

Deciding What to Teach in a Specialty Contracting Field – an Industry Survey

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Advances in construction technology and practices reflect the need for a curriculum that addresses an increasingly complex construction environment. Most higher education learning institutions that offer a construction management related program subscribe to the American Council for Construction Education (ACCE) accreditation requirements. While these guidelines for accreditation provide a degree of uniformity among institutions, they typically cover only essential core skills and do not identify every element that should be taught over an entire curriculum. This paper describes the preliminary efforts and methods used to determine topics that would be most useful for Auburn University to teach in the area of electrical knowledge. Through interviews and literature reviews, a survey was developed to gain feedback from industry. The methods used to develop a useful set of questions to be used in the survey are discussed along with a presentation of the questions themselves. This research is the basis for a further study to be conducted in coming months to determine just what to teach in the electrical field. The same methods can be used to investigate appropriate course content for other specialty contracting fields.

Key words: Construction Curriculum, Electrical Knowledge, Construction Education, Electrical Survey

Introduction

Historically construction management programs have risen from a variety of other disciplines. There is a wide variety of degrees and courses of study that can ultimately land a college graduate in a construction management position within the construction industry. Aspects of early civil engineering programs lend themselves to the area of construction education. Throughout the 1900's there was a growth of knowledge that somewhat formalized specialty tracts of civil engineering. In the first half of the twentieth century there were a few civil engineering programs that showed a specialization in construction engineering. As this specialization gained popularity there was more curriculum than could adequately be incorporated in the civil engineering degree. After World War II there was a gradual need for the formation of construction specialty degree undergraduate programs (Abudayyeh, Russell, Johnston, & Rowings, 2000). This specialty degree was civil engineering at its roots but incorporated aspects of structural engineering. Initially construction engineering education was civil engineering with a focus on the entire life cycle of a physical facility, which includes conception, design, procurement, construction, operation, and maintenance (Householder & Rutland, 1990). The construction boom following WWII created a demand for more construction engineers. In response to this boom there was an establishment of a Bachelor of Science degree in construction. The BS in construction was not engineering accredited but incorporated many engineering courses as its foundation.

The construction industry recognized the need for educational programs that teach the "business of managing the construction process" (Badger, Robson, & others, 2000). Construction management education's mission was to create college educated constructors. A number of universities currently offer non-engineering BS degrees in construction management, building science, building construction, and industrial technology. The American Council for Construction Education (ACCE) accredits these degrees. There are currently 62 baccalaureate construction programs accredited by the ACCE. These curricula are a combination of engineering technology, construction techniques, business and management. There is a larger emphasis placed on management and business and less on math, science, engineering and other technical knowledge in many of today's construction management programs (Abudayyeh et al., 2000).

The skills a construction manager brings to a company or project team play a major role in the success of its projects. As the demand for higher performance throughout the life cycle of new buildings increases, owners call for more complex projects insisting teams complete them "better, faster, cheaper, and always safer" (Tatum, 2005). With trends like these, industry is looking for graduates whom are able to manage the construction process and are job ready as they leave their construction management programs. Providing a construction education that parallels the changing expectations of the construction industry is the only way to achieve this. With ACCE program accreditation there is some uniformity, however a wide variety of degree titles and locations of programs within different departments at different universities exists. Construction management programs must constantly be adjusted and enhanced to address the education needs of industry and hence the students (Farooqui & Ahmed, 2009). There is no absolute way to do this without research into what the industry's perception is on the current state of construction management education. To gain the knowledge necessary to properly adjust the spotlight of construction education curriculums is an arduous process. There is no magic bullet to quickly determine what is necessary to most effectively prepare the building professionals of tomorrow for their career in the construction industry. The rapid development of new technologies and innovations combined with new delivery methods and construction practices have caused a demand for graduates with a strong foundation of technical knowledge to effectively manage the construction process. Within technical knowledge there is a predominant amount of electrical skills that lend themselves to a majority of construction activities.

Within the past 3 years, Auburn University conducted a review of its curriculum to not only ensure compliance with ACCE requirements but also to determine if the needs of supporting industry partners were being met. One result of the review concluded that industry would like to see graduates have a better understanding of electrical and mechanical subjects. In response to this, the curriculum was expanded from one combined three hour mechanical/electrical course to two separate three hour courses, each with a lab component. Once the decision was made to change the course content, the next logical question was to ask just what should be taught in these courses. This paper describes the process that was used to develop a survey tool to help answer that question for an electrical course. A similar strategy can be used for other fields of study. The results for this phase of the study conclude with the survey itself. The actual survey results and formulation of an appropriate course outline are far too extensive to include in this conference proceedings paper and are left for further analysis and future publication.

The majority of graduates from Auburn University's program begin employment with either a construction management (CM) or general contracting (GC) firm. Placement opportunities with specialty contractors do occur however, so early in the investigation it became evident that there may be more than one answer to the "what should we teach" question, depending on what type of contractor answers. Auburn's program is designed to prepare graduates to enter the construction field primarily in the area of construction management. While many students are well suited, and may even prefer, a position with a specialty contractor, Auburn University does not offer specialty "tracts" that focus on a particular area of expertise in a specialty contracting field. The general knowledge offered by the program in estimating, scheduling, contracts, materials and management still makes graduates attractive to specialty contractor recruitment. In developing a course in the electrical area it is desirable to teach topics that not only benefit the GC/CM environment but also the electrical contractor (EC). Since only a limited number of curriculum hours can be devoted to the electrical subject, it became clear that a research tool needed to be structured so that topics could eventually be ordered in a most desirable to least desirable hierarchy. An added advantage to obtaining results that allow topics to be ranked makes the results useful for other institutions that may devote additional hours to the subject with multiple courses or specialty tracts. The results of this research led to the development of an extensive survey that is intended to be delivered to industry, both GC/CM companies as well as electrical contractors, to help answer the question "what topics should be covered in an electrical course as part of a construction management degree". From the approach taken in this research, others may follow similar procedures to collect useful knowledge from industry practitioners that may be used to formulate or update construction management courses.

Background Studies

There have been similar efforts by others to bridge the gap between what industry believes is important for a construction management program and what academia deems important. Other attempts have focused more on broad knowledge sets or key skill sets that need to be addressed by the curriculum as a whole. *Key Competencies for U.S. Construction Graduates: Industry Perspective* (Ahn, Kwon, Pearce, & Shin, n.d.) discusses competencies that are necessary for graduates to succeed in the dynamic industry that is construction. These competencies include: ethical issues, problem solving skills, interpersonal skills, leadership, adaptability, collaborative skills, safety issues, interdisciplinary application, practical awareness, technical skills, computer skills, estimating/scheduling skills, communication, and environmental awareness. For data collection a survey instrument was used. The survey was created with three sections: industry demographics, interviewee's demographics, and importance of the key competencies for construction graduates. The respondents to the survey were asked to rate their degree of agreement, using a Likert scale, with the responses: strongly disagree, disagree, neutral, agree, and strongly agree. The use of the Likert scale captured the intensity of a respondents feelings for a given item, allowing the results to reveal a pattern that could be used to rate the importance of the topics. Cognitive competency skills included problem solving skills, interdisciplinary application, and code/safety issues. Technical competency skills included technical skills, practical awareness and estimating/scheduling skills (Ahn et al., n.d.). These two areas of competency led to further research in creating topics for the electrical survey.

Key Skills for Graduating Construction Management Students-A Comparative Study of Industry and Academic Perspectives (Farooqui & Ahmed, 2009) is another study undertaken to identify key skill sets required for graduating construction management students as perceived by the industry and academia. This study also sought to determine the extent of agreement between industry and the academia as to the most important skills necessary for graduating construction management students. Researchers developed and distributed a questionnaire that consisted of two parts. Part A requested respondent's personal demographic information and company information. Part B consisted of comprehensive skill sets composed from literature review and a preliminary survey conducted with industry professionals. The preliminary study of industry professionals was used to identify the positions that graduates of construction management programs assume. Once feedback from both parts of the survey was received, there was an assessment of industry perspective, educator perspective, the overall perspective, and the difference in the importance of skills as perceived by industry and educators. The topics included within the questionnaire were grouped into skill categories. Some categories applicable to this study included industry & business skills, technical skills, and people skills. Industry & business skills contained attributes like knowledge of building codes & regulations and knowledge of health and safety regulations. Technical skill attributes were scheduling/plans interpretation/blueprint reading and knowledge of construction operations. These attributes are relevant to the electrical knowledge research and were looked at in developing the electrical survey questions.

Research Methodology and Results

Using information gained from the above studies and survey results, the process was begun to develop a set of applicable questions for an electrical subject survey. The first source of topics for the survey came from textbooks that have historically been used in the curriculum as well as other texts that are popular with other programs. Several textbooks were found to be used among the majority of construction management programs. These included: *Electrical Principles and Practices* (Mazur& Zurlis, 2003), *Mechanical and Electrical Systems for Construction Managers* (American Technical Publishers, 2007), *Mechanical and Electrical Equipment for Buildings*, (Stein, Reynolds, Grondzik, & Kwok, 2006) and *Mechanical and Electrical Systems in Architecture, Engineering, and Construction* (Wujek, 2010). These texts contain a large amount of information and cover a broad array of subjects. Rather than establishing topics on their own, the researchers felt these resources would represent topics which were already considered applicable to electrical education in a construction management program, at least from an academic point of view. Including many of these topics in the survey allowed an opportunity to get additional feedback from industry.

Another important source of topics was the current edition of the National Electrical Code. The researchers found it interesting that building codes don't seem to be integrated very well into the construction curriculum or texts. As this code defines the electrical requirements for building installations and has been adopted almost exclusively throughout the U.S., the contents provided an additional array of topical subjects to be investigated.

As questions were developed, they were reviewed with current students who had gained experience in the electrical field having completed at least one internship with an electrical contractor. These students provided insight on subjects they felt could have helped them in their work experience with an electrical contractor. Previous students who were now working with GC/CM contractors on local projects were also consulted. These former students, who were familiar with the current curriculum, were able to provide similar insight on subjects from a different perspective – managing or coordinating with an EC but not necessarily working directly in the trade. Phone and personal interviews were also conducted with industry professionals in GC/CM and EC areas to assist in formulating a meaningful set of questions. The goal was to investigate and develop subject areas that could be useful to both general construction management as well as electrical contracting fields.

Once a preliminary set of questions were compiled, it became clear that the nature and wording of the survey questions was going to require a great deal of thought if meaningful results were to be obtained from the responses. The first questions of the survey were designed to determine the construction background of the participant. This is an extremely important question. From a viewpoint of extremes, a general contractor may agree that a graduate could use more knowledge in the electrical field, but because of his own lack of knowledge, may not have any idea as to what the details of that knowledge should be. On the other end of the extreme spectrum, an electrical contractor seeking to hire graduates from a construction program might indicate that all the electrical subjects are of the highest importance. If not aware of this, it would be difficult to glean from the responses any type of ranking as to the importance of the topics. As stated earlier, this is a critical aspect of the survey. There is simply not enough time to teach every topic and depending on how much time a particular program devotes to the subject, being able to rank the topics in order of importance becomes important. Below is an outline of the preliminary topics that were established as a first step in survey question development.

Preliminary Electrical Topics

- Personal Information/Project Experience
    - Discipline/Type of Contractor
    - Types of Projects Familiar With
- Basic Knowledge
    - Electrical Principles
    - Building Electrical Systems
    - Electrical Distribution Equipment
    - Lighting
    - Special Systems
    - Emergency Systems
- Knowledge from the National Electrical Code
    - Electrical Materials
    - General Electrical Requirements
    - Electrical Circuits
    - Electrical Utilization Equipment
- Electrical Project Execution
    - General Electrical Work
    - Plans & Specifications
    - Estimating
    - Scheduling
    - Contracts

Fifty preliminary survey questions were developed asking respondents to rate the importance, or value, of various topics dealing with areas in the above list. A five level Likert scale was used, from least degree of importance to highest degree of importance. The questions were arranged in survey format and the survey was made accessible using an Apple Ipad. Members of the construction industry, who were attending a school career fair for construction management students, were asked to complete the trial survey. Using the tablet, multiple respondents were approached in order to have them complete the survey while attention could be paid to their responses and attitudes regarding the topics being addressed. This proved very successful as the trial run provided an opportunity to gain additional feedback from general industry personnel. This provided valuable information on the questions that were easily answered as well as those that needed clarification or refinement. The opportunity was taken to not only gain useful data from the questions for further use, but also to make note of the respondents opinions regarding the design and content of the survey. This proved to be useful in further development of the electrical survey to be distributed.

One problem discovered during the initial testing of the survey involved the participant's knowledge of a particular topic. For example, when asked the question 'do you think graduates should have a knowledge of power factor?': the GC may not know what the term power factor means, while the EC would. Re-phrasing the question to ask 'do you think graduates should know why generators have both KW and KVA ratings' might be better understood for both respondents. In order to understand the difference in KW and KVA ratings, it's necessary to teach about power factor. It was found that especially for the technical areas, one must phrase a question so its impact is apparent to someone without a lot of technical expertise in the subject. In other words, for some questions, it is necessary to define a topic before or while asking the question. Another method to keep from unnecessarily skewing the results was to add a response choice for 'do not know'. This circumvented including responses to rank the importance of topics where a choice might have been made without knowledge or understanding of the question.

Discussion and Conclusions

The research provided useful considerations for the creation and distribution of a survey to help evaluate course content as it relates to specialty contracting areas in a general construction management curriculum. Researching other survey efforts helped determine appropriate methods of collecting topics of key knowledge for a construction management education. Studies consulted also exemplified appropriate ways of posing questions and gathering useful information. It was through this research that a questionnaire survey was selected as the most effective way to collect data on the topics being investigated. Review of current curriculum content and texts typically used in construction management curriculums provided a topical base and the National Electrical Code provide additional topics on which to build appropriate questions for an electrical survey.

The use of interviews and preliminary survey instruments allowed the research to go through multiple iterations during which findings were made to enhance a final survey. From preliminary studies it was observed that different responses were received on multiple topics based on the respondent's professional background. It was important to recognize that distinction in order to filter survey responses effectively from multiple disciplines. An advantage was created when researchers performed the trial run and were able to be present while respondents answered the survey questions. This allowed feedback on the design and layout of the survey as well as the content. This would not have been possible had the survey been distributed via email or web and not undergone a trial phase. The ability for first person empirical evidence to be recorded was highly beneficial.

It was expected that the ranking of topic importance would vary depending on the participant's background. While the electrical contractor might have the most technical knowledge, his/her answers tended to rate a large number of subjects with the highest importance. When this was done, it lessened the ability to rank topics based on the survey results. A solution to this problem has not yet been found but efforts in this area continue in hopes of mitigating the problem before the next phase of the study gets underway. During the testing phase for the survey, several respondents made comments as they worked thru the questions such as 'I wish I had not marked so many questions with a five' (five indicating strongly agree or most important). Other comments included 'I wish there was a six or seven' for that question. These comments indicated that the respondents were thinking about the overall relative importance of the topics. The ability to relate relative ranking among survey questions is not inherent in the process of answering the individual questions. A possible solution to this problem would be to instruct, encourage, and allow respondents to go back over the entire survey, once completed, in order to better rank topics in relation to one another with the available Likert scaling.

The conclusion of this effort was to develop a suitable survey for distribution in a future effort to develop a curriculum outline for a construction management electrical course. The researchers produced the survey and will use an online service (zoomerang.com) to distribute the survey. Aside from 2 personal information questions, which were multiple selection answers, the survey totaled 52 questions. Respondents were asked to rate the topics on their degree of importance using a five point Likert scale, from lowest degree of importance to highest degree of importance. The methods described in this paper can be followed in a similar manner to establish surveys for other specialty or technical subject areas to be included in a construction management curriculum. The survey is included in the appendix below.

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Appendix

Final Electrical Survey

1. Which of the following best describes you? (Your company)
   General Contractor
   Construction Management
   Electrical Contractor
   Other (Please Specify)

2. What types of projects are you most familiar with? (Select all that apply)

Healthcare	Hotel/Apartment/Condo
Educational	Retail
Office	Industrial
Other (Please Specify)	

Please answer the following questions regarding electrical knowledge of recent construction management graduates with a selection 1-5, where a 1 being what you believe to be the LEAST important and 5 being the MOST important

Electrical Principles

3. Electrical Energy Sources-solar, batteries, generators, hydroelectric, nuclear, coal, etc.
4. AC and DC systems-why do we use AC for buildings
5. Transformer Types-how they function
6. Voltage drop in circuits and how to calculate
7. Power factor in AC circuits-primarily caused by motor loads and is considered in generator sizing
8. Measuring AC voltage and current true RMS values and harmonics

Building Electrical Systems

9. Electrical distribution systems-why are there different system voltages
10. How single phase and three phase systems work-what is the difference
11. How series and parallel circuits are used in buildings, switches and load connections

Electrical Distribution Equipment

12. How electrical panels supply different voltages-1 pole, 2 pole, & 3 pole circuit breakers
13. Circuit Breakers and Fuses-overcurrent and short circuit protection
14. Types of major electrical equipment-switchboards, switchgear, panel boards, loadcenters, motor control centers, and transformers

Lighting

15. Lighting sources-fluorescent, incandescent, HID, LED, etc.
16. Lighting design-calculating lighting levels

Special Systems

17. Lighting control systems-dimming, automation, and energy savings
18. Access control systems- (card, keypad, etc.) and intrusion detection
19. Intercom, Nurse Call, and other audio systems
20. Communication systems telephone and data
21. Ability to read and understand control diagrams-ladder diagrams, relays, interlocks and switches (limit, proximity, temperature, pressure, flow, etc.

Emergency Systems

22. Generators and UPS systems
23. Battery backup for egress/emergency lighting
24. Fire Alarm systems

Electrical Materials

25. Understanding conductor ratings-insulation type, temperature, and ampacity
26. Wiring methods-conductor cables, conductors in raceways
27. Electrical raceway systems- conduit types, cable tray, wireways, flexible conduit, etc.
28. Electrical devices-receptacles, switches, disconnects, and fixtures, NEMA designations
29. Methods used to make wiring connections- marking & color coding

General Electrical Requirements

30. Electrical equipment clearances and installation requirements
31. Lockout/Tagout procedures

Electrical Circuits

32. Calculating basic circuit sizes-finding the ampacity requirements for branch circuits and feeders
33. Residential and commercial service calculations
34. Electrical grounding and bonding requirements
35. Arc Fault and Ground Fault equipment requirements

Electrical Utilization Equipment

36. Requirements and calculations for motor circuits, short circuit and overload protection for single phase and three phase motors
37. Requirements and calculations for air conditioning circuits- nameplate ratings, minimum circuit ampacity, maximum fuse/circuit breaker size and full load amp

Electrical Project Execution

38. Temporary jobsite power and lighting
39. OSHA requirements
40. Familiarity with the National Electrical Safety Code
41. Ability to use typical metering and test equipment
42. How to bend conduit and pull wire
43. Ability to make electrical connections- including communication cable terminations
44. Installing and connecting basic electrical devices and equipment-outlets, switches, fixtures, etc.
45. Understanding basic electrical plan symbols
46. Understanding and reading electrical single line (or riser) diagrams
47. Understanding and ability to read panel schedules
48. Ability to perform an electrical plan takeoff
49. Acquiring pricing information from vendors and other sources
50. Preparing an electrical bid including labor and markups
51. Determining crew size and project man loading schedules
52. Learning typical coordination requirements with other contractors and systems
53. Writing an electrical scope of work
54. Review of typical contracts for electrical work with different delivery methods-prime contractor, subcontractor, design build, etc.