Two respondents (50%) indicated a neutral level and two respondents (50%) indicated that they were

satisfied. The average of supervisor responses was 4.0, the average of graduate responses was 3.0, and the overall average was 3.5.

Results from questionnaire item two: Ability to solve design problems. Two respondents (50%) indicated a neutral level and two respondents (50%) indicated that they were satisfied. The average of supervisor responses was 3.5, the average of graduate responses was 3.5, and the overall average was 3.5.

Results from questionnaire item three: Knowledge of material design. One respondent (25%) indicated extreme dissatisfaction, two respondents (50%) indicated a neutral level, and one respondent (25%) was satisfied. The average of supervisor responses was 2.5, the average of graduate responses was 3.0, and the overall average was 2.8.

Results from questionnaire item four: Knowledge of sustainability practices. One respondent (25%) was dissatisfied, one respondent (25%) indicated a neutral level, and two respondents (50%) indicated that they were satisfied. The average of supervisor responses was 3.0, the average of graduate responses was 3.5, and the overall average was 3.3.

Results from questionnaire item five: Knowledge of design principles. One respondent (25%) indicated a neutral level and three respondents (75%) indicated that they were satisfied. The average of supervisor responses was 4.0, the average of graduate responses was 3.5, and the overall average was 3.8.

Results from questionnaire item six: Ability to manage suppliers. One respondent (25%) indicated a neutral level, two respondents (50%) indicated that they were satisfied, and one respondent (25%) indicated extreme satisfaction. The average of supervisor responses was 4.5, the average of graduate responses was 3.5, and the overall average was 4.0.

Results from questionnaire item seven: Ability to manage customer relationships.

One respondent (25%) indicated a neutral level, two respondents (50%) indicated that they were satisfied, and one respondent (25%) indicated extreme satisfaction. The average of supervisor responses was 4.5, the average of graduate responses was 3.5, and the overall average was 4.0.

Results from questionnaire item eight: Ability to manage procurement risks.

Two respondents (50%) indicated a neutral level and two respondents (50%) indicated that they were satisfied. The average of supervisor responses was 3.5, the average of graduate responses was 3.5, and the overall average was 3.5.

Results from questionnaire item nine: Knowledge of logistics practices.

One respondent (25%) indicated a neutral level and three respondents (75%) indicated that they were satisfied. The average of supervisor responses was 4.0, the average of graduate responses was 3.5, and the overall average was 3.8.

Results from questionnaire item ten: Knowledge of warehousing practices.

Two respondents (50%) indicated a neutral level and two respondents (50%) indicated that they were satisfied. The average of supervisor responses was 4.0, the average of graduate responses was 3.0, and the overall average was 3.5.

Results from questionnaire item eleven: Ability to commit to team goals.

One respondent (25%) indicated a neutral level and three respondents (75%) indicated extreme satisfaction. The average of supervisor responses was 5.0, the average of graduate responses was 4.0, and the overall average was 4.5.

Results from questionnaire item twelve: Ability to make value-based decisions.

One respondent (25%) indicated a neutral level, two respondents (50%) indicated that they were

satisfied, and one respondent (25%) indicated extreme satisfaction. The average of supervisor responses was 4.0, the average of graduate responses was 4.0, and the overall average was 4.0.

Results from questionnaire item thirteen: Ability to communicate openly. One respondent (25%) indicated a neutral level and three respondents (75%) indicated extreme satisfaction. The average of supervisor responses was 5.0, the average of graduate responses was 4.0, and the overall average was 4.5.

Results from questionnaire item fourteen: Ability to act respectfully. One respondent (25%) indicated a neutral level and three respondents (75%) indicated extreme satisfaction. The average of supervisor responses was 5.0, the average of graduate responses was 4.0, and the overall average was 4.5.

Results from questionnaire item fifteen: Knowledge of contract law. One respondent (25%) indicated a neutral level and three respondents (75%) indicated that they were satisfied. The average of supervisor responses was 4.0, the average of graduate responses was 3.5, and the overall average was 3.8. Table 2 provides a summary of the first analysis method.

Table 2

Questionnaire Response Frequency

Response	Frequency	Percentage
Extremely dissatisfied	1	2%
Dissatisfied	1	2%
Neutral	20	33%
Satisfied	26	43%
Extremely satisfied	12	20%
No opinion	0	0%

The second analysis method was to calculate average scores for each group of items. The results indicated that respondents were least satisfied with training in engineering skills (3.4 out of 5 possible) followed by procurement skills (3.8 out of 5 possible) and then collaborative skills (4.3 out of 5 possible). The average of all scores was 3.8 out of 5 possible indicating that overall satisfaction levels are between “neutral” and “satisfied”. Figure 1 presents the results from the second analysis method.

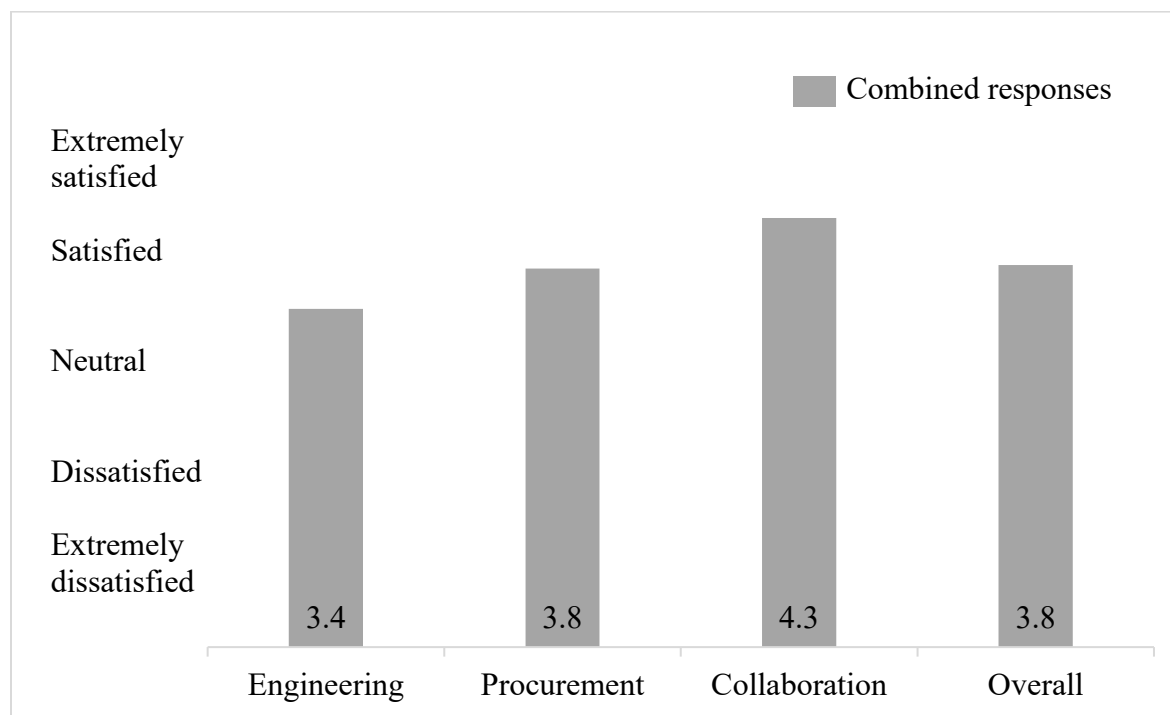


Figure 1. Combined satisfaction levels for each skill group.

The third analysis method was to compare average supervisor and average graduate scores in engineering, procurement, and collaborative item groups. In all three groups, supervisors reported higher satisfaction levels than graduates. The largest gaps were in procurement and collaborative skill groups. Figure 2 presents the results from the third analysis method.

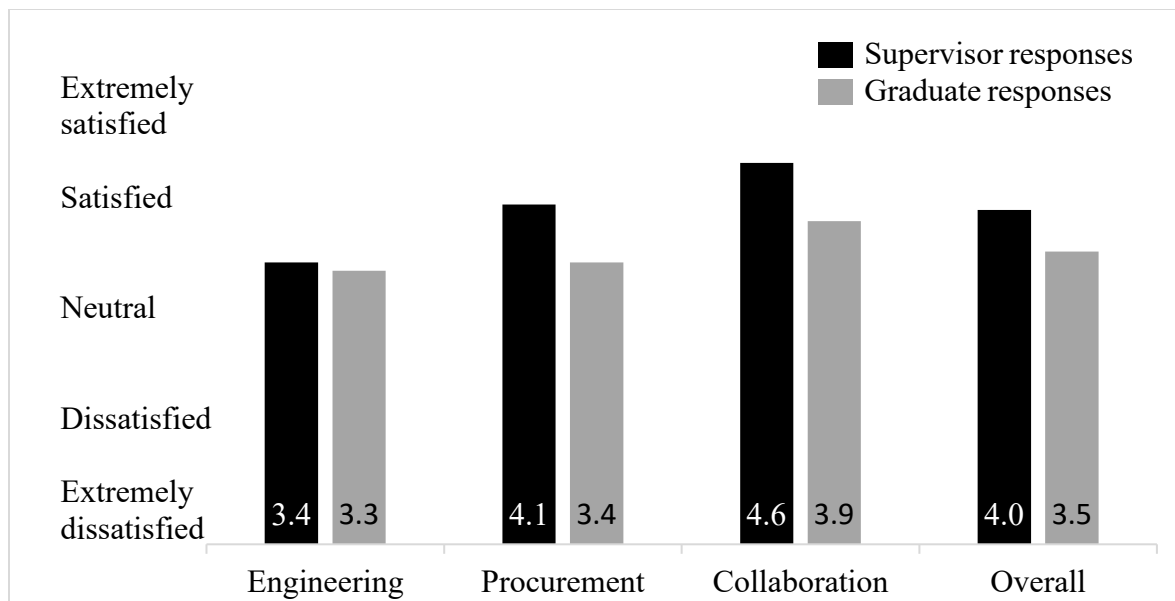


Figure 2. Comparison of satisfaction levels for each skill group.

Chapter V: Discussion

The purpose of this research was to investigate the adequacy of engineering, procurement, and collaborative curricula in WTCS construction management programs. The research was guided by the following objectives: (1) Identify engineering, procurement, and collaborative skills needed in the construction industry; (2) Measure the extent to which Wisconsin builders expect graduates that are prepared with engineering, procurement, and collaborative skills; and (3) Measure the extent to which WTCS construction management students are prepared to succeed on integrated projects. This chapter describes the researcher's conclusions, recommendations related to the study, and recommendations for future research.

Restatement of the Problem

It is unclear whether WTCS construction management programs adequately prepare students with the engineering, procurement, and collaborative skills needed on integrated projects. If the programs do not properly train students, graduate employability may be compromised.

Restatement of the Limitations of the Study

The following limitations apply to this study:

1. The sample of supervisors who were subjects in this research may not be representative of supervisors in other companies or markets.
2. The sample of graduates who were subjects in this research may not be representative of graduates from other WTCS construction programs.
3. Convenience sampling was used in this study and may limit the extent to which the results can be generalized.
4. The sample size of six subjects may not adequately represent the population.

5. The researcher developed the questionnaires used in this study. They were not tested for validity or reliability.
6. The researcher obtained responses using several collection strategies which resulted in a unique experience for each respondent. This may have introduced interaction bias (Gall et al., 2003).
7. Respondent identity became known to the researcher when follow-up contact was required. This lack of anonymity could be a source of bias.

Methodology

This study involved two phases. First, the researcher reviewed existing literature to identify skills that may be relevant to construction professionals working on integrated projects. Next, the researcher distributed closed-item questionnaires to a convenience sample of graduates and their supervisors. The data was analyzed using descriptive statistics and response-frequency methods. Prior to generalizing the results, readers should consider similarities of this sample to populations of interest and recognize that further research may be required to validate findings.

Conclusions for Research Objective One

The researcher developed objective one in order to identify engineering, procurement, and collaborative skills that are needed in the construction industry. The literature review revealed a variety of skills that emphasize the spirit of integrated projects, and the researcher selected fifteen skills to use as the basis for the questionnaires.

Due to the variety of skills identified during the literature review, the researcher concluded that there is no standard skill set for integrated projects. Every project requires a unique combination of skills that cannot be accurately measured with a universal questionnaire. However, the American Institute of Architects has developed a guide to IPD projects, and

organizations such as the American Society of Civil Engineers and the American Production and Inventory Control Society are leaders in skill identification. The researcher expects this trend to continue as integrated project models are defined more precisely.

Conclusions for Research Objective Two

The researcher developed objective two in order to measure the extent to which Wisconsin builders expect graduates that are prepared with engineering, procurement, and collaborative skills. All projects and delivery strategies involve collaboration by the project team. However, design-build, engineer-procure-construct, and IPD strategies emphasize engineering, procurement, and collaborative skills. Respondents were not limited to “best-fit” choices, but rather could select all applicable strategies. Two of the respondents (50%) indicated use of the design-build strategy, none (0%) selected the engineer-procure-construct strategy, and one respondent (25%) indicated use of the IPD strategy. In comparison, traditional strategies were more prominent. Three respondents (75%) selected the bid-build strategy and three (75%) selected the construction management strategy. The researcher concluded that the sample is more likely to use traditional delivery strategies than integrated strategies.

Conclusions for Research Objective Three

The researcher developed objective three in order to measure the extent to which WTCS construction management students are prepared to succeed on integrated projects. The data showed, that overall, the average skill training satisfaction level was 3.8 out of 5 or slightly below satisfied. Respondents indicated that they were satisfied with collaborative skill training (4.3 out of 5) and they were less than satisfied with engineering (3.4 out of 5) and procurement (3.8 out of 5) skill training. These scores suggest that there is room for improvement in engineering and procurement curricula compared to collaborative curricula. More specifically,

questions three and four, which dealt with material design and sustainability knowledge, received the lowest individual ratings (1 out of 5 and 2 out of 5, respectively) and lowest average ratings (2.8 out of 5 and 3.3 out of 5, respectively) out of all questions. These ratings suggest the need to evaluate engineering curricula related to material design and sustainability. Additionally, supervisors had more favorable perceptions of graduate skill training than graduates did. The difference in perceptions may indicate differences between graduate and supervisor expectations about performance standards or job duties.

Recommendations Related to the Study

Based on the results and conclusions of this study, the researcher recommends the following actions: (1) FVTC CMT curriculum developers should consult with an advisory board to explore potential gaps in curricula related to engineering and procurement skills; (2) FVTC CMT curriculum developers should review an existing task analysis with respect to engineering and procurement content and, specifically, content related to material design and sustainability concepts; (3) CMT program faculty should monitor future professional publications about project delivery strategies; and (4) supervisors and employees should thoroughly and frequently discuss actual and expected performance.

Recommendations for Future Research

Given the relative youth of integrated contracting strategies and the variations in construction projects, the potential impact of similar research is promising. Researchers should consider variations in markets, clients, and locations. Based on the results and conclusions of this study, the researcher recommends the following future research: (1) a similar study with another graduating class from the same institutions; (2) a pilot study of similar nature performed in another location served by Wisconsin technical colleges such as Milwaukee, Madison, Eau

Claire, or neighboring Minneapolis; and (3) a pilot study performed for Wisconsin bachelor's degree programs such as those offered by the University of Wisconsin-Stout in Menomonie and Milwaukee School of Engineering in Milwaukee.

References

- ABET. (2018). *Criteria for accrediting engineering programs, 2017-2018*. Retrieved from <http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2017-2018/>
- AlMaian, R. Y., Needy, K. L., Walsh, K. D., & Alves, T. C. L. (2015). Supplier quality management inside and outside the construction industry. *Engineering Management Journal*, 27(1), 11-22.
- American Institute of Architects [AIA]. (2007). *Integrated project delivery: A guide* (1st ed.). Washington, DC: American Institute of Architects & American Institute of Architects California Council.
- American Production and Inventory Control Society [APICS]. (2011). *APICS operations management body of knowledge framework* (3rd ed.). Chicago, IL: APICS The Association for Operations Management.
- Beck, E. (2012). Delivering IPD. *Architect*, 101(3), 31-32.
- Board of Regents of the University of Wisconsin System. (2018). *Bachelor of science in mechanical engineering*. Retrieved from <https://www.engr.wisc.edu/department/mechanical-engineering/academics/bachelor-of-science-in-mechanical-engineering/>
- Body of Knowledge Committee of the Committee on Academic Prerequisites for Professional Practice [BKCCAPPP]. (2008). *Civil engineering body of knowledge for the 21st century* (2nd ed.). Reston, VA: American Society of Civil Engineers.
- Bott, P. A. (1996). *Testing and assessment in occupational and technical education*. Needham Heights, MA: Allyn & Bacon.

- Cheville, A. & Bunting, C. (2011). Engineering students for the 21st century: Student development through the curriculum. *Advances in Engineering Education*, 2(4), 8-9.
- Daswani, R., Poindexter, J., & Reed, D. (2015). IPD: What's in it for the engineer? *Consulting-Specifying Engineer*, 52(5), 26-32.
- El Asmar, M., Hanna, A. S., & Loh, W. (2013). Quantifying performance for the integrated project delivery system as compared to established delivery systems. *Journal of Construction Engineering & Management*, 139(11), 1-14.
[http://dx.doi.org/10.1061/\(ASCE\)CO.1943-7862.0000744](http://dx.doi.org/10.1061/(ASCE)CO.1943-7862.0000744)
- Ellis, R. T. (2016). Integrated project delivery. *Engineered Systems*, July 2016, 18.
- Fox Valley Technical College. (2017). *Spring 2017 graduate employment research report: Employment status for class of 2016 and 2011*. Retrieved from <https://www.fvtc.edu/our-grads-get-jobs>
- Fox Valley Technical College. (2018). *Construction management technology*. Retrieved from <https://www.fvtc.edu/courses/construction/10-455-4/construction-management-technology>
- Gall, M. D., Gall, J. P., & Borg, W. R. (2003). *Educational research: An introduction*. Boston, MA: Allyn and Bacon.
- Harper, C. M., & Hazleton, R. (2014). New engineer's knowledge for success with subcontractors and trade partners. *Practice Periodical on Structural Design and Construction*, 19(1), 15-19.
- Knight, M. D. (2008). Teams, contracts, and BIM. *ASHRAE Journal*, 50(9), 72-80.
- Kuchera, S. S. (2015). Using IPD and lean in building design. *Consulting-Specifying Engineer*, 52(2), DE-1-DE-3.

- Moynihan, G. P., & Harsh, C. (2016). Evolution and current state of construction project delivery methods: A two stage investigation. *International Journal of Construction Project Management*, 8(1), 57-67.
- National Center for O*NET Development [O*NET]. (2017a). *Summary report for: 17-2071.00 – electrical engineers*. Retrieved from <https://www.onetonline.org/link/summary/17-2071.00>
- National Center for O*NET Development [O*NET]. (2017b). *Summary report for: 13-1023.00 - purchasing agents, except wholesale, retail, and farm products*. Retrieved from <https://www.onetonline.org/link/summary/13-1023.00>
- Northeast Wisconsin Technical College [NWTC]. (2017). *Graduate employers*. Retrieved from <https://www.nwtc.edu/student-experience/career-services/graduate-success/graduate-employers>
- Northeast Wisconsin Technical College [NWTC]. (2018a). *Construction management-carpentry associate degree*. Retrieved from <https://www.nwtc.edu/programs/fields-of-interest/architecture-and-construction/construction/carpentry-pathway/construction-management-carpentry>
- Northeast Wisconsin Technical College [NWTC]. (2018b). *Construction management-electricity associate degree*. Retrieved from <https://www.nwtc.edu/programs/fields-of-interest/architecture-and-construction/construction/electricity-pathway/construction-management-electricity>

Northeast Wisconsin Technical College [NWTC]. (2018c). *Construction management-masonry associate degree*. Retrieved from <https://www.nwtc.edu/programs/fields-of-interest/architecture-and-construction/construction/masonry-pathway/construction-management-masonry>

Patton, M. Q. (2002). *Qualitative research & evaluation methods* (5th ed.). Thousand Oaks, CA: Sage Publications, Inc.

Post, N. M., & Leonidas, T. Jr. (2010). Integrated-project-delivery boosters ignore many flashing red lights. *Engineering News Record*, 264(15), 22-25.

Reed, B. (2017). *Integrated project delivery; Important caveats to consider*. Retrieved from <http://neworleanscitybusiness.com/blog/2017/01/23/integrated-project-delivery-important-caveats-to-consider/>

Tatum, C. B. (2011). Core elements of construction engineering knowledge for project and career success. *Journal of Construction Engineering and Management*, 137(10), 745-750.

US Bureau of Labor Statistics [BLS]. (2015). *Occupational outlook handbook: Architecture and engineering occupations*. Retrieved from <https://www.bls.gov/ooh/architecture-and-engineering/home.htm>

U.S. Green Building Council. (2018). *How LEED works*. Retrieved from <https://new.usgbc.org/leed#how-leed-works>

Wisconsin Technical College System [WTCS]. (2018a). *Type of degrees/credentials*. Retrieved from <http://www.wistechcolleges.org/your-education/types-degreescredentials>

Wisconsin Technical College System [WTCS]. (2018b). *Career pathways*. Retrieved from <http://www.wistechcolleges.org/preparing-college/resources-help-you-succeed/career-pathways>

Appendix A: WTCS A.A.S. Construction Management Programs

Institute: Fox Valley Technical College

Program: Construction Management Technology

Catalog Description: *Are you ready to move up to project manager or supervisor in residential, commercial or industrial construction? This program will give you the necessary skills to determine the human, physical, and financial resources necessary for project activities. You'll learn to control costs, manage documents, and supervise others to be an effective project manager. Your training will include work with subcontractors, suppliers, and field staff to learn how to provide timely, cost-effective project completion. If you have limited construction background, internships will give you valuable experience. You will be well prepared to assume the duties of a construction project manager.*

Course Name	Cr.
Site Layout and Construction	2
Introduction to Construction Management	1
Understanding Construction Drawings	1
Construction Safety Management	2
Foundation Systems	2
Structural Systems	2
Exterior Enclosure Systems	2
Interior Building Finishes	2
Construction Management Internship	2
Construction Management Field Study	1
Principles of Accounting	3
Supervision	3
Construction Estimating	2
Construction Contracts & Law	2
Construction Scheduling	2
Revit Architecture	2
Mechanical, Electrical, & Plumbing Systems	3
Construction Engineering Fundamentals	3
Construction Project Management	2
Computer-Integrated-Construction	2
Sustainable Design and Construction	2
Construction Financial Management	2
Written Communication	3
Oral/Interpersonal Communication	3
College Technical Math 1A	3
College Physics 1	3
Economics	3
Psychology of Human Relations	3
Total Credit Hours	63

(Fox Valley Technical College, 2018).

Institute: Northeast Wisconsin Technical College
Program: A.A.S. Construction Management – Carpentry

Catalog Description: *The Construction Management - Carpentry associate degree is designed to provide fundamental job management skills to those already working in the trade to advance their career in the construction field. Subject areas covered include managing construction costs, project and personnel management, site supervision, estimating, and project scheduling.*

Course Name	Cr.
College 101	1
OSHA 30	1
Math 1-Trades	2
Introduction to Carpentry	1
Floor Framing Systems	3
Wall Framing Systems	3
Roof & Ceiling Framing Systems	3
Building Codes - Carpentry	1
Carpentry Prints & Specifications	2
Masonry for Carpenters	2
Carpentry Estimating	2
Exterior Building Finishes	3
Interior Building Finishes	3
Stairs & Cabinets	3
Carpentry Internship	1
Building Materials in Construction	2
Contract Documents & Construction Law	2
Planning & Scheduling	2
Economics	3
Mathematical Reasoning	3
Supervision	3
Introduction to Psychology	3
Construction Project Management	2
Introduction to Construction Estimating	2
Construction Productivity & Cost Management	2
English Composition 1	3
Oral/Interpersonal Communication	3
Introduction to Sociology	3
Introduction to Diversity Studies	3
Total Credit Hours	67

(Northeast Wisconsin Technical College [NWTC], 2018a).

Institute: Northeast Wisconsin Technical College
Program: A.A.S. Construction Management – Electricity

Catalog Description: *The Construction Management - Electricity associate degree is designed to provide fundamental job management skills to those already working in the trade to advance their career in the construction field. Subject areas covered include managing construction costs, project and personnel management, site supervision, estimating, and project scheduling.*

Course Name	Cr.
College 101	1
Residential Electrical Code 1	2
Residential Electrical Code 2	2
Introduction to Residential Circuits	2
Residential Circuits & Design	2
Residential Wiring	2
DC Circuits	2
Fundamentals of Electricity	2
OSHA 30	1
Math-Algebra/Trades	2
Commercial Electrical Code	2
Industrial Code	2
Industrial Controls	2
Electric Motor Control	2
Commercial Wiring Techniques	2
Motors/Transformers	2
AC Circuits	2
Building Materials in Construction	2
Contract Documents & Construction Law	2
Planning & Scheduling	2
Economics	3
Mathematical Reasoning	3
Supervision	3
Introduction to Psychology	3
Construction Project Management	2
Introduction to Construction Estimating	2
Construction Productivity & Cost Management	2
English Composition 1	3
Oral/Interpersonal Communication	3
Introduction to Sociology	3
Introduction to Diversity Studies	3
Total Credit Hours	68

(NWTC, 2018b).

Institute: Northeast Wisconsin Technical College
Program: A.A.S. Construction Management – Masonry

Catalog Description: *The Construction Management- Masonry associate degree is designed to provide fundamental job management skills to those already working in the trade to advance their career in the construction field. Subject areas covered include managing construction costs, project and personnel management, site supervision, estimating, and project scheduling.*

Course Name	Cr.
College 101	1
OSHA 30	1
Math 1-Trades	2
Introduction to Masonry	1
Masonry Fundamentals	3
Block Masonry	3
Brick Masonry	3
Advanced Brick & Block Masonry	3
Masonry Prints & Specifications	2
Masonry Estimating	2
Stone Masonry	3
Tile Fundamentals	3
Concrete Structures & Flatwork	3
Decorative Concrete	3
Building Materials in Construction	2
Contract Documents & Construction Law	2
Planning & Scheduling	2
Economics	3
Mathematical Reasoning	3
Supervision	3
Introduction to Psychology	3
Construction Project Management	2
Introduction to Construction Estimating	2
Construction Productivity & Cost Management	2
English Composition 1	3
Oral/Interpersonal Communication	3
Introduction to Sociology	3
Introduction to Diversity Studies	3
Total Credit Hours	69

(NWTC, 2018c).

Appendix B: Supervisor Questionnaire

The purpose of this research is to measure the adequacy of engineering, procurement, and collaborative skill training provided in Wisconsin Technical College construction management programs.

Please indicate whether your company employs graduates from the following institutions.

Institution	Yes	No	Unsure
Fox Valley Technical College			
Northeast Wisconsin Technical College			

Considering employees that may have graduated from FVTC or NWTC, indicate your satisfaction level with employee performance in each of the following categories.

- 1 = Extremely Dissatisfied
- 2 = Dissatisfied
- 3 = Neutral
- 4 = Satisfied
- 5 = Extremely Satisfied
- 0 = No Opinion

1	2	3	4	5	0	
						Ability to recognize design problems
						Ability to solve design problems
						Knowledge of material design
						Knowledge of sustainability practices
						Knowledge of design principles
						Ability to manage suppliers
						Ability to manage customer relationships
						Ability to manage procurement risks
						Knowledge of logistics practices
						Knowledge of warehousing practices
						Ability to commit to team goals
						Ability to make value-based decisions

						Ability to communicate openly
						Ability to act respectfully
						Knowledge of contract law

The remaining questions are about demographics. Please indicate whether each of the following phrases describes your company's market.

Target market	Yes	No	Unsure
Residential construction			
Commercial construction			
Industrial construction			
Retail construction			
Institutional construction			
Infrastructure construction			
Other type of construction			

Please indicate whether each of the following phrases describes your company's project delivery strategy.

Delivery strategy	Yes	No	Unsure
Design-bid-build			
Bid-build			
Design-build			
Construction manager			
Engineer-procure-construct			
Integrated project delivery			

Please indicate whether each of the following phrases describes your company's market area.

Area served	Yes	No	Unsure
Eastern Wisconsin			
Other			

Appendix C: Graduate Questionnaire

The purpose of this research is to measure the adequacy of engineering, procurement, and collaborative skill training provided in Wisconsin Technical College construction management programs.

Please indicate if you are a graduate of the following programs.

Institution	Yes	No	Unsure
Fox Valley Technical College			
Northeast Wisconsin Technical College			

Indicate your satisfaction level with your collegiate preparation in each of the following categories.

1 = Extremely Dissatisfied

2 = Dissatisfied

3 = Neutral

4 = Satisfied

5 = Extremely Satisfied

0 = No Opinion

1	2	3	4	5	0	
						Ability to recognize design problems
						Ability to solve design problems
						Knowledge of material design
						Knowledge of sustainability practices
						Knowledge of design principles
						Ability to manage suppliers
						Ability to manage customer relationships
						Ability to manage procurement risks
						Knowledge of logistics practices
						Knowledge of warehousing practices
						Ability to commit to team goals
						Ability to make value-based decisions

						Ability to communicate openly
						Ability to act respectfully
						Knowledge of contract law

The remaining questions are about demographics. Please indicate whether each of the following phrases describes your company's market.

Target market	Yes	No	Unsure
Residential construction			
Commercial construction			
Industrial construction			
Retail construction			
Institutional construction			
Infrastructure construction			
Other type of construction			

Please indicate whether each of the following phrases describes your company's project delivery strategy.

Delivery strategy	Yes	No	Unsure
Design-bid-build			
Bid-build			
Design-build			
Construction manager			
Engineer-procure-construct			
Integrated project delivery			

Please indicate whether each of the following phrases describes your company's market area.

Area served	Yes	No	Unsure
Eastern Wisconsin			
Other			

Appendix D: Telephone Scripts

Introductory phone call to Human Resource managers:

Hello, and thank you for taking my call. I am a graduate student in UW-Stout's career and technical education program. I'm studying the effectiveness of construction management programs at Fox Valley and Northeast Wisconsin technical colleges.

I've called to request your help in identifying two participants for a short, anonymous, online survey that I hope will lead to improvements in Wisconsin Technical College construction programs. If you would kindly provide an email address, I will summarize my entire request in a short email.

Thank you for helping construction education programs.

Voicemail #1:

I am a graduate student at UW-Stout and I'm researching the effectiveness of construction management programs at Fox Valley and Northeast Wisconsin technical colleges. I would like to speak with a human resource professional at (company name omitted) about my research. Please return my call at your earliest convenience to discuss how we would both benefit from this important study. My phone number is (phone number omitted). Thank you for your consideration.

Voicemail #2:

I am a graduate student at UW-Stout and I'm following up about a voicemail I left on (date omitted). I'm researching the effectiveness of construction management programs at Fox Valley and Northeast Wisconsin technical colleges. I would like to speak with a human resource professional at (company name omitted) about my research. Please return my call at your earliest convenience. My phone number is (phone number omitted). Thank you for your consideration.

Appendix E: Email Template

Email:

(Addressee name omitted),

Thank you for taking my call today. I'm researching the effectiveness of construction management programs at Fox Valley (FVTC) and Northeast Wisconsin (NWTC) technical colleges.

I'm requesting your help to identify two participants for a short, anonymous, online survey that I hope will lead to improvements in Wisconsin Technical College construction programs. Please provide contact information for (1) an employee who studied construction management at FVTC or NWTC, and (2) a manager likely to supervise program graduates.

Employee

First name:

Email:

Supervisor

First name:

Email:

I will email each participant a link to an anonymous survey using the Qualtrics survey platform. The survey is voluntary and has been reviewed by UW-Stout's Institutional Review Board and by my research advisor. No company or employee names will be collected or reported. Please contact me by phone or email if you have any questions.

Please respond by (date omitted). Thank you again for contributing to this important research.

Sincerely,

(signature and contact information omitted)