Construction Degree Graduates: An Evaluation of Depth of Skill Understanding and Skill Priority by Construction Industry Professionals

Ben F. Bigelow PhD
Texas A&M University, bbigelow@arch.tamu.edu

Edelmiro Escamilla PhD
Texas A&M University, eescamilla@arch.tamu.edu

Lauren Kuecker MSCM
Texas A&M University, Wortham89@tamu.edu

ABSTRACT
Previous studies have been conducted to determine the skills the construction industry expects graduates and entry level professionals to possess. The majority of those studies report soft skills and technical expertise as the main qualities graduates should have upon entering the industry. Many differing skills have been reported, but neither the expected depth of understanding in those skills nor the industry's priority of those skills have been explored. To do so, a survey was administered to members of the Construction Industry Advisory Council at Texas A&M University asking these questions. Depth of understanding was evaluated on a four level basis (Awareness, Comprehension, Application, and Analysis) and priority was based on participant ranking. The results show that soft and technology skills are expected to be understood at a higher level, while other construction skills are expected at a lower level. Further, soft skills comprised 8 of the top 10 skills in priority.

Keywords: Construction Education, Skills, Competencies

Dr. Ben F. Bigelow is an Assistant Professor in the Department of Construction Science at Texas A&M University, his research focuses on construction education, workforce issues, housing, and Underrepresented groups in construction.

Dr. Edelmiro Escamilla is an Instructional Assistant Professor in the Department of Construction Science at Texas A&M University. His research focuses on Hispanic issues in construction, workforce shortages, and construction education.

Lauren Kuecker is a graduate of the Masters of Science Construction Management program at Texas A&M University, and earned her bachelors degree in Environmental Design also at Texas A&M University. She is an assistant project manager at Kieschnick General Contractors.

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INTRODUCTION

The skills needed to be successful in the construction industry have been the subject of many studies (Ahn, Kwon, Pearce, & Shin 2010; Souder & Gier 2006; Badger, Wiezel, & Bopp 2007; Perreault 1993; Banik 2008), and as a result many broad skill sets and even more specific skills have been identified as necessary in the construction industry. These studies however typically have been performed individually, and have focused on specific skill set areas, so as each study has been performed the list skills needed to work in the construction industry has continued to grow.

Previous studies report that there is a need for technical, soft, and other skill sets among graduates, however there is no prioritization of the skills. Further the depth of understanding of skills, that graduates should poses, has not been explored. Love et al. (2001) pointed out that managers should be tolerant and considerate of the inexperience of recent graduates, but by preparing students not only with the appropriate skills, but also the appropriate depth of understanding, they will be better prepared to contribute upon entering the industry.

Departments of construction higher education frequently utilize advisory councils, made up of industry professionals, for direction on what skills the construction industry expects of graduates. Feedback may occur in an annual meeting (Hynds & Smith 2001), or through informal communication. This information collected from the industry is valuable and helps attenuate any disconnect between academia and industry. However this feedback is unlikely to be formally disseminated, and as a result does not reach many faculty and administrators. The purpose of this study is to provide empirical data supporting a prioritized list of the skills needed by construction graduates and to provide a minimum depth of understanding of these skills for educators to use in guiding their curriculum. This information will allow universities to better prepare students to succeed in the construction industry.

This study asked; what is the skill depth of understanding that the construction industry expects of graduates entering the construction industry? Further it asked, among the many skills identified as necessary by previous study, which skills does the construction industry place the highest priority on? These questions are significant and add to the body of knowledge on this subject for two reasons. First, while many studies have presented skills or skill sets needed by graduates, they have not compared the different skills, and in the cases where skills have been compared and prioritized they have compared a limited listing of skills, not an exhaustive listing of the skills reported as necessary in the literature. Second, previous studies have focused on skill needed, but have not evaluated the depth of understanding expected in those skill areas, which was a primary focus of this study.

LITERATURE REVIEW

Twenty years ago Perreault (1993) determined computer skills and field and technical skills as necessary in construction. Ten years later computer literacy was again reported as a necessary skill (Love, Haynes & Irani 2001). A foundation of technical and construction skills and other competencies such as computer skills are expectations required of graduates to succeed in the construction industry (Ahn et al. 2010). While researchers generally concluded that recent

graduates, from programs of construction higher education, have satisfactory technical skills and meet industry expectations, they report that graduates lack training in soft skills, and concluded that universities do not place enough emphasis on them, specifically on communication (Banik 2008). Souder and Gier (2006) also report a need for emphasis on other skill areas. This need for soft skill training likely contributes to why construction student competition are so valued by the construction industry, as participants gain soft skills through participation (Bigelow, Glick, Arragon, 2012). Pant and Baroudi (2008) concluded that a balance needs to be struck in education between technical and soft skills.

Of the primary skill requirements of construction graduates determined by Perreault (1993), three of them were in soft skills: team work, effective oral and written communication, and analytical and management skills. In terms of fundamental soft skills, Souder and Gier (2006), and subsequently Ahn et al. (2010), found that ethical issues, leadership, communication and business writing, and management organization to be the primary expectations of professionals. Love et al. (2001) found that students failed to meet expectations with certain soft skills such as intrapersonal skills, time management, and being able to exercise personal judgment. Badger, Wiesel, and Bopp (2007) also found leadership to be an expected skill required by graduates. They classified soft skills such as communication and team work as leadership qualities. Over the years, soft skills such as ethical issues, oral and written communication, leadership, team work, and management skills appear consistently as necessary (Perreault 1993; Love et al. 2001; Souder & Gier 2006; Badger et al. 2007; Ahn et al. 2010), unfortunately the depth of understanding of those skills has not been addressed.

While soft and technical skill sets were the most common throughout the research, a number of other skill sets were identified that are more directly related to the construction industry. Perreault (1993) found contract and legal documentation knowledge to be primary requirements of graduates. Souder and Gier (2006) reported negotiation skills, along with skills such as estimating, plan and specification reading, safety, and scheduling. Ahn et al. (2010) determined that problem solving skills were needed.

METHODOLOGY

In order to address the questions posed by this study:

- What is the skill depth of understanding that the construction industry expects of graduates entering the construction industry?
- Among the many skills identified as necessary by previous study, which skills does the construction industry place the highest priority on?

All of the different skills needed by graduates identified in the literature review, were used to inform this study. From those skills the survey was produced that was used for data collection, specifically allowing for prioritization and evaluation of expected depth of understanding.

Population

This study used the Construction Industry Advisory Council (CIAC) at Texas A&M University as the selected sample. The Texas A&M CIAC was selected for convenience to the researchers, however because of its size (at the time, over 100 members) it could still provide a robust sample *(n)*. A total of 61 responses were received, and after filtering 56 usable responses emerged.

Responses were delimited to those with at least 4 years of experience, and holding a management position. Participants did not provide feedback for every single skill, so pairwise deletion was used and the *n* for each skill varies from 46 and 49. The majority of respondents (32) were Senior Executives, with other management categories such as Project or Program Management, Superintendents, Construction Managers, and Resource Managers included. The majority (44) had more than 15 years of experience. 43 participants classified themselves as being from the general building sector of the construction industry. The remaining 12 came from the heavy industrial and infrastructure sectors of the construction industry.

The sample in this study represents a good cross-section of types of construction companies and sizes, however the small sample ($n = 56$) and the regional nature of the participants (state of Texas) present threats to the external validity of this study. The authors assert that the sample is representative of the population, which is a vital consideration in external validity (Gliner, Morgan, & Leech, 2009), but results should only be generalized outside the state of Texas with great caution.

Data Collection & Analysis

Institutional Review Board (IRB) approval was received before beginning the data collection process. The survey was organized based on the skill sets reported in the literature and a total of four skill set areas were identified and they include: soft, technology, project development, and project execution skills. Within each skill set area, individual skills were presented and participants were asked to report at what depth of understanding they expected students to possess each skill. Four different options for depth of understanding were provided:

- *Awareness*- The simplest level, the graduate is aware of the skill and its meaning.
- *Comprehension*- The graduate has an understanding of the skill, but is not yet able to apply it.
- *Application*- The graduate can apply the skill.
- *Analysis*- The highest level, the graduate is able to not only apply a skill, but also able to analyze and understand it completely.

After providing an expected depth of understanding for each skill, participants were asked to rank the skills they believe are most important for a recent graduate to have when entering the construction industry. Rankings from 1 to 10 were requested, with 1 being the most important skill. Although the list included more than ten skills, participants were only asked to rank their top ten. The remaining unranked skills were assigned an 11.

ANALYSIS & DISCUSSION

A quick overview of the responses was not surprising, they indicated that most skills (77%) should be understood at a comprehension or application level, indicating graduates should have more than just knowledge of the skills in question, but are not expected to be experts. 723 (39%) were on an Application level, 699 (38%) were on a Comprehension level. Only 5% of responses indicated an analysis level, the highest level, as the expected depth of understanding. 18% of responses indicated the need of only an awareness level, the lowest level, depth of understanding. To better understand these aggregate numbers each skill set area was considered.

Table 1 reveals consistency among soft skills. According to the participants most skills falling in the soft skill set area are expected to be understood at an application level. So while graduates are not expected to be experts they are expected to have more than just a basic understanding of these skills. Graduates are expected to be able to apply these soft skills in their positions.

Table 1. Soft Skills Response Breakdown

	Depth of Understanding				
Skill(s)	Awareness	Comprehension	Application	Analysis	*n*
Accountability	0	12	30	7	49
Cultural/Gender/Generational	19	22	8	0	49
Ethics	3	11	27	7	48
Leadership	3	21	23	2	49
Non-Native Language	38	7	3	0	48
Oral Communication	0	5	42	2	49
Professionalism	1	8	35	4	48
Team Work	1	5	39	4	49
Written Communication	1	5	38	5	49

Despite the consistency between most of the soft skills, there are some exceptions. Non-native language skills and cultural/gender/generational awareness were two exceptions to the application depth of understanding expected with other soft skills. Cultural/gender/generational awareness was closely split between awareness and comprehension indicating expectations are lower regarding this skill. However non-native language skills have the lowest expectation of any skill set, with nearly 80% of participants indicating that they expected only an awareness depth of understanding (the lowest level). This result is particularly interesting given the high participation rate of non-English speakers in the construction workforce. The researchers point out that this study does not question the value of the skills presented, it only evaluated the expected depth of understanding for graduates so it should not be construed that non-native language skills are not desirable or beneficial, only that graduates are not currently expected to have more than an awareness of them.

Like with soft skills, the construction industry has great expectations of students in regard to their depth of understanding of technology skills. As shown in table 2, with 9 responses for an analysis level depth of understanding, computer skills have the highest expectations of any skill in this study. In fact 96% of respondents indicated that they expected graduates to have computer skills at an application or analysis level, which is also higher than any other skill in this study. Proficiency with specific software did not have quite the same expectation as computers in general. However it was still clear that the industry has a high expectation of a graduate's depth of understanding regarding software. Graduates are expected not only to possess, but to be able to apply skills with computers and different software packages. Skill expectations with technology are the highest of all skill areas surveyed.

Table 2. Technology Skills Response Breakdown

	Depth of Understanding				
Skill(s)	Awareness	Comprehension	Application	Analysis	*n*
Computers	0	2	35	9	46
Software Proficiency	1	9	30	7	47

While soft skills and technology skills could apply to almost any industry, project development skills represent a skill set area focused on construction specific applications. While a few respondents

indicated that these skills should be understood at higher levels, about half of all responses indicated these skills should be understood at a comprehension level, where graduates would be expected to have only a basic knowledge of the skill. Table 3 displays all the results for project development skills.

Table 3. Project Development Skills Response Breakdown

	Depth of Understanding				
Skill	Awareness	Comprehension	Application	Analysis	*n*
Constructability, Operability, Maintainability	10	22	16	0	48
Contract Process, Administration, Negotiation	7	32	9	1	49
Delivery Method	10	24	13	2	49
Engineering & Design	17	22	7	2	48
Green Building/Sustainability	14	25	7	2	48
LEAN Construction	16	24	7	1	48
Legal Issues	23	18	8	0	49
Marketing & Customer Satisfaction	14	21	14	0	49
Needs Assessments	17	21	9	1	48
Project Economics	15	23	8	2	48
Project Life-Cycle Process	15	23	9	1	48
Requests for Services/Proposals	11	25	11	1	48

While most responses regarding project development skills indicated an expectation of a comprehension level depth of understanding, with only one exception, between 20% and 30% of responses indicated that these skills were only expected at the lowest level, awareness. The results are intriguing as these skills are certainly important skills for a construction professional. Despite their importance, they are not expected to be developed in new graduates. The researchers conclude that these skills are expected to be acquired in a work environment, not in college. The researchers conclude this to be the case because project development skills are connected to positions that are unlikely to be filled by a recent graduate, these positions are typically filled by more experienced individuals.

Legal issues represent a variation within the project development skill set. Overall the expectations for graduates regarding legal issues is low, with 47% of responses indicating only an awareness depth of understanding, while other skills were expected at a comprehension level. These results do not devalue skill with legal issues, however it is clear that expectations of these skills is low and second only to non-native language skills as having the lowest expectation regarding a graduate's depth of understanding.

Project development skills are more likely to be used in higher ranking positions, but project execution and control skills fall to positions that a recent graduate is likely to occupy. As can been seen in table 4, the expectations for graduates regarding project execution and control skills are higher than project development skills. Graduates should be able to understand these skills and apply them at a low level.

Table 4. Project Execution & Controls Skills Response Breakdown

	Depth of Understanding				
Skill(s)	Awareness	Comprehension	Application	Analysis	*n*

Change Management	9	23	15	1	48
Construction	2	26	17	3	48
Environmental Health & Safety	7	22	17	1	47
Estimating	3	24	20	1	48
Graphic Communications	6	18	22	2	48
Planning & Scheduling	2	22	21	3	48
Procurement	6	26	15	1	48
Schedule & Cost Controls	2	21	24	1	48
Specifications	6	21	22	0	49

Comparing tables 3 and 4 we see a shift in expectations from the project development skill set to project execution and controls skill set. While the depth of understanding expected for most of these skills in both areas are at the comprehension level, there is a shift from an awareness-comprehension for project development to comprehension-application for project execution and controls. Based on these results it is clear that the construction skills that should be focused on in construction education are those found in the project execution and controls skill set.

The more profound depth of understanding expected for most soft skills is particularly interesting when soft skills are compared to the responses for other skill set areas. As is shown in tables 3 and 4, skills that are more technical in nature dealing with construction specific skills do not have the same expectations regarding depth of understanding. These results indicate that the industry has greater expectations in soft skill areas than they do regarding most technical construction skills. This finding is of particular importance given the subject matter of most construction education courses, where a construction skill is the focus and soft skills are accessories to the subject. These results indicate that perhaps the opposite approach would better prepare students to work in the construction industry, making soft skills the focus of courses and construction skills as accessories.

Like soft skills, Technology skills were shown to have high expectations regarding a graduate's depth of understanding. Although technology skills only included two specific skills, expectations were notably higher for them than for any of the more construction specific skills and were comparable to many soft skills. The industry clearly has high expectations of graduate's abilities to use technology. This depth of understanding expected regarding both soft skills and technology skills seems to indicate that the construction industry places greater importance on these areas.

Depth of understanding is an important measuring stick of student preparation for careers in the construction industry. However, high industry expectations are not necessarily the same as importance when comparing one skill to another. This study supports previous research regarding skill needs of construction graduates and concludes that all of the skills identified in the literature are valued by the construction industry and are expected of graduates from programs of construction higher education. Because the depth of understanding expected in each of these skills varies, it is important to recognize skills with a higher level of understanding may merit additional time or emphasis in a curriculum, but are not necessarily more important than other skills with lower expectations regarding depth of understanding.

Skills that have a higher depth of understanding expectation could easily be construed as more important than another skill, as a result this study also explored the priority placed on the different

skills identified by the construction industry. To evaluate priority among the skills identified, the study asked participants to prioritize the skills they feel are most important for graduates to possess.

Participants ranked their top ten most important skills in order with 1 as the most important skill a graduate should possess. Because there were more than 10 skills to choose from, an 11 was assigned to any skill which participants did not include in their top ten. Using the 11 for the non-responses prevented the data from becoming skewed. Table 5 lists the rankings of the skills based on the average score, with lower scores indicating greater importance. The skill set category for each skill is also listed to illustrate which categories received the most attention concerning priority.

Table 5 Skill Priority by Average Score

Rank	Skill	Average Score	Skill Set Area
1	Ethics	6.625	Soft Skills
2	Team Work	6.946	Soft Skills
3	Accountability	7.321	Soft Skills
4	Written Communications	7.357	Soft Skills
5	Oral Communications	7.536	Soft Skills
6	Time Management & Multitasking	8.018	Soft Skills
7	Professionalism	8.143	Soft Skills
8	Planning & Scheduling	8.411	Project Execution
9	Leadership	8.607	Soft Skills
10	Computer Skills	8.929	Technology
11	Estimating	9.089	Project Execution
12	Problem Solving	9.500	Soft Skills
13	Construction	9.571	Project Execution
14	Schedule & Cost Controls	9.589	Project Execution
15	Software Proficiency	9.821	Technology
16	Marketing & Customer Satisfaction	10.036	Project Development
17	Constructability, Operability, Maintainability	10.089	Project Development
18	Graphics Communications	10.214	Project Execution
19	Scope Development	10.232	Project Development
20	Change Management	10.304	Project Execution
21	Project Economics	10.321	Project Development
22	Delivery Method	10.321	Project Development
23	Engineer & Design	10.339	Project Development
24	Procurement	10.393	Project Execution
25	Risk Management	10.446	Project Development
26	Contract (Process, Administration, Negotiating, Development)	10.464	Project Development
27	Green Building/Sustainability	10.482	Project Development
28	Environmental Health & Safety	10.500	Project Execution
29	Specifications	10.536	Project Execution
30	LEAN Construction	10.554	Project Development
31	Needs Assessments	10.571	Project Development
32	Project Life-Cycle Process	10.607	Project Development
33	Quality Assurance/Quality Control (QA/QC)	10.607	Project Execution
34	Legal issues	10.625	Project Development
35	Cultural/Gender/Generation Differences	10.643	Soft Skills
36	Request for Services/Proposals	10.679	Project Development
37	Non-Native Language Skills	10.714	Soft Skills
38	Lessons Learned	10.821	Soft Skills

The high expectations of most skills in the soft skill area coincide with the high priority identified for construction professionals and at number 12, problem solving just missed the top ten. It should be noted however that the remaining soft skills constituted three of the four lowest priority skills. This somewhat bipolar result among the soft skills set is important as it indicates that a broad focus on soft skills (or any one particular skill area) may not serve a graduate well, rather there are certain soft skills which are considered significantly more important, and for which a graduate's depth of understanding is expected to be much higher. Even given the low priority of three of the soft skills, the value of soft skills in general is punctuated by the fact that eight of the top ten most important skills are soft skills.

Technology skills remained high on the priority list however their rankings were lower than might have been expected based on the reported depth of understanding expectations. An evaluation based solely on the expected depth of understanding would have made a solid argument for computer skills as the single most important skill, and software proficiency at least in the top ten. In the priority results however, computer skills and software proficiency ranked 10th and 14th respectively, indicating that while these skills have high importance, the construction industry does not value them as highly as most soft skills and even a few project execution skills. While the depth of understanding results and priority results do not exactly coincide, the data presented indicates that technology skills are among the most important skills a student should possess upon graduation.

The skill of planning and scheduling represented the one construction specific skill that made the top ten. It is worth noting however that estimating came in at 11, only a 16th of a point behind the number ten skill. Scheduling and estimating skills were split between a comprehension and application expectation for depth of understanding, so they are skills whose value could have easily been overlooked. Based on the priority rankings, these two skill areas are considered the most important construction specific skills for graduates to possess, making them arguably the construction skills deserving of the greatest focus in construction education. But despite that argument for their importance, the construction industry has a very reasonable, comprehension-application, expectation of graduates regarding these skills.

Project execution skills were scattered from number 9 to number 33 on the priority list, however most of these skills fell within the top twenty skills. As might be expected from the depth of understanding expectations, project executions skills generally fell in behind soft skills, and were comparable with technology skills based on priority. Project execution skills generally include those construction skills that graduates will be required to perform in their positions upon entering the construction industry. While there is an expectation that graduates will have a comprehension-application depth of understanding of most of these skills, they are considered less important than soft skills for graduates. This study confirms the need and expectation of these skills for graduates, however based on the results, the researchers conclude that even more important than these construction specific skills is the ability to communicate in their regard on a job site.

The fourth skill area considered was project development skills. These skills had an awareness-comprehension depth of understanding expectation, and their rankings in regard to importance ranged from 16 to 36 reinforcing the conclusion that these are skills that the construction industry expects graduates to be aware of, but that they will acquire in depth with time and experience

working. These findings do not mean project development skills are not important for graduates, rather they indicate that these skills and topics should be accessories to construction education not its focus. The researchers conclude this is primarily because these skills are not typically utilized in positions filled by new graduates, so they are a lower priority.

The results regarding depth of understanding and skill priority reaffirm the importance of a diverse skill set in the construction industry. Soft skills, technology skills, and construction specific skills are all valued and expected, but there is a distinct hierarchy among them and the level of understanding of each skill varies. Soft skills are seen as the highest priority skills to possess, whereas technology skills have the highest expectation for depth of understanding. As a result construction programs should tailor to meet those priorities and expectations. The researchers assert that knowing the depth of understanding expected and the priority of these skills are both vital pieces of information for shaping construction education as some skills may be important but have low depth of understanding expectations which should impact instruction and training in those skills.

Despite the findings of this study, indicating the importance of soft and technology skills, it is project execution and development skills that are the focus of most classes in programs of construction higher education. While the skills taught in these classes are important, these findings clearly indicate that construction education is likely focusing on areas that are less important for a graduate upon entering the construction industry. The results do have exceptions, as skills such as scheduling and estimating have a high priority, but in general these findings indicate that the focus of most construction education programs should be soft skills with construction specific skills as an accessory. Based on both sets of findings, the researchers conclude that a graduate who is able to apply soft skills such as ethics, team work, communications, and professionalism will acquire technology and project specific skills, however the opposite may not be true.

The scope of this study did not consider current teaching pedagogy in construction education, and how these findings could be applied, beyond the anecdotal experience of the researchers. As a result the researchers recommend for future study the following topics:

- How do programs of construction higher education currently align with these conclusions regarding depth of understanding and priority?
- Do recent graduates' skills align with these expectations?
- How is and individual's depth of understanding in soft skills determined?
- Are these results from the state of Texas consistent with other parts of the country?

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