# An Analysis of Mechanical and Electrical Construction Competencies in the Wisconsin and Minnesota Construction Industry

By

Richard A. Larrabee

A Research Paper
Submitted in Partial Fulfillment of the
Requirements for the
Master of Science Degree
In

Career and Technical Education

Approved: Two (2) Semester Credits

Dr. Hans Timper

The Graduate School

University of Wisconsin-Stout

May 2007

**The Graduate School**
**University of Wisconsin-Stout**
**Menomonie, WI**

**Author:** **Larrabee, Richard A.**

**Title:** **Analysis of Mechanical and Electrical Construction Competencies in the Wisconsin and Minnesota Construction Industry**

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

**Research Advisor:** **Hans Timper, Ed.D.**

**Month/Year:** **May, 2007**

**Number of Pages:** **75**

**Style Manual Used: American Psychological Association, 5th edition**

## ABSTRACT

The purpose of this study was to identify competencies (tasks, skills, and responsibilities) needed to effectively and productively work as project managers in the field of mechanical and electrical construction. Nine members of the UW-Stout Construction Program Advisory Board, who function in the capacity of owner and/or project manager for their respective mechanical and electrical construction companies, were interviewed for this study. The geographical area where surveys were distributed was limited to Wisconsin and Minnesota; however the majority of respondents perform work nationally as well.

The interview included 18 questions, seven of which were demographic in nature and the remaining 11 were open ended questions related to perceived competencies in the mechanical and electrical construction industry. Interview responses were evaluated, consolidated, and summarized in relationship to reoccurring themes, concepts, and ideas

which possibly define competencies in the mechanical and electrical construction industry. The final analysis consolidated and summarized the overall list of responses into 25 general competencies which are listed in Chapter 5. The UW-Stout Construction Program will use these mechanical and electrical competencies to assist in the development of curriculum for the mechanical and electrical construction minor.

The Graduate School

University of Wisconsin Stout

Menomonie, WI

## Acknowledgments

I would like to especially thank my wife Barb for her continued love, support, and help as I pursued still yet, another dream. After 25 years, it remains an exciting adventure. I love you. I would like to also thank my children; Hannah, Ben, Rachel and Emily for all your love and support during this time of our lives together. You each have made unselfish sacrifices in order for me to complete my master's degree.

I would also like to acknowledge others who assisted me completing this study:

- Dr. Lee for your instruction, humor, positive affirmation, and continuing assurance that it was possible to complete my Master's Degree in one year.
- Dr. Timper for giving me the opportunity to teach others, being a positive mentor, and all your assistance in completing this paper.
- Rod Hildahl for your friendship, encouragement, and unselfish sacrifice.
- Participating members of the Construction Program Advisory Board, thank you for your dedication and commitment to the advancement and success of the UW-Stout Construction Program.

Most importantly I would like to thank my Lord and Savior, Jesus Christ for answered prayers. You were faithful and continually met my family's needs during this time. My prayer is that in pursuing Your will for my life that I remain faithful and use the talents and abilities You have blessed me with.

TABLE OF CONTENTS

.....Page

ABSTRACT.....ii

List of Tables.....vi

Chapter I: Introduction .....1

*Background* ..... 1

*Statement of the Problem*.....5

*Purpose of the Study*.....5

*Research Objectives* .....6

*Justification for the Study* .....6

*Limitations of the Study* .....8

*Definitions of Terms*.....9

Chapter II: Literature Review.....10

*Introduction* .....10

*History* .....10

*Current Program* .....11

*Construction Industry Competencies* .....13

*Task Analysis* .....27

*Summary* .....32

Chapter III: Methodology.....34

*Introduction* .....34

*Subject Selection and Description* .....34

*Instrumentation*.....35

*Data Collection and Recording*.....35

*Data Processing and Analysis*.....36

*Limitations of Technology*.....36

*Summary*.....37

Chapter IV: Results and Discussion.....38

*Demographics* .....38

*Research and Item Analysis*.....41

*Summary of Findings* .....53

Chapter V: Summary, Conclusion, and Recommendations.....54

*Summary* .....54

*Findings* .....55

*Conclusions*.....57

*Recommendations for Future Studies*.....58

References.....60

Appendix A: Interview Questions.....63

Appendix B: Cover Letter .....66

Appendix C: Consent to Participate in UW-Stout Approved Research.....68

# List of Tables

Table 1: Divisions of the Construction Industry.....39

Table 2: Categories of the Construction Industry.....40

Table 3: States Respondents Perform Work.....41

# Chapter I: Introduction

## *Background*

Building construction directly and indirectly impacts the lives of everyone in America. Construction plays a vital role in the employment of its citizens and the economy of America. There are over six million people employed annually in the building industry, in one segment or another, in the United States (Feirer & Feirer, 2004). Employment is directly related to the physical activities of building and managing construction and indirectly related to activities associated with the equipment, manufacturing and delivery of the materials used in construction. For every billion dollars spent for new construction, 47,000 jobs are created, of which 13,000 jobs are directly related to construction itself (Clough, Sears, & Sears, 2005). It is estimated that the direct and indirect expenditures associated with construction accounts for over 10% of the gross national product (Nunnally, 1993).

The construction industry is divided into four general classifications or markets: residential, building, engineering, and industrial (Clough, Sears, & Sears, 2005). Construction companies tend to operate in one of the classifications and focus their attention and resources on meeting that specific need in society. In previous years, construction companies would employ and provide the majority of resources and services necessary to complete the entire project from start to finish, relying very little on outside resources. Today however, as a result of changes in the size and complexity of the majority of construction projects, one construction company cannot perform all the activities and provide all the materials and resources necessary to complete an entire construction project. Therefore, the majority of construction projects completed today

consist of one entity, often referred to as a general contractor, overseeing many different entities, known as specialty contractors, subcontractors, and material suppliers in the completion of a construction project.

Construction companies are further classified into two different categories depending on the scope of their work in relationship to building construction, general contractors, and specialty contractors. General contractors typically contract with the owner of the project and provide all the management, equipment, and services necessary to complete a project. Specialty contractors (subcontractor) limit the scope of their work to specific activities associated with the construction project (Nunnally, 1993). The primary specialty contractors on the majority of building projects are involved in the installation of the mechanical systems: plumbing, heating, ventilating, and air conditioning (HVAC), and electrical systems.

The construction industry has earned the reputation of having the second highest failure rate among all other businesses as a result of having inexperienced, incompetent and poorly trained construction managers (Clough, Sears, & Sears, 2005). Building construction is constantly changing as a result of a variety of factors; the development of new construction materials, building components, governmental regulations, economic and environmental factors, and the complexity of modern building and remodeling projects. Companies that effectively manage all areas of the construction project, from start to finish, are those who continue to grow and succeed in a highly competitive industry (Nunnally, 1993).

At the start of a project, a project manager is assigned to coordinate, schedule, and oversee each phase of construction. The project manager's knowledge of the overall

building process, materials, and systems has to be sufficient enough to meet the daily challenges involved in managing the construction project. Many of the skills necessary to be a qualified project manager are acquired through further education at colleges offering programs in construction management. There are many colleges throughout the United States that offer accredited programs in construction management.

University of Wisconsin-Stout (UW-Stout) offers a Bachelor of Science degree in Construction which is accredited through the American Council for Construction Education (ACCE). "UW-Stout's Construction Program is designed to produce leaders with the organizational, analytical, technical and communication abilities to direct the most complicated construction operations" (UW-Stout Construction, 2005, n.p.). The UW-Stout Construction Program has been very successful in meeting the needs of the construction industry by providing the industry with experienced and qualified graduates, with placement rates at 100% for the past five years (UW-Stout Career Services, n.d.a; n.d.b; n.d.c; n.d.d; n.d.e). As construction projects continue to increase in complexity as a result of changes in standards, types of materials, environmental and energy issues, all of which relate directly to mechanical and electrical systems, the need for project specific managers will continue to grow (Nich, n.d.).

The majority of construction graduates work in general construction companies, with very few working for specialty contractors in the area of mechanical or electrical construction. With the exception of large utility and municipal construction projects, specialty contractors typically do not oversee the operation and management of the construction project, although their contracts may often account for as much as 50% of the overall project cost (Tao & Janis, 2001).

One area which is experiencing some of the greatest innovations and changes in technology is in the field of mechanical and electrical construction. UW-Stout's Construction Program requires graduates to complete two semesters related to mechanical and electrical systems. The two required courses are Environmental Systems I and II, one focusing on heating, ventilating, and air conditioning systems and the other focusing on plumbing, electrical, and illumination systems (UW-Stout, n.d.). The objectives of these two courses meet the demands of graduates working as and for general contractors which require a general knowledge of mechanical and electrical systems. According to David Nielsen, Vice President Parsons (personal communication, February 1, 2007) and Ken Fermanich, Project Director Cherne Contracting Corporation, (personal communication, February 2, 2007), the current coursework does not provide graduates with the depth of knowledge and experience necessary to manage the construction, installation, and operation of large industrial, mechanical, and electrical projects. The UW-Stout Construction Program Industry Advisory Board, consisting of over 30 general contractors, specialty contactors, and construction industry suppliers, recognizes the need in the construction industry for, and has requested the development and implementation of, a minor in mechanical and electrical construction. The intention is to provide additional competencies in the area of mechanical and electrical construction for graduates seeking to gain employment working for specialized mechanical and electrical contractors and provide graduates working as general contractor's greater knowledge related to mechanical and electrical construction (UW-Stout Construction Program, 2006). Advanced and higher level training and education are required to provide graduates with the skills needed to successfully operate and compete

in the field of mechanical and electrical construction in the area of heating, ventilating, air conditioning, plumbing, and electrical systems.

*Statement of the Problem*

The construction industry continues to evolve and become more highly technical, computerized, and automated in the field of mechanical and electrical construction. UW-Stout's Construction Program is successful in providing construction managers with the skills necessary to function as a project manager for the majority of general contractors operating in the construction industry. However, additional education needs to be provided that educates and trains students in the highly technical field of mechanical and electrical construction. The mechanical and electrical competencies (tasks, skills, and responsibilities) are necessary to move the Construction Program forward in developing the objectives and coursework required for a minor in mechanical and electrical construction.

*Purpose of the Study*

The purpose of this study was to identify the competencies (tasks, skills, and responsibilities) needed to effectively and productively work as project managers in the field of mechanical and electrical construction. Owners and project managers of construction businesses related to the mechanical and electrical industry were interviewed to provide the data and statistics necessary to analyze and determine the required competencies of students graduating with the mechanical and electrical construction minor. The geographical area where surveys were distributed was limited to Wisconsin and Minnesota. The UW-Stout Construction Program will also use these mechanical and

electrical competencies for development of coursework and curriculum for the mechanical and electrical construction minor.

*Research Objectives*

This research addressed the following objectives:

1. Identify the competencies of project managers in the mechanical and electrical construction industry.

2. Categorize competencies based on three specific areas of mechanical and electrical construction: plumbing, HVAC, and electrical.

3. Determine if there is a difference in project manager's competencies in relationship to the size of the mechanical and electrical construction company.

*Justification for the Study*

Determination of the mechanical and electrical competencies is justified as follows:

1. As mechanical and electrical systems continue to evolve into more highly developed, computerized, and mechanized systems, greater competencies of the overall mechanical and electrical systems are necessary for project managers working in the construction industry. UW-Stout's current mechanical and electrical construction courses may lack sufficient depth or are unable to cover material needed of graduates entering the field of mechanical and electrical construction. Determining competencies necessary to productively work and manage projects in the mechanical and electrical industry will provide UW-Stout with a list of competencies to develop the mechanical and electrical construction minor.

2. There are many colleges that offer construction-management oriented degrees comparable to the Construction Program at UW-Stout. Using the research data to further develop a mechanical and electrical construction minor provides graduates with another level of competency and experience which may not be available at other universities. UW-Stout's construction graduates earning a minor in mechanical and electrical construction should be more marketable when compared to other graduates and more marketable than graduates from universities offering only a construction-management oriented degree.

3. Data collected should be used to evaluate the objectives and competencies of the current mechanical and electrical construction courses required by the Construction Program. Making a comparison between the existing objectives and objectives based on new research should alleviate any repetition between existing courses and new courses developed for the mechanical and electrical construction minor.

4. Other universities offering a construction-management oriented degree could use all or segments of the data to evaluate competencies of their existing mechanical and electrical construction courses or develop new courses in mechanical and electrical construction. With a global emphasis on environmental issues, concerns about conserving and optimizing natural resources, the development and management of mechanical and electrical systems will continue to expand, thus increasing the demand for graduates with a background in mechanical and electrical construction, not only in the America, but throughout the world.

*Limitations of the Study*

The following are limitations to the study:

1. The majority of research was restricted to business and industry located in Wisconsin and Minnesota and may have limitations to other parts of the United States or world. Each geographical area of the United States and world are different from another. Examples of different geographical characteristics are type and availability of labor, material and equipment resources, work ethic, skill level, education level, seasonal and environmental conditions, and political affiliation.

2. The research utilized an interview using a list of questions developed, constructed, delivered, and analyzed by the researcher. This may result in human errors in delivery, collection, interpretation, lack of appropriate data, and analysis not intended or foreseen by the researcher.

3. Research and analysis provided is current as of the data in which the research took place and was presented. Due to constantly changing information and technology in the field of mechanical and electrical construction, collected data related to specific competencies of managing mechanical and electrical systems may become outdated and need to be evaluated and assessed on a continual basis.

*Definition of Terms*

*American Council for Construction Education (ACCE).* Accredits construction education programs in colleges and universities with four year baccalaureate degree programs in construction, construction science, construction management, and construction technology (ACCE; 2007).

*Competencies.* Suitable or sufficient skills and knowledge to perform required tasks (Dictionary.com.Online).

*General Contractor.* The inclusive contractor who oversees and is responsible for all the work performed, including subcontractor work, on construction project. (RS Means Dictionary.Online).

*Gross National Product (GNP).* "The total monetary value of all goods and services produced in a country during one year" (Dictionary.com.Online).

*Project Manager.* Individual person designated to manage a specific project including administrative and technical responsibilities (RS Means Dictionary.Online).

*Specialty Contactor.* Contractor who performs work associated with one specific trade. Also known as subcontractor (Contractor School Online®.Online).

*Subcontractor.* Contractor under contract to prime or general contractor to perform a specific portion of the project (RS Means Dictionary.Online).

# Chapter II: Literature Review

## *Introduction*

This chapter will include a discussion on the history of the Construction Program at UW-Stout, followed by an overview of UW-Stout's current Construction Program, and content related to electrical and mechanical construction. In addition, a general list of competencies (tasks, duties, and responsibilities) associated with working in the construction industry will be formulated. The chapter will conclude with a discussion concerning the methods and procedures used to facilitate a task analysis.

## *History*

UW-Stout's Construction Program originated as a concentration within the Industrial Technology degree. In 1965, UW-Stout became a member of the Associated Schools of Construction (ASC) and the Building Construction Concentration was implemented in 1969. This Building Construction Concentration was replaced by the current Construction degree in 1989, was initially accredited by the American Council for Construction Education (ACCE) in 1994, and reaccredited in 1999 and 2004 (Timper, 2004). UW-Stout is one of 60 colleges accredited by ACCE with a baccalaureate construction degree (ACCE, 2007).

During the 20 years of the Industrial Technology – Building Construction Concentration (1969 and 1989), the student enrollment fluctuated between 150 to 250 students (Timper, 2004). After starting in 1989, the Construction Program has grown to its current 2006 enrollment of 473 students. The program's enrollment increased 62% in the past eight years from 292 students in 1998 to its current enrollment (UW-Stout, 2002-2003; 2005-2006).

UW-Stout Registration and Records indicated the number of graduates from the Industrial Technology – Building Construction Concentration was 108 students total from 1984 – 1989. During the past eight years (1989-1996), the number of graduates from the B.S. Construction ranged from a low of 34 in 1998 to a high of 70 graduates in 2006 (L. Graves, personal communication, March 14, 2007). Mitchell Spencer, Construction Program Director, estimates the number of graduates for 2007 at 74 and anticipates the number of graduates to remain at this level in the future (M. Spencer, personal communication, March 19, 2007).

*Current Program*

The B.S Degree in Construction requires a total of 129 credits, 74 of which are directly related to architecture, engineering, and construction. Currently the two primary courses providing technical education in mechanical and electrical systems are AEC-452 Environmental Systems-HVAC and AEC-453 Environmental Systems-Plumbing and Electrical (UW-Stout Construction Program, 2006). The two courses provide graduates with a basic knowledge and understanding of mechanical and electrical construction as defined by the following course objectives (N. Timper, personal communication, March 5, 2007).

Course objectives for AEC- 452 Environmental Systems- HVAC are as follows:

1. Understand terminology used by construction professionals in describing heating, ventilating and air conditioning (HVAC) systems.
2. Understand the use of energy, requirements for comfort, and the effect of climate on buildings.
3. Understand the properties of moist air.

4. Understand common HVAC equipment and application.

5. Calculate heating and cooling requirements.

6. Conceptually design a simple HVAC system including determination of requirements and sizing of major components.

7. Understand air distribution in a building.

Course objectives for AEC-453 Environmental Systems – Plumbing and Electrical are as follows:

1. Understand terminology used by construction professionals in describing plumbing and electrical systems.

2. Have a basic knowledge of the use of electricity, the use of water, and the removal of waste water in buildings.

3. Know the common types of electrical distribution systems and their characteristics.

4. Have an understanding of common electrical equipment and materials.

5. Have an understanding of common electrical load requirements as specified in the National Electrical Code.

6. Understand the fundamentals of lighting design in buildings.

7. Have a basic understanding of available light sources and their characteristics.

8. Have an understanding of common piping materials and their uses.

9. Know the major components of a fire protection system.

10. Understand the design process for a simple waste piping system including determination of flow requirements, venting, and sizing of major components.

11. Understand the design process for a simple building water supply system including determination of flow requirements and sizing of major components.

*Construction Industry Competencies*

Management and estimating competencies associated with managing construction projects as a general contractor are similar to those required for managing construction projects as a specialty contractor in the area of mechanical and electrical construction. What is needed by mechanical and electrical contractors are managers and estimators who have greater competencies relating to mechanical and electrical systems. Occupational Information Network (O*NET) provides an occupational data base which is continually expanded and updated with current occupational specifications for many occupations. O*NET specifies what knowledge, skills, and abilities are necessary for specific work activities and tasks related to occupations such as Construction Manager, Cost Estimators, and the different trades associated with the mechanical and electrical construction industry; heating, ventilating and air conditioning, plumbing, and electrical (Occupational Information Network Resource Center, n.d.).

For the purpose of this research, one area of focus will be directed towards the task and work activities of Construction Managers and Cost Estimators which are applicable to both general construction managers and specialty construction managers, mechanical or electrical. Mechanical or electrical construction mangers do not require engineering backgrounds in the mechanical or electrical construction, but do require greater knowledge than typical general construction managers. Therefore, tasks and work activities related to tradesmen working in the mechanical and electrical construction industry will be evaluated for the level of competencies necessary for managers in the

mechanical or electrical construction industry. The task and work activities of each occupation will be used to assess the competencies required by construction managers and estimators employed in the mechanical and electrical construction industry.

Construction Manager. O*NET (O*NET OnLine, 2004a, n.p.) list the tasks for Construction Managers as:

1. Confer with supervisory personnel, owners, contractors, and design professionals to discuss and resolve matters such as work procedures, complaints, and construction problems.
2. Plan, organize, and direct activities concerned with the construction and maintenance of structures, facilities, and systems.
3. Schedule the project in logical steps and budget time required to meet deadlines.
4. Determine labor requirements and dispatch workers to construction sites.
5. Inspect and review projects to monitor compliance with building and safety codes, and other regulations.
6. Interpret and explain plans and contract terms to administrative staff, workers, and clients, representing the owner or developer.
7. Prepare contracts and negotiate revisions, changes and additions to contractual agreements with architects, consultants, clients, suppliers and subcontractors.
8. Obtain all necessary permits and licenses.
9. Direct and supervise workers.
10. Study job specifications to determine appropriate construction methods.

O*NET (O*NET OnLine, 2004a, n.p.) list the primary work activities for Construction Managers as:

1. Making Decisions and Solving Problems — Analyzing information and evaluating results to choose the best solution and solve problems.
2. Monitor Processes, Materials, or Surroundings — Monitoring and reviewing information from materials, events, or the environment, to detect or assess problems.
3. Organizing, Planning, and Prioritizing Work — Developing specific goals and plans to prioritize, organize, and accomplish your work.
4. Inspecting Equipment, Structures, or Material — Inspecting equipment, structures, or materials to identify the cause of errors or other problems or defects.
5. Scheduling Work and Activities — Scheduling events, programs, and activities, as well as the work of others.
6. Communicating with Persons Outside Organization — Communicating with people outside the organization, representing the organization to customers, the public, government, and other external sources. This information can be exchanged in person, in writing, or by telephone or e-mail.
7. Getting Information — Observing, receiving, and otherwise obtaining information from all relevant sources.
8. Coordinating the Work and Activities of Others — Getting members of a

group to work together to accomplish tasks.

9. Communicating with Supervisors, Peers, or Subordinates — Providing information to supervisors, co-workers, and subordinates by telephone, in written form, e-mail, or in person.

10. Estimating the Quantifiable Characteristics of Products, Events, or Information — Estimating sizes, distances, and quantities; or determining time, costs, resources, or materials needed to perform a work activity.

Cost Estimators. O*NET (O*NET OnLine, 2003a, n.p.) list the tasks for Cost Estimators as:

1. Analyze blueprints and other documentation to prepare time, cost, materials, and labor estimates.
2. Assess cost effectiveness of products, projects or services, tracking actual costs relative to bids as the project develops.
3. Consult with clients, vendors, personnel in other departments or construction foremen to discuss and formulate estimates and resolve issues.
4. Confer with engineers, architects, owners, contractors and subcontractors on changes and adjustments to cost estimates.
5. Prepare estimates used by management for purposes such as planning, organizing, and scheduling work.
6. Prepare estimates for use in selecting vendors or subcontractors.
7. Review material and labor requirements to decide whether it is more cost-effective to produce or purchase components.

8. Prepare cost and expenditure statements and other necessary documentation at regular intervals for the duration of the project.
9. Prepare and maintain a directory of suppliers, contractors and subcontractors.
10. Set up cost monitoring and reporting systems and procedures.

O*NET (O*NET OnLine, 2003a, n.p.) list the main work activities for Cost Estimators as:

1. Communicating with Persons Outside Organization — Communicating with people outside the organization, representing the organization to customers, the public, government, and other external sources. This information can be exchanged in person, in writing, or by telephone or e-mail.
2. Scheduling Work and Activities — Scheduling events, programs, and activities, as well as the work of others.
3. Communicating with Supervisors, Peers, or Subordinates — Providing information to supervisors, co-workers, and subordinates by telephone, in written form, e-mail, or in person.
4. Getting Information — Observing, receiving, and otherwise obtaining information from all relevant sources.
5. Establishing and Maintaining Interpersonal Relationships — Developing constructive and cooperative working relationships with others, and maintaining them over time.
6. Estimating the Quantifiable Characteristics of Products, Events, or

Information — Estimating sizes, distances, and quantities; or determining time, costs, resources, or materials needed to perform a work activity.

7. Performing for or Working Directly with the Public — Performing for people or dealing directly with the public. This includes serving customers in restaurants and stores, and receiving clients or guests.
8. Coordinating the Work and Activities of Others — Getting members of a group to work together to accomplish tasks.
9. Making Decisions and Solving Problems — Analyzing information and evaluating results to choose the best solution and solve problems.
10. Organizing, Planning, and Prioritizing Work — Developing specific goals and plans to prioritize, organize, and accomplish your work.

Heating and Air Conditioning Mechanics and Installers. O*NET (O*NET OnLine, 2003b, n.p.) list the tasks for Heating and Air Conditioning Mechanics and Installers as:

1. Obtain and maintain required certifications.
2. Comply with all applicable standards, policies, and procedures, including safety procedures and the maintenance of a clean work area.
3. Repair or replace defective equipment, components, or wiring.
4. Test electrical circuits and components for continuity, using electrical test equipment.
5. Reassemble and test equipment following repairs.

6. Inspect and test system to verify system compliance with plans and specifications and to detect and locate malfunctions.
7. Discuss heating-cooling system malfunctions with users to isolate problems or to verify that malfunctions have been corrected.
8. Record and report all faults, deficiencies, and other unusual occurrences, as well as the time and materials expended on work orders.
9. Test pipe or tubing joints and connections for leaks, using pressure gauge or soap-and-water solution.
10. Adjust system controls to setting recommended by manufacturer to balance system, using hand tools.

O*NET (O*NET OnLine, 2003b, n.p.) list the main work activities for Heating and Air Conditioning Mechanics and Installers as:

1. Performing General Physical Activities — Performing physical activities that require considerable use of your arms and legs and moving your whole body, such as climbing, lifting, balancing, walking, stooping, and handling of materials.
2. Repairing and Maintaining Mechanical Equipment — Servicing, repairing, adjusting, and testing machines, devices, moving parts, and equipment that operate primarily on the basis of mechanical (not electronic) principles.
3. Handling and Moving Objects — Using hands and arms in handling, installing, positioning, and moving materials, and manipulating things.
4. Getting Information — Observing, receiving, and otherwise obtaining

information from all relevant sources.

5. Operating Vehicles, Mechanized Devices, or Equipment — Running, maneuvering, navigating, or driving vehicles or mechanized equipment, such as forklifts, passenger vehicles, aircraft, or water craft.

6. Making Decisions and Solving Problems — Analyzing information and evaluating results to choose the best solution and solve problems.

7. Performing for or Working Directly with the Public — Performing for people or dealing directly with the public. This includes serving customers in restaurants and stores, and receiving clients or guests.

8. Communicating with Persons Outside Organization — Communicating with people outside the organization, representing the organization to customers, the public, government, and other external sources. This information can be exchanged in person, in writing, or by telephone or e-mail.

9. Inspecting Equipment, Structures, or Material — Inspecting equipment, structures, or materials to identify the cause of errors or other problems or defects.

10. Communicating with Supervisors, Peers, or Subordinates — Providing information to supervisors, co-workers, and subordinates by telephone, in written form, e-mail, or in person.

Plumbers. O*NET (O*NET OnLine, 2004b, n.p.) list the main tasks for Plumbers as:

1. Assemble pipe sections, tubing and fittings, using couplings, clamps, screws, bolts, cement, plastic solvent, caulking, or soldering, brazing and welding equipment.
2. Fill pipes or plumbing fixtures with water or air and observe pressure gauges to detect and locate leaks.
3. Review blueprints and building codes and specifications to determine work details and procedures.
4. Prepare written work cost estimates and negotiate contracts.
5. Study building plans and inspect structures to assess material and equipment needs, to establish the sequence of pipe installations, and to plan installation around obstructions such as electrical wiring.
6. Keep records of assignments and produce detailed work reports.
7. Perform complex calculations and planning for special or very large jobs.
8. Locate and mark the position of pipe installations, connections, passage holes, and fixtures in structures, using measuring instruments such as rulers and levels.
9. Measure, cut, thread, and bend pipe to required angle, using hand and power tools or machines such as pipe cutters, pipe-threading machines, and pipe-bending machines.
10. Install pipe assemblies, fittings, valves, appliances such as dishwashers and water heaters, and fixtures such as sinks and toilets, using hand and power tools.

O*NET (O*NET OnLine, 2004b, n.p.) list the main work activities for Plumbers as:

1. Performing General Physical Activities — Performing physical activities that require considerable use of your arms and legs and moving your whole body, such as climbing, lifting, balancing, walking, stooping, and handling of materials.
2. Getting Information — Observing, receiving, and otherwise obtaining information from all relevant sources.
3. Handling and Moving Objects — Using hands and arms in handling, installing, positioning, and moving materials, and manipulating things.
4. Identifying Objects, Actions, and Events — Identifying information by categorizing, estimating, recognizing differences or similarities, and detecting changes in circumstances or events.
5. Repairing and Maintaining Mechanical Equipment — Servicing, repairing, adjusting, and testing machines, devices, moving parts, and equipment that operate primarily on the basis of mechanical (not electronic) principles.
6. Performing for or Working Directly with the Public — Performing for people or dealing directly with the public. This includes serving customers in restaurants and stores, and receiving clients or guests.
7. Making Decisions and Solving Problems — Analyzing information and evaluating results to choose the best solution and solve problems.

8. Controlling Machines and Processes — Using either control mechanisms or direct physical activity to operate machines or processes (not including computers or vehicles).
9. Inspecting Equipment, Structures, or Material — Inspecting equipment, structures, or materials to identify the cause of errors or other problems or defects.
10. Monitor Processes, Materials, or Surroundings — Monitoring and reviewing information from materials, events, or the environment, to detect or assess problems.

Electricians._ O*NET (O*NET OnLine, 2004c, n.p.) list the primary tasks for Electricians as:

1. Assemble, install, test, and maintain electrical or electronic wiring, equipment, appliances, apparatus, and fixtures, using hand tools and power tools.
2. Diagnose malfunctioning systems, apparatus, and components, using test equipment and hand tools, to locate the cause of a breakdown and correct the problem.
3. Connect wires to circuit breakers, transformers, or other components.
4. Inspect electrical systems, equipment, and components to identify hazards, defects, and the need for adjustment or repair, and to ensure compliance with codes.
5. Advise management on whether continued operation of equipment could be hazardous.

6. Test electrical systems and continuity of circuits in electrical wiring, equipment, and fixtures, using testing devices such as ohmmeters, voltmeters, and oscilloscopes, to ensure compatibility and safety of system.
7. Maintain current electrician's license or identification card to meet governmental regulations.
8. Plan layout and installation of electrical wiring, equipment and fixtures, based on job specifications and local codes.
9. Direct and train workers to install, maintain, or repair electrical wiring, equipment, and fixtures.
10. Prepare sketches or follow blueprints to determine the location of wiring and equipment and to ensure conformance to building and safety codes.

O*NET (O*NET OnLine, 2004c, n.p.) list the main work activities for Electricians as:

1. Making Decisions and Solving Problems — Analyzing information and evaluating results to choose the best solution and solve problems.
2. Communicating with Supervisors, Peers, or Subordinates — Providing information to supervisors, co-workers, and subordinates by telephone, in written form, e-mail, or in person.
3. Performing General Physical Activities — Performing physical activities that require considerable use of your arms and legs and moving your whole body, such as climbing, lifting, balancing, walking, stooping, and handling of materials.

4. Organizing, Planning, and Prioritizing Work — Developing specific goals and plans to prioritize, organize, and accomplish your work.
5. Updating and Using Relevant Knowledge — Keeping up-to-date technically and applying new knowledge to your job.
6. Getting Information — Observing, receiving, and otherwise obtaining information from all relevant sources.
7. Evaluating Information to Determine Compliance with Standards — Using relevant information and individual judgment to determine whether events or processes comply with laws, regulations, or standards.
8. Handling and Moving Objects — Using hands and arms in handling, installing, positioning, and moving materials, and manipulating things.
9. Scheduling Work and Activities — Scheduling events, programs, and activities, as well as the work of others.
10. Inspecting Equipment, Structures, or Material — Inspecting equipment, structures, or materials to identify the cause of errors or other problems or defects.

O*NET (O*NET OnLine, 2003b; 2004b; 2004c, n.p.) list the knowledge required for each of the mechanical and electrical trades in ranked order of significance. While each of the trades ranks the categories of knowledge differently, they include each of the following categories of knowledge as most significant.

1. Building and Construction — Knowledge of materials, methods, and the tools

involved in the construction or repair of houses, buildings, or other structures such as highways and roads.

2. Mechanical — Knowledge of machines and tools, including their designs, uses, repair, and maintenance.
3. Mathematics — Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.
4. English Language — Knowledge of the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar.
5. Public Safety and Security — Knowledge of relevant equipment, policies, procedures, and strategies to promote effective local, state, or national security operations for the protection of people, data, property, and institutions.
6. Customer and Personal Service — Knowledge of principles and processes for providing customer and personal services. This includes customer needs assessment, meeting quality standards for services, and evaluation of customer satisfaction.
7. Design — Knowledge of design techniques, tools and principles involved in production of precision technical plans, blueprints, drawings, and models.
8. Education and Training — Knowledge of principles and methods for curriculum and training design, teaching and instruction for individuals and groups, and the measurement of training effects.

*Task Analysis*

In order to determine what competencies are needed to work as a construction manager in the mechanical and electrical construction industry, an organized task analysis needs to be completed. The task analysis determines what activities and responsibilities are performed in an occupation and further uses this information to formulate occupational training or assist in the development of educational curriculum (Lee & Nelson, 2006). There are several different techniques that can be used in colleting data for the task analysis: focus groups, DACUM process, Delphi technique, questionnaires-surveys, and interviews. Each technique has its own unique set of strengths and weaknesses dependent on the goals of the research and the extent of knowledge and understanding the researcher has about the research topic.

Focus groups produce qualitative data from a group of subjects who typically have knowledge about or an interest in the research topic. Subjects comment on and discuss questions directly related to the research. Responses and comments are recorded and evaluated by the researcher. The purpose of the focus group is not to come to a consensus on a topic of discussion; rather the data received is in the form of individual comments that convey feelings, perceptions, and ideas. Focus groups are extremely effective in identifying problems and needs (Lee & Nelson, 2006).

DACUM is an acronym for "develop a curriculum" and was developed to identify tasks and competencies necessary to perform a specific job or activity. A committee of participants, knowledgeable of the research topic, and compiles a sequential list of tasks and activities necessary to perform a job. The final product identifies the general areas of competencies and tasks for a job (Lee & Nelson, 2006). While a DACUM is effective in

generating a sequential list of job tasks specifically related to a job or occupation, it needs to be conducted by someone who has experience and training related to the DACUM methods and processes.

The Delphi Technique utilizes experts in the field of study and attempts to come to a consensus on a topic without meeting the other participants. This allows for responses that are unrestricted by controlling personalities which tend to restrict open discussion, decisions, and research. The Delphi process is based on several rounds of surveys, open ended questions mailed to participants for feedback. The feedback is summarized and redistributed to participants for additional feedback. The process is repeated until the group of participants comes to a consensus on the topic of study.

Questionnaires, also referred to as surveys, are effective in producing both qualitative and quantitative data from a list of questions and answers. Questionnaires work well with a pre-existing list of questions or items to rate, but typically do not allow for any additional feedback or responses from the participants.

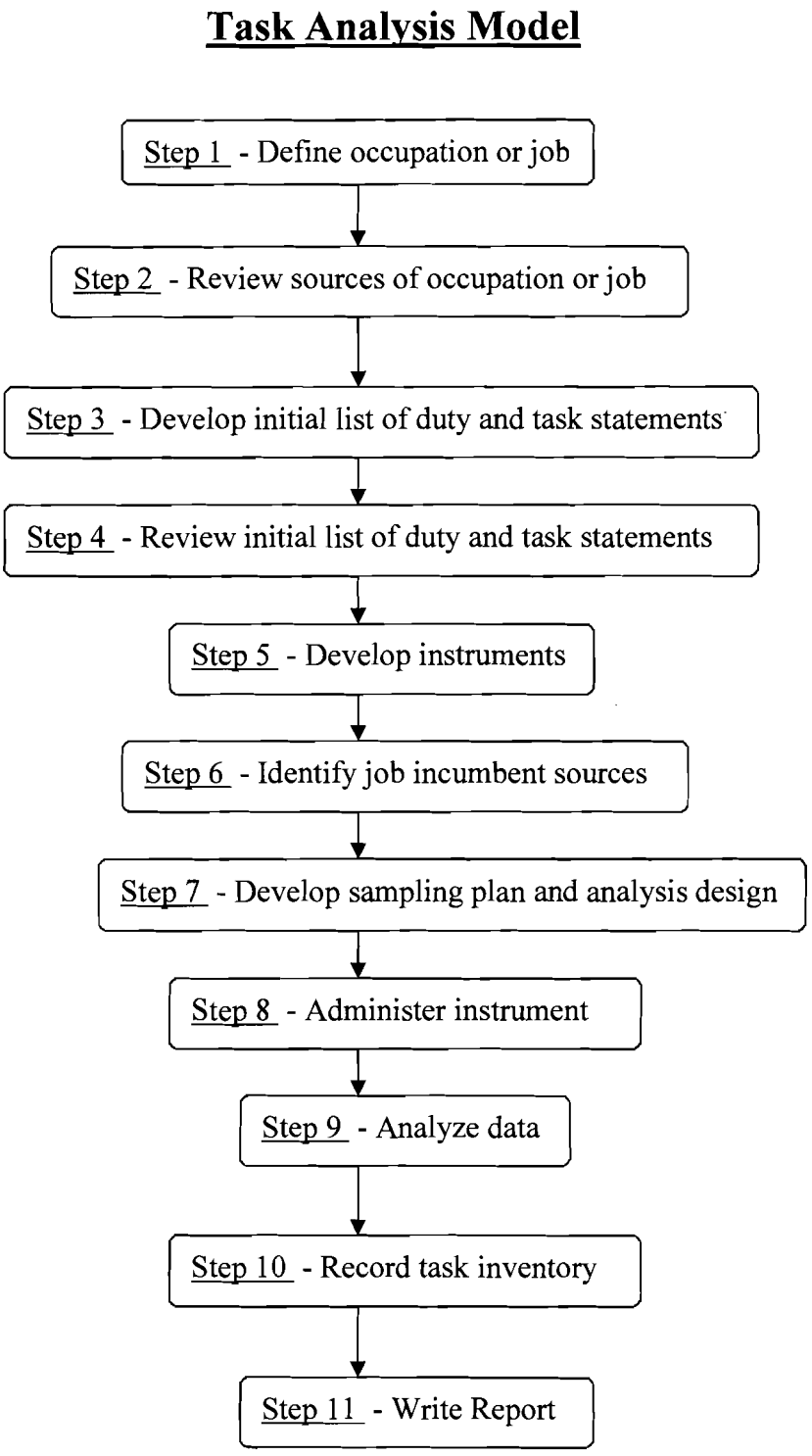
Interviews provide research data from face-to-face or verbal communication between the participant and researcher. The participant responds to questions presented by the researcher, who records the responses for further analysis. Interviews can be structured or unstructured. Structured interviews provide a specific list of questions which the participant responds to without any additional feedback. An unstructured interview begins with a specific list of questions and allows for additional feedback from the participants. Interviews are effective when the researcher has limited knowledge of the topic of study or may not know how to ask the right questions to obtain pertinent data.

Regardless of which method of collecting data is used, Lee and Nelson (2006)

encourage the use of an analysis model to systematically formulate a list of tasks and duties directly associated with the occupation or job being assessed. See Figure 2-1 on the following page. Following a systematic task analysis results in the formation of a list of specific competencies (task, skills, and responsibilities) for construction managers working in the mechanical and electrical construction industry. The following steps explain the task analysis process as outlined by Lee and Nelson (2006) in relationship to this study:

1. Define Occupation or Job. Narrowly defining the occupation or job allows for greater detail in creating a specific list of task and responsibilities. For the purpose of this study the occupations have been narrowed down to construction managers – mechanical contractors and construction managers – electrical contractors.
2. Review Sources of Occupational or Job Analyses. Research existing sources of information related to occupation and job descriptions. O*NET was the resource used to generate a list of task and work activities related to the occupations being evaluated.
3. Draft Duty and Task Statements. Create a relevant list of task and duties for the occupation(s) being analyzed. The construction industry was interviewed to formulate the list of task and responsibilities.
4. Review Initial List of Duty and Task Statements. The purpose of this step is to reassess and refine the generated list of task and responsibilities to assure their relevance and accuracy in relationship to each occupation or job under study

Figure 2-1 (Lee & Nelson, 2006, p. 125)



5. Develop Instrument. Develop the instrument, survey, used for submission to human subjects who will evaluate and rate the list of task and responsibilities. For the purpose of this study an unstructured interview was developed with questions directed towards the mechanical and electrical construction industry.
6. Identify Job Incumbent Sources. Select the group of human subjects to send the instrument to for feedback. Human subjects should have knowledge of what task and responsibilities are associated with the occupation or job under study. Construction managers, owners and executives of mechanical and electrical construction companies were the subjects used in this study.
7. Develop Sampling Plan and Analysis Design. Determine what segment of the population related to the occupation understudy that will be used to rate and respond to the instrument and how the data will be analyzed.
8. Administer Instrument. Send out instrument with corresponding cover letters and instructions. Interview questions were sent to subjects for review prior to the scheduled interview.
9. Analyze Data. Analyze and record information received back from the survey. Evaluate data to determine the relevance and importance of occupational and job related task and responsibilities.
10. Record Task Inventory. Generate a list of accepted and rejected task from the survey instrument.

11. Write Report. Write a report that reiterates everything included in the first ten steps and what the end results determined. The results of the task analysis are used in this study and used in the development of occupational training or educational curriculum.

The purpose of this study was to determine what competencies will best assist and prepare UW-Stout graduates working in the mechanical and electrical construction industry. Therefore, the main source of obtaining data was specifically directed towards the mechanical and electrical construction industry, those who know and understand the industry and employ future graduates. Data from this study received from the mechanical and electrical industry will be used, in addition to the O*NET resources, to evaluate mechanical and electrical competencies. Data will also be available for development of coursework for the mechanical and electrical construction minor at UW-Stout.

*Summary*

The same management and estimating competencies are required for either a general contractor or a specialty contractor in mechanical or electrical construction. The difference between the two managers is in the area of their expertise and knowledge of the field in which they are managing. Specialty construction managers require greater knowledge in the specific field in which they are operating: heating and air conditioning, plumbing, and electrical. While specialty construction managers do not require an advanced engineering background, they do require greater competencies related to mechanical and electrical construction than the typical general construction manager. Therefore, it is necessary to study what competencies are necessary to function successfully as a construction manager in mechanical and electrical construction. These

competencies can further be used in the development and implementation of a minor in mechanical and electrical construction.

# Chapter III: Methodology

## *Introduction*

The purpose of this study was to determine what competencies (task, skills and responsibilities) are required by construction managers working in the mechanical and electrical construction industry. This study provides initial guidance and assistance in the development of a Mechanical and Electrical Construction minor at UW-Stout. This chapter includes a description of the subjects and how they were selected. In addition, the following items will be explained; development of the instrument, the processes and procedures used for data collection, and the methods used for data analysis. This chapter will conclude with a list of methodological limitations.

## *Subject Selection and Description*

The subjects used in this study were not randomly selected from a population of mechanical and electrical contractors; rather they were selected from participating members of the UW-Stout Construction Program Industry Advisory Board. There are currently 30 plus members on the Advisory Board, 12 of which are specialty contractors working in the mechanical and electrical construction industry. These 12 professional contractors were selected to participate in the study based on their experience and knowledge of the mechanical and electrical construction industry and their familiarity with existing UW-Stout Construction Program. The selected subjects work for contractors or own companies located and performing construction services in Minnesota and Wisconsin.

*Instrumentation*

There were no existing surveys found to meet the specific needs of this study, therefore original interview questions were designed by the researcher. The interview consisted of 18 questions, seven demographic questions directly related to the companies the participants were currently working for, and the remaining eleven unstructured interview questions pertained to competencies (tasks, skills, and responsibilities) related to the mechanical and electrical construction industry. Because it was constructed specifically for this study, there are no documented measures of validity or reliability. A copy of the survey is located in Appendix A.

*Data Collection and Recording*

Inter view questions were developed, submitted to, and approved by UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46. Permission to participate in the study was sought from each UW-Stout Construction Program Industry Advisory Board member during the month of March 2007. Upon verbal approval to participate in the study, a copy of both the Consent to Participate in UW-Stout Approved Research, and Mechanical and Electrical Construction Interview questions were e-mailed to each participant for review. A cover letter, hard copy of both the Consent to Participate in UW-Stout Approved Research and the Mechanical and Electrical Construction Interview questions was mailed to each subject. A return envelope was also included in the mailing for the purpose of returning the original signed consent to participate letter. A copy of the cover letter and Consent to Participate in UW-Stout Approved Research is located in Appendix B and Appendix C, respectively. During the initial phone conversation, an appointment date and time was established to conduct the interview.

Contact was made at the scheduled appointment date and time to answer and discuss the interview questions. The responses were recorded by the researcher. The interview was followed up with a written thank you note mailed to each participating subject.

*Data Processing and Analysis*

The data collected by this study was primarily qualitative in nature and was compiled and evaluated for reoccurring themes which pointed to potential mechanical and electrical construction competencies. Based on the unstructured interview questions and the relatively small number of participating subjects, statistical analysis of the data was limited. The interpretation of the data will assist in further development and refinement of the competencies related to the mechanical and electrical construction industry.

*Limitations of Methodology*

The results of this research may be influenced by the following factors:

1. Interviews were completed over the telephone, which restricted the researcher from observing and noting any nonverbal communication, which may have limited the amount and type of responses from the participants.

2. The interview questions were developed by a researcher with limited experience and therefore may impact validity and reliability.

3. Interviews were completed during the workday, which may have restricted the participants' responses based on their schedules and busyness of their workday.

4. Participants were all members of the UW-Stout Construction Program, Industry Advisory Board and several were graduates of UW-Stout's Construction Program which may have introduced bias to their responses.

*Summary*

Telephone interviews were used to collect data for this study. Participants in the study were limited to members of the UW-Stout Construction Program Industry Advisory Board who were actively working or involved in the mechanical and electrical construction industry. Telephone interviews were selected as a result of time constraints and the use of a specific sample in a limited geographical area. The interviews will provide relevant data obtained directly from the mechanical and electrical construction industry and will be available as a resource for the development of UW-Stout's Mechanical and Electrical Construction Minor.

# Chapter IV: Results and Discussion

Interviews were conducted to identify competencies of Managers working in the Mechanical and Electrical Construction Industry. The sample group of participants were members of the UW-Stout Construction Program Industry Advisory Board, those who work in or are directly affiliated with the mechanical and electrical construction industry. The first seven questions were demographic in nature and the remaining 11 questions were directed towards responses related to the mechanical and electrical construction industry. Nine out of the 12 original participants (75%) responded and completed the entire interview process. Interview responses were evaluated, consolidated, and summarized in relationship to reoccurring themes, concepts, and ideas which possibly define competencies in the mechanical and electrical construction industry.

## *Demographics*

For the purpose of this study the mechanical and electrical construction industry was divided into three separate divisions: Plumbing, HVAC, and Electrical. However, several respondents were involved in multiple divisions, making it necessary to include four additional divisions to the research: HVAC/Plumbing, Plumbing/Electrical, HVAC/Plumbing/Electrical and Other. Out of the nine respondents, 44.4% were involved in the combined divisions of HVAC/Plumbing. Two of the remaining respondents, 22.2%, were affiliated with all divisions: Electrical, HVAC, and Plumbing. The remaining respondents were evenly divided between the division of Electrical, Plumbing/Electrical, and Other. See Table 1 on the following page for a complete breakdown between the different mechanical and electrical construction industry divisions. In relationship to the three main divisions: plumbing, HVAC, and electrical,

20% of the respondents perform the majority of their work in plumbing, 11% in HVAC, and 12% in electrical.

Table 1.

Divisions of the Construction Industry n = 9

| Divisions | Number | Percentage |
|---|---|---|
| Plumbing | 0 | 0 |
| HVAC | 0 | 0 |
| Electrical | 1 | 11.1 |
| HVAC/Plumbing | 4 | 44.4 |
| Plumbing/Electrical | 1 | 11.1 |
| Plumbing/HVAC/Electrical | 2 | 22.2 |
| Other | 1 | 11.1 |
| Total | 9 | 100 |

Respondents also provided data in relationship to which category of construction they were associated with; Industrial, Commercial and Residential. As with the divisions of construction several respondents work in multiple categories, therefore two additional categories were included; commercial/industrial and industrial/commercial/residential. The majority of the respondents, 56%, were affiliated with multiple categories; industrial/commercial. One respondent was affiliated with all three categories, another with commercial only and the remaining 22%, industrial only. None of the respondents selected residential as their primary category of affiliation. See Table 2 below for a

complete breakdown of the categories of the construction industry associated with the respondents.

Table 2.

Categories of the Construction Industry n = 9

| Category | Number | Percentage |
|---|---|---|
| Industrial | 2 | 22 |
| Commercial | 1 | 11 |
| Residential | 0 | 0 |
| Industrial/Commercial | 5 | 56 |
| All Categories | 1 | 11 |
| Total | 9 | 100 |

Annual revenues for the respondents range from less than two million US dollars to more than 250 million dollars. One respondent's revenues were less than two million dollars, another ranged from 5 – 10 million dollars, two had revenues over 250 million dollars and the remaining respondents, 55.6%, ranged from 100 – 250 million dollars.

The geographical area in which this study was limited to was Wisconsin and Minnesota. However, the majority of the respondents, 66.7%, work for national companies, doing work in both Wisconsin and Minnesota. One respondent solely worked in Wisconsin, one in Minnesota and one worked in both states. See Table 3 on the following page for a summary of which states the respondents worked in. There is a

positive relationship to those respondents working nationally and their annual revenues. Respondents working nationally had annual revenues of over 100 million.

Table 3.

States Respondents Perform Work n = 9

| State | Number | Percentage |
|---|---|---|
| Wisconsin | 1 | 11.1 |
| Minnesota | 1 | 11.1 |
| Wisconsin/Minnesota | 1 | 11.1 |
| National | 6 | 66.7 |
| Total | 9 | 100 |

The majority of the respondents were either graduates of the UW-Stout Construction Program and/or had colleagues working with them who were. One respondent was not a graduate of the Construction Program; the remaining 88.9% were graduates of the Construction Program.

*Research and Item Analysis*

The remaining analysis is related to 11 questions (interview questions 8 – 18) asked during the unstructured telephone interviews. Results were evaluated, consolidated, and summarized in relationship to reoccurring themes, concepts, and ideas. Questions will be paraphrased and responses are consolidated into a list including an analysis of reoccurring themes.

Interview question eight focuses on the respondent's experiences, perceptions and observations related to strengths of the existing UW-Stout Construction Program. All participants responded to the question resulting in a list of 12 strengths. The majority of the strengths are related to different aspects of and quality of education. The most reoccurring strength listed by respondents was - technical based education (33.3%). Following is the list of responses to Question 8: Based on your experience or observations and feedback from previous UW-Stout Graduates, what are the strengths of the UW-Stout Construction Management Program?

- Technical based education
- Practical hands-on education
- Balanced between construction and engineering
- Good leadership from instructors
- Good understanding of means and methods
- Business oriented
- Good work ethic
- Knowledgeable about construction safety/risk control
- Able to use current software programs
- Overall understanding of scheduling projects
- Basic understanding of construction law
- People skills – Student Construction Association, student competitions, community service

Interview question nine focuses on the respondent's experiences, perceptions and observations related to perceived weaknesses of the existing UW-Stout Construction

Program. All participants responded to the question resulting in a list of eight different weaknesses. Three weaknesses were consistent in response between the different respondents; cost control, electrical and mechanical construction education and subcontractor education. Following is the list of responses to Question 9: Based on your experience or observations and feedback from previous UW-Stout Graduates, what are the weaknesses of the UW-Stout Construction Management Program?

- Construction program grouped with non-similar programs
- People skills/ team work
- Cost control
- Insufficient electrical and mechanical construction education for entry level mechanical and electrical construction
- Lack of subcontractor education
- Financial forecasting
- Project booking
- Little emphasis on industrial construction sector

Interview question 10 related to job titles and job descriptions. Question 11 related to the tasks and work activities related to each of the job titles. Interview responses connected the two questions together making it difficult to differentiate between the two. Therefore, the data for question 10 and 11 is combined together listing job titles followed by a list of the affiliated job description, job tasks, and work activities. Different respondents refer to the same job descriptions using different names, therefore job descriptions were segregated into four different job categories: Field Engineer/Coordinator, Safety Engineer, Project Director/Project Manager/Contracts

Manager, and Preconstruction Services/Estimator. Following is the list of responses to Question 10: List job titles for graduates working in your company including their respective job descriptions? And question 11: What specific tasks and/or work activities are the responsibilities of the different management positions?

- Field Engineer/Coordinator
    - Manpower scheduling
    - Problem solving
    - Job progress reporting
    - Basic engineering and construction methods
    - Cost engineering
    - Assist Project Manager/Director
- Safety Engineer
    - Safety education
    - Safety monitoring
    - Safety reports
    - Federal, state, local, owner and company safety compliance
- Project Director/Project Manager/Contracts Manager
    - Procurement/Purchasing
    - Subcontract administration
    - Invoicing
    - Job costing
    - Scheduling
    - Quality control

  - Jobsite safety
  - Cost control
  - Budget development
  - Delivering secured projects
  - Risk Management
  - Claims resolution
  - Project documentation
  - Shop drawing/submittal processing
  - Changer order process
- Preconstruction Services/Estimator
  - Estimating
  - Scheduling
  - Risk management
  - Negotiations
  - Subcontractor/material supplier relations

Interview questions 12 related to the skills required to function effectively and productively in a position as manager. Thirty-four different responses were consolidated into a list of 18 different skills. The most reoccurring skills listed by respondents were communication skills (55.6%), written and verbal, and organizational skills (44.4%). Following is the list of responses to Question 12: <u>List the skills required to function effectively and productively in each of the different management positions.</u>

- Organizational skills
- Leadership skills

- Prioritization skills
- Communication skills – written and verbal
- Personal skills
- Negotiating
- Accounting/financing
- Safety
- Quality control
- Problem solving
- Understanding codes
- Estimating
- Scheduling
- Material and labor procurement
- Marketing
- Team player
- Strong work ethic
- Computer/software knowledge

Interview question 13 related to the different computer software programs used in the respondents construction firms. The responses were broken down into four different categories: Estimating, Scheduling, Design, and Management. All respondents did not specify software programs for each of the four categories; 66.7% specified estimating software, 66.7% specified scheduling software, 55.6% specified design software, and 33.3% specified managerial software. With the exception of managerial software there was one primary software program listed more consistently than other software programs.

Estimating, 44.4% of the total responses were MC2, scheduling, 55.6% of the responses were Primavera, and design, 28.6% were Auto Cad. Following is the list of responses to Question 13: List the types of computer software used at your company for design, estimating, scheduling, and management.

- Estimating
    - MC2 – Ice
    - AutoBid
    - Quick Pen - mechanical
    - Accubid – electrical
    - Internally developed system
- Scheduling
    - Primavera Project Planer
    - MS Project
    - Sure Track
    - Outlook
- Design
    - Auto Cad
    - Pipe Cad
    - Pipe Cad Duct
    - Trane Trace/Carrier
    - Auto Sprink
    - ME-Mate
    - MAPS

  - Auto Cad w/
    - Bently Autopipe
    - Bently Autoplant
    - Hydro-Tech
  - Navis Works
- Management
  - In-house program
  - JD Edwards
  - Prolog
  - Microsoft
  - View Point
  - Primavera Expedition

Interview question 14 related to the types of courses the respondents would develop and implement into the mechanical and electrical construction minor. The course most often listed by respondents (77.8%) was: Mechanical and electrical - means and methods. Following is the list of responses to Question 14: <u>If given the responsibility to develop courses for the proposed mechanical and electrical construction minor, what courses would be developed and what would their objectives include?</u>

- Scheduling/Work Packaging – activities/manpower
- Equipment erection – methods of equipment setting
- Estimating mechanical and electrical
- Financial forecasting
- Cost control

- Mechanical and Electrical systems – means and methods
- Mechanical and Electrical equipment and material recognition
- Design basics – drafting, analysis and calculations
- Mechanical and electrical codes
- Contractor/subcontractor contracts and relationship
- Blueprint reading
- Mechanical and Electrical specifications
- Systems integration
- Computer design/ 3-D Modeling and coordination drawings
- Emerging environmental technologies
- Material management
- Accounting

Interview question 15 relates to the necessity of lab activities as a significant part of the construction program curriculum and suggested lab activities. All respondents (100%) felt lab activities were a necessity and 33.3% listed the application of mechanical and electrical theory including the hands-on operations of welding and soldering as possible lab activities. The following list summarizes responses to Question 15: Are lab activities a necessary part of the Construction Program curriculum? If yes, what types of lab activities and/or experiences are necessary?

- Welding/soldering
- Project field trips
- Mechanical and electrical methods
- Inspection techniques

- Application of mechanical and electrical theories
- Scheduling
- Estimating
- Identification and use of materials

Interview question 16 refers to how the respondents would define the construction program graduate that would best meet all their company's goals and expectations. A list of 25 different characteristics or skills was generated by the data. The primary characteristic or skill listed by respondents, 44.4%, was having a good technical background in the mechanical and electrical construction industry including installation, fabrication, equipment, and components. Following is a summary of Question 16: Define the UW-Stout Construction Program Graduate that would meet all your company needs and expectations?

- Willingness to work/learn
- Technical background – installation, fabrication, equipment, components
- Scheduling work activities, subcontractors and materials
- Good work ethic
- Solve and report field problems
- Organizational skills/sequencing
- Sense of urgency
- Involved in extra curricular activities
- Fits company core values
- High grade point average
- Knowledge of mechanical and/or electrical codes

- Professional appearance
- Fluently speaks English
- People skills
- Committed to quality
- Committed to lifelong learning
- Mechanical and electrical theory
- Estimating
- Accounting
- Scheduling
- Safety awareness
- Communication/public speaking skills
- Computer skills
- Multi-tasking
- Leadership skills

Question 17 relates to the importance of internships or co-ops in the mechanical or electrical field prior to graduation or employment. All respondents felt that internships/co-ops were important for the graduate. Industry exposure and experience was the primary reason amongst respondents (66.7%). Following are the responses associated with Questions 17: How important is it for students to participate in an internship or co-op in the mechanical or electrical field prior to graduation and/or employment?

- Industry exposure/experience
- Mandatory in discipline

- Jumpstarts career
- Greater value to employer

Interview question 18 relates to what new or upcoming concepts, ideas or technologies are forthcoming in the mechanical and electrical construction industry that should be included in the developing curriculum. Four of the items were listed my multiple respondents; 3-D modeling, BIM - building information modeling, lean scheduling, green building technology, and LEED – leadership in environmental and energy design. Following is a summary for Question 18: What concepts, ideas, theologies are new or expected to be forthcoming in the future that should be incorporated into the mechanical and electrical curriculum?

- Electronic transmittals
- Project reporting
- 3-D modeling
- BIM – building information modeling
- Lean Scheduling
- Green building technology
- Ground source heat pumps
- Radiant heating and cooling systems
- LEED – leadership in energy and environmental design
- Alternative power – wind, hydro, solar, biodiesel, ethanol
- Demographic changes in labor
- Marketing

*Summary of Findings*

The purpose of this study was to identify what competencies are required for those working in the mechanical and electrical construction industry. Interviews were conducted with nine members of the UW-Stout Construction Program Industry Advisory Board who are actively participating in or involved in the mechanical and electrical construction industry. Common and reoccurring themes were discussed and summarized in the research and item analysis section of each question.

# Chapter V

## Summary, Conclusions, and Recommendations for Future Study

### *Summary*

This chapter includes a summary of the study with a restatement of the problem, followed by a review of the methods used for obtaining the research data, and conclusions. Finally, recommendations for future study conclude this chapter.

#### Restatement of the Problem

The construction industry continues to evolve and become more highly technical, computerized, and automated in the field of mechanical and electrical construction. UW-Stout's Construction Program is successful in providing construction managers with the skills necessary to function as a project manager for the majority of general contractors operating in the construction industry. However, additional education needs to be provided that educates and trains students in the highly technical field of mechanical and electrical construction. The mechanical and electrical competencies (tasks, skills, and responsibilities) are necessary to move the Construction Program forward in developing the objectives and coursework required for a minor in mechanical and electrical construction.

#### Methods and Procedures

Interviews were conducted to identify competencies of managers working in the mechanical and electrical construction industry. The sample group represented mechanical and/or electrical members of the UW-Stout Construction Program Industry Advisory Board. Nine of the 12 (75%) Industry Advisory Board Members participated in the study. The interview instrument included 18 questions, seven of which were

demographic in nature and the remaining 11 were open ended questions related to perceived competencies in the mechanical and electrical construction industry. Interview responses were evaluated, consolidated, and summarized in relationship to reoccurring themes, concepts, and ideas which possibly define competencies in the mechanical and electrical construction industry.

*Findings*

This section addresses each research question qualitatively and quantitatively when applicable using the data obtained during the research.

Question 1: "Identify competencies of project managers in the mechanical and electrical construction industry." Competencies (tasks, activities, and responsibilities) were consolidated from responses to interview questions 8 – 18. Competencies are listed in random order and not in order of importance or relative significance as follows:

- Organizational skills – prioritizing and sequencing work, time management, multi-tasking
- Leadership skills – motivating and leading others, team player
- Written and verbal communication skills
- Negotiating strategies
- Business finance, accounting, and cost control
- Safety awareness, policies, regulations and procedures
- Quality awareness and control
- Problem solving skills - recognition, documenting and corrective procedures
- Knowledge and understanding of national codes
- Estimating project materials and manpower

- Bidding protocol – subcontractor and material suppliers
- Professional appearance
- Marketing awareness
- Computer/Software - design, estimating, and scheduling
- Scheduling materials, subcontractors, manpower, work packages
- Equipment – application and use
- Mechanical and electrical systems – means and methods
- Material and parts recognition and application
- Design basics – drafting, analysis, calculations, and system integration
- Contractor/Subcontractor contracts requirements, laws and regulations
- Blueprint reading – symbol recognition, layout of systems
- Awareness of emerging systems and technologies
- Personal - positive attitude and work ethic
- Communicate clearly and professionally with others
- Professional development – lifelong learning, company values

Based on the data obtained from the respondents, competencies are similar to the management competencies, tasks and work activities, outlined in the literature review. However, the task and work activities listed in the literature review for tradesmen working in the field as heating and air conditioning mechanics and installers, plumbers, and electricians were not typically referenced in the survey responses as perceived competencies.

Question 2: "Categorize competencies based on three specific areas of mechanical and electrical construction: plumbing, HVAC and electrical." After analyzing the data it

is apparent that the list of competencies is not restricted to or confined to one specific area or division of the mechanical and electrical construction industry. Therefore, it is impossible to categorize them between the different divisions. The only difference between the divisions is the specific technical education or curriculum being provided which is directed towards the field of study; HVAC, plumbing or electrical.

Question 3: "Determine if there is a difference in project manager's competencies in relationship to the size of the mechanical and electrical construction company." The majority of respondents, 78%, were affiliated with larger companies having annual revenues in excess of $100 million. Regardless, the recorded data from the respondents of different size companies was similar in nature and content. Therefore, there does not appear to be any difference in perceived management competencies based on the company size.

*Conclusions*

1. Based on the data provided by respondents, the existing UW-Stout Construction Program is sufficiently providing graduates with the knowledge, skills, and experience necessary to meet the needs of the general construction industry. However, respondents overwhelmingly see a deficiency in providing or offering an option to students, additional and higher levels of mechanical and electrical education. This data confirms the need for the Construction Program to complete the development of the mechanical and electrical construction minor.

2. The lists of competencies obtained through this study were generated from data provided by reliable and qualified industry sources, those working directly in or associated with the mechanical and/or electrical construction industry. Therefore,

curriculum being developed for the mechanical and electrical construction minor needs to focus on objectives that align with and result in a mechanical and electrical construction education that match the perceived construction industry competencies related to this study.

3. The list of competencies outlined in this study is not exclusive and needs to be further defined in its relationship to the mechanical and electrical construction industry and how it translates to curriculum. The participating members of the UW-Stout Construction Program Industry Advisory Board are a valuable resource and are willing to participate in and assist in the continued development of the minor. Utilizing the participants of the study in a DACUM (develop a curriculum) process would further develop and define what knowledge, skills, standards, tools, and attitudes are necessary for relevant mechanical and electrical curriculum.

*Recommendations for Further Studies*

1. The sample group was limited to members of the UW-Stout Construction Program Industry Advisory Board, resulting in nine participants. For future study it would be beneficial to broaden the sample group to professionals affiliated with the mechanical and electrical construction industry outside the UW-Stout Construction Program Industry Advisory Board

2. The majority, 78%, of the respondents have annual revenues in excess of 100 million US dollars. Based on the research data there were consistent responses between the smaller and larger companies, however, because the majority of participants were from larger firms there could be a bias in data. Opening up the survey to a larger sample

group of the population would broaden the annual revenues of the sample group and provide additional data from the smaller construction firms.

3. The data collection technique used for this study was telephone interviews. Copies of the interview questions were sent to participants to fill out and return prior to the telephone interview. Respondents were faithful in sending back the completed interview questions, but due to time constraints and business responsibilities of the participants, telephone interviews were not fully completed. Future study could use data collection techniques that require face-to face interaction or only require written responses.

References

ACCE. (2007). *Baccalaureate degree programs.* Retrieved February 23, 2007, from: www.acce-hq.org/baccalaureateprograms.htm

Clough, R., Sears, G., & Sears, S. (2005). *Construction contracting.* Hoboken,NJ: John Wiley & Sons.

Feirer, M. & Feirer, J. (2004). *Carpentry and building construction.* Peoria, IL: Glencoe/McGraw-Hill.

Lee, H.D., & Nelson, O.W. (2006). *Instructional analysis and course development.* Homewood, IL: American Technical Publishers, Inc.

Nich, C. (n.d.). *What can you do with a college major in construction management?* Retrieved January 23, 2007, from: www.worldwidelearn.com/online-education-guide/business/construction-management-major.htm

Nunnally, S. (1993). *Construction methods and management.* Englewood Cliffs, NJ: Prentice Hall Career & Technology.

Occupational Information Network Resource Center. (n.d.) *What is O*NET?.* Retrieved March 12, 2007, from: www.onetcenter.org/overview.html

O*NET OnLine, (2003a). *Summary report for: 13-1051.00 – cost estimators.* Retrieved March 13, 2007, from: http://online.onetcenter.org/link/summary/13-1051.00

O*NET OnLine. (2003, n.p.b.). *Summary report for: 49-9021.01 - heating and air conditioning mechanics and installers.* Retrieved February 23, 2007, from: http://online.onetcenter.org/link/summary/49-9021.01

O*NET OnLine. (2004a). *Summary report for: 11-9021.00 – construction managers.* Retrieved February 26, 2007, from: http://online.onetcenter.org/link/summary/11-9021.00#menu

O*NET OnLine. (2004b). *Summary report for: 47-2152.02 - plumbers.* Retrieved February 23, 2007, from: http://online.onetcenter.org/link/summary/47-2152.02

O*NET OnLine. (2004c). *Summary report for: 47-2111.00 - electricians.* Retrieved February 23, 2007, from: http://online.onetcenter.org/link/summary/47-2111.00

Tao, W., & Janis, R. (2001). *Mechanical and electrical systems in buildings.* Upper Saddle River, NJ: Prentice-Hall, Inc.

Timper, H. (2004). *University of Wisconsin Stout self-evaluation study.* (Available: 281 Technology Wing – Jarvis Hall, UW Stout, Menomonie, WI 54751)

UW Stout. (2002-2003). *Factbook.* Retrieved March 13, 2007, from: www.uwstout.edu//bpa/ir/factbook.pdf

UW Stout. (2005-2006). *Factbook.* Retrieved March 13, 2007, from: www.uwstout.edu//bpa/ir/factbook06.pdf

UW-Stout. (n.d.). *Undergraduate courses: AEC architecture, engineering and construction.* Retrieved January 23, 2007, from: www.uwstout.edu/ugbulletin/ug_aec.html

UW-Stout Career Services. (n.d.a). *2004-2005 summary: Undergraduate degrees.* Menomonie, WI: Author.

UW-Stout Career Services. (n.d.b.).*2003-2004 summary: Undergraduate degrees.*

Menomonie, WI: Author.

UW-Stout Career Services. (n.d.c). *2002-2003 summary: Undergraduate degrees*: Menomonie, WI: Author.

UW-Stout Career Services. (n.d.d). *2001-2002 summary: Undergraduate degrees*: Menomonie, WI: Author.

UW-Stout Career Services. (n.d.e). *2000-2001 summary: Undergraduate degrees*: Menomonie, WI: Author.

UW-Stout Career Construction. (2005). *Program recruitment brochure*. (Available: 281 Technology Wing- Jarvis Hall, UW Stout, Menomonie, WI 54751)

UW Stout Construction Program. (2006). *Construction program advisory board minute, Friday, October 6, 2006.* (Available: 281 Technology Wing – Jarvis Hall, UW Stout, Menomonie, WI 54751)

UW Stout Construction Program. (2006). *Program plan sheet: B.S. degree in construction.* (Available: 281 Technology Wing – Jarvis Hall, UW Stout, Menomonie, WI 54751)

# Appendix A

## Interview Questions

**This research has been approved by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46.**

# Mechanical and Electrical Construction Interview

Date: _____

Name: _____ (optional)

Title/Position: _____ (optional)

Business Name: _____ (optional)

Please answer all questions in relationship to the specific field of construction your company is involved with.

1. Which division of construction; heating, ventilating and air conditioning or plumbing or electrical, is your company primarily involved with?

2. If multiple divisions, at what percentage is your company involved in each division?

3. Which category of construction; residential, commercial, industrial or other, is your company working in?

4. If involved in multiple categories, at what percentage is your company working in each category?

5. What is the range of annual revenues your business performs?

| | |
|---|---|
| _____ Up to $2,000,000 | _____ $20,000,001 - $50,000,000 |
| _____ $2,000,001 – $5,000,000 | _____ $50,000,001 - $100,000,000 |
| _____ $5,000,001 - $10,000,000 | _____ $100,000,001 – $250,000,000 |
| _____ $10,000,001 - $20,000,000 | _____ More Than $250,000,001 |

6. Which state(s) does your company perform work?

7. Are you and/or does your company employ UW-Stout Construction Graduates?

8. Based on your experience or observations and feedback from previous UW-Stout Graduates, what are the strengths of the UW-Stout Construction Management Program?

9. Based on your experience or observations and feedback from previous UW-Stout Graduates, what are the weaknesses of the UW-Stout Construction Management Program?

10. List job titles for graduates working in your company including their respective job descriptions?

11. What specific tasks and/or work activities is the responsibility of the different management positions?

12. List the skills required to function effectively and productively in each of the different management positions?

13. List the types of computer software used at your company for design, estimating, scheduling, and management?

14. If given the responsibility to develop courses for the proposed mechanical and electrical construction minor, what courses would be developed and what would their objectives include?

15. Are lab activities a necessary part of the Construction Program curriculum? If yes, what types of lab activities and/or experiences are necessary?

16. Define the UW-Stout Construction Program Graduate that would meet all your company needs and expectations?

17. How important is it for students to participate in an internship or coop in the mechanical or electrical field prior to graduation and/or employment?

18. What concepts, ideas, theologies are new or expected to be forthcoming in the future that should be incorporated into the mechanical and electrical curriculum?

# Appendix B

## Cover Letter

March 27, 2007

Re: UW-Stout Consent to Participate and Survey

Dear Specialty Contractors,

I would like to thank you for your time and willingness to participate in this survey. It is our desire to develop the Mechanical and Electrical Construction Minor based on your needs and the needs of the mechanical and electrical construction industry. Please do not limit your responses to the list of questions on the survey alone, any and all feedback is welcomed and will be used in the development of the Construction Minor.

Please sign and return the accompanying Consent to Participate in UW-Stout Approved Research form. I am unable to use any data presented by survey subjects, unless I have a signed copy of the consent form on record. Thanks Again.

As previously discussed on the phone, it is my desire to complete the survey according to the following format and schedule.

- Respond to survey questions and e-mail responses to me.
- Upon receipt of completed survey I will call to schedule an appointment to discuss your responses.
- I need to complete this phase of data collection before April 14, 2007.

Thanks again for your commitment and help. If you have nay questions, comments and/or concerns please feel free to contact me at any time.

Respectively,

Rick Larrabee
UW-Stout
162 Technology Wing, Jarvis hall
Menomonie, WI. 54751
Direct Phone: 715-232-1134
Email: larrabeeri@uwstout.edu

# Appendix C

## Consent to Participate in UW-Stout Approved Research

**Consent to Participate in UW-Stout Approved Research**

**Title**: An Analysis of Mechanical and Electrical Construction Competencies in the Wisconsin and Minnesota Construction Industry

**Investigator:**
Rick Larrabee
715-232-1134
162 Tech Wing
UW-Stout
Menomonie, WI. 54751

**Research Advisor:**
Dr. Hans Timper
715-232-5399
233 Tech Wing
UW-Stout
Menomonie, WI. 54751

**Description:** The primary purpose of this study is to assess what competencies (task, skills and responsibilities) are required for UW Stout Construction Management graduates working in the mechanical and electrical construction industry.

**Risk and Benefits:** The risks associated with participation in this survey are expected to be minimal. There is no identified or known risk to your participation in this survey. Your input and discussion is vitally important in the development and implementation of the mechanical and electrical construction minor in the UW-Stout Construction Program.

**Time commitment:** It is estimated that the time it will take to complete the survey is approximately 45 to 60 minutes.

**Confidentiality:** Any identifying information will remain confidential. All identifiable information is listed as optional and will not be included in any of the completed documents. Research conducted by UW-Stout is required to remain confidential.

**Right to Withdraw:** Your participation in this study is entirely voluntary. You may choose not to participate without any adverse consequences to you. Should you choose to participate and later wish to withdraw from the study, you may discontinue your participation at this time without incurring adverse consequences.

**IRB Approval:** This study has been reviewed and approved by the University of Wisconsin-Stout's Institutional Review Board (IRB). The IRB has determined that this study meets the ethical obligations required by federal law and University policies. If you have questions or concerns regarding this study please contact the Investigator or Advisor. If you any questions, concerns, or reports regarding you rights as a research subject, please contact the IRB Administrator.

**Statement of Consent:** "By signing this consent form you agree to participate in the project entitled, An Analysis of Mechanical and Electrical Construction Competencies in the Wisconsin and Minnesota Construction Industry."

_____

Signature.....Date