Advisory Board Feedback on Construction Education Learning Outcomes

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This research compares the opinions of members of two distinct construction Industry Advisory Boards: one serving University of Colorado Denver's graduate Construction Engineering and Management program and one serving California State University, Fresno's undergraduate Construction Management program. Both Advisory Boards' members were asked to evaluate the American Council for Construction Education's (ACCE) student learning outcomes. Results suggest that general consensus exists that ACCE's learning outcomes have value relative to today's construction industry, and, in particular, both Advisory Boards identified written communication as the top learning outcome. Overall differences included stronger interest in nearly all learning outcomes for the CEM program, with particular added emphasis on learning outcomes related to "creating." Of the 20 learning outcomes assessed, Advisory Boards opinions showed statistically significant differences in four cases. Differences highlight the need for accreditation bodies as well as institutions to adapt and revise learning outcomes in order to stay current with an evolving construction industry. Findings also suggest that different construction programs and different industry practices support a range of learning outcomes.

Keywords: Industry Advisory Boards, Construction Education, Learning Outcomes, Competency

Introduction

The primary goal of construction education is to provide students with the skills and competencies necessary to support and maintain successful careers in the construction industry. Construction Management (CM) programs primarily focus on preparing students for the business of construction, while Construction Engineering and Management (CEM) programs seek to also provide the technical skills necessary to make design and planning decisions related to construction. In general, CM programs are accredited by the American Council for Construction Education (ACCE), and CEM programs are accredited by the Accreditation Board for Engineering and Technology (ABET). American Society of Civil Engineer's (ASCE) also defined its own educational outcomes (BOK, 2008). Academic accreditation is voluntary, and significantly more common at the undergraduate rather than graduate level. An important feature of the accreditation process is "outcomes assessment" (Palomba and Banta, 1999), which refers to a process of identifying learning outcomes for students, using a variety of measures to assess those outcomes, and then forming the gathered information into a feedback loop to guide decisions about program improvement (Wolf and Goodwin, 2007). ACCE defines 20 learning outcomes in their standards and criteria for accreditation (ACCE, 2014) and ABET defines 11 (ABET, 2016).

Nevertheless, variation in assessments exist across academic programs. Previous research has attempted to provide frameworks to aid in the standardization of mapping competencies across construction curricula or to aid in the

assessment of technology-based competencies emergent in construction education (Perera et al., 2016). Other research has identified classes of competencies for construction graduates including: (1) general competency, (2) affective competency, (3) cognitive competency, and (4) technical competency (Ahn et al.,2012). Still other research has focused on assessing how well competency-based models can predict students' future performance in the construction industry (Dainty et al., 2010). Recent research has also explored to what extent the use of technology and goals related technology-based competencies in construction can be assessed using traditional learning outcomes, whether such skills require a new pedagogy, and to what extent student backgrounds play a role in student learning outcomes (Nguyen, et al 2012).
Within the current body of research exploring competencies and assessment in construction education, a general consensus is emerging that soft-skills involving team-work, communication and collaboration are essential components of construction education, and that large gaps can occur between desired and actual levels of learning related to communication, leadership and social skills (Male et. al, 2010). Ahn, for example, identified 14 key competencies for construction graduates with the majority of these competencies focused on soft rather than hard skills (Ahn et al., 2012). Additional research has validated the importance of effective teamwork in the construction industry (Krug, 1997; Levi, 2013).

Despite the significant contribution of such studies in advancing construction related education, additional research is needed to further explore the applicability and relevance of ACCE learning outcomes to construction education today. ACCE learning outcomes were selected for study since they are construction specific. The authors sought the opinions of two Industry Advisory Boards (IABs), one serving California State University, Fresno's (Fresno State) undergraduate construction management program, and one serving University of Colorado Denver's (CU Denver) graduate construction engineering and management program. Industry opinions are critical since the construction industry is, ultimately, the beneficiary and consumer of construction students' skills and competencies. The significance of influence of IABs on construction management and similar degree programs, especially their curricula and contents, has been acknowledged among the Associated Schools of Construction and well received by ACCE (McIntyre, 2015; Hauck, 2016). As indicated by Emmer and Ghanem (2013), the top three contributions of the IABs include "ensuring curriculum is consistent with industry expectation", "ensuring students are taught current trends", and "ensuring students are learning current technology". Meanwhile, Emmer and Ghanem (2013) suggested factors including the culture, values, and priorities of the institution, program, and the board itself may contribute to the overall effectiveness of an advisory board. The underlying motivation of the research is to compare and contrast the opinions of these regionally and programmatically distinct IABs in order to measure and assess ACCE's learning outcomes from the perspective of active industry.

Methodology

This research studies the opinions of members of two distinct IABs: CU Denver's CEM program and Fresno State's CM program regarding the importance of ACCE's defined 20 construction education learning outcomes (ACCE, 2014). ACCE learning outcomes are listed in Table 1. A short (1 page) survey instrument was administered to IAB members at both institutions during advisory board meetings in fall, 2016. A survey data collection method was selected since the intent of the research was to sample opinions of a target population, in this case construction industry leaders with interest in construction education. The brief survey included a question which instructed respondents to "Select the priority of each Learning Outcome." It provided check boxes next to each competencies using a Likert type scale coded from 1-5, with 1= *Very Low* or *Extremely Irrelevant* and 5 = *Very High* or *Extremely Relevant*. All survey results were extracted to Microsoft Excel for analysis. The authors applied T-test statistical analysis to identify patterns and detect statistically significant differences in responses for the two IABs. Due to the size of the sample as well as sampling techniques used, results of this survey may only reflect the specifics of the construction education programs at the two institutions.

Table 1 Learning Outcomes for 4yr post-secondary construction education programs (ACCE, 2014)

A	**Create** written communications appropriate to the construction discipline.
B	**Create** oral presentations appropriate to the construction discipline.
C	**Create** a construction project safety plan.
D	**Create** construction project cost estimates.
E	**Create** construction project schedules.
F	**Analyze** professional decisions based on ethical principles.
G	**Analyze** construction documents for planning and management of construction processes.
H	**Analyze** methods, materials, and equipment used to construct projects.
I	**Apply** construction management skills as member of a multi-disciplinary team.
J	**Apply** electronic-based technology to manage the construction process.
K	**Apply** basic surveying techniques for construction layout and control.
L	**Understand** different methods of project delivery and the roles and responsibilities of all constituencies involved in the design and construction process.
M	**Understand** construction risk management.
N	**Understand** construction accounting and cost control.
O	**Understand** construction quality assurance and control.
P	**Understand** construction project control processes.
Q	**Understand** the legal implications of contract, common, and regulatory law to manage a construction project.
R	**Understand** the basic principles of sustainable construction.
S	**Understand** the basic principles of structural behavior.
T	**Understand** the basic principles of mechanical, electrical and piping systems.

Please note that, ACCE learning outcomes (ordered letter) groups learning outcomes by action to "create" (A-E), "analyze" (F-H), "apply," (I-K) and "understand" (L-T). As such, the further up the alphabet represents a decrease in learning level as defined by Bloom's Taxonomy (Anderson et al., 2001)

Demographics of Survey Respondents

A total of ten CU Denver CEM IAB members and seventeen Fresno State CM IAB members responded to the survey. A paper-based version was administered at fall Advisory Board meetings held on September 28th at CU Denver and September 23rd at Fresno State. Ten of the 12 members of the CU Denver's CEM advisory board were present at the meeting and completed the survey (83.3% response rate). 11 of 12 present board members were male. 11 of 12 members are active in the construction industry, with one retired from industry. Most hold titles of Vice President or higher. Many hold bachelor degrees in engineering with several holding a B.S. in civil engineering from CU Denver. Figure 1a presents a breakdown of the types of firms where CU Denver's CEM advisory board members work. Specifically, the "other" category included companies identified as Owner's Representative or Government Agency. Figure 2a presents a breakdown of the primary sector for all CU Denver's IAB members' firms. At Fresno State, six CM advisory board members of the 15 in attendance completed the paper-based survey. An additional 11 responses were gathered using an on-line survey administered through Qualtrics between the dates of August 2nd and Sep 30th making the response rate 40% for the 42 IAB members. These members are active leaders in construction industry with many being graduates of the Fresno State CM program. Figure 1b presents a breakdown of the types of firms where Fresno State CM IAB members work. Figure 2b presents a breakdown of the primary sector for the Fresno State's IAB members' firms.

In general, demographics of the two IABs show relatively comparable and heterogenic memberships, representing a variety of firm types working within a range of sectors. The one difference that may be worth noting is that the Fresno State CM IAB includes more sub-contractors with one individual representing residential construction.

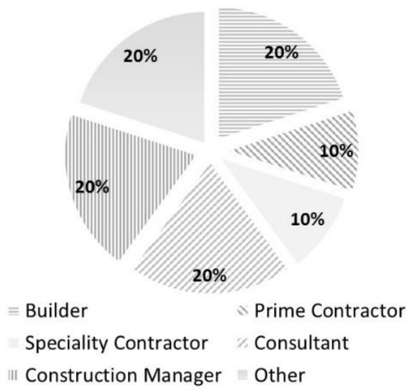

Figure 1a A breakdown of types of companies where CU Denver CEM advisory board members work.

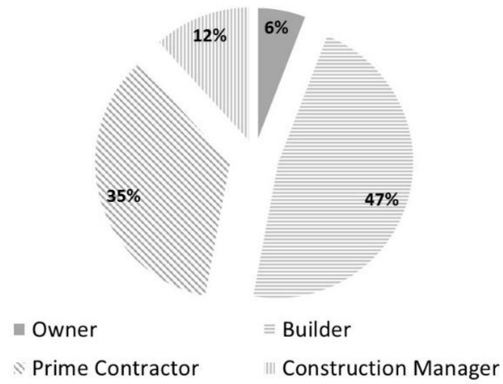

Figure 1b A breakdown of types of companies where Fresno State CM advisory board members work.

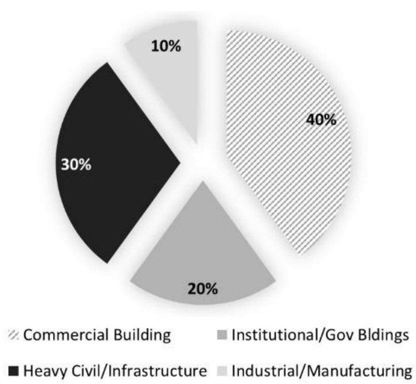

Figure 2a Primary sector of CU Denver CEM IAB firms.

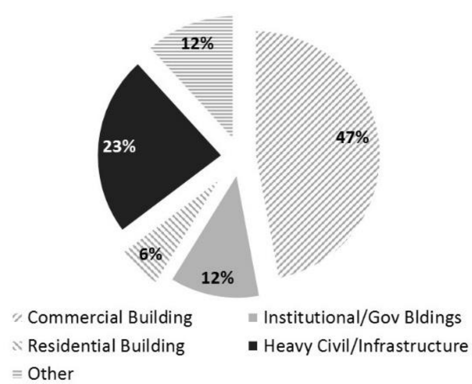

Figure 2b Primary sector of Fresno State CM IAB firms.

Results and Analysis

Survey results indicated that CU Denver CEM IAB and Fresno State CM IAB ranked the importance of the 20 learning outcomes somewhat differently. Rankings based on mean averages from the Likert scales are shown for both IABs in Table 2. Note that initial presentation of ACCE learning outcomes (ordered letter) groups learning outcomes by action to “create” (A-E), “analyze” (F-H), “apply,” (I-K) and “understand” (L-T). As such, the further up the alphabet represents a decrease in learning level as defined by Bloom’s Taxonomy (Anderson et al., 2001)

Table 2 Rank of priority for Learning Outcome for CU Denver CEM and Fresno State CM advisory board members

Rank	CU Denver CEM Advisory Board's List of Competencies	Rank	Fresno State CM Advisory Board's List of Competencies
1	**A: Create** written communications appropriate to the construction discipline.	1	**A: Create** written communications appropriate to the construction discipline.
2	**I: Apply** construction management skills as member of a multi-disciplinary team.	2	**G: Analyze** construction documents for planning and management of construction processes.
3	**B: Create** oral presentations appropriate to the construction discipline.	3	**P: Understand** construction project control processes.
4	**M: Importance** construction risk management.	4	**I: Apply** construction management skills as member of a multi-disciplinary team.
5	**L: Importance** different methods of project delivery and the roles and responsibilities of all constituencies involved in the design and construction process.	5	**J: Apply** electronic-based technology to manage the construction process.
6	**F: Analyze** professional decisions based on ethical principles.	6	**F: Analyze** professional decisions based on ethical principles.
7	**E: Create** construction project schedules.	7	**H: Analyze** methods, materials, and equipment used to construct projects.
7	**G: Analyze** construction documents for planning and management of construction processes.	7	**L: Understand** different methods of project delivery and the roles and responsibilities of all constituencies involved in the design and construction process.
9	**Q: Understand** the legal implications of contract, common, and regulatory law to manage a construction project.	9	**D: Create** construction project cost estimates.
10	**D: Create** construction project cost estimates.	9	**Q: Understand** the legal implications of contract, common, and regulatory law to manage a construction project.
10	**O: Understand** construction quality assurance and control.	11	**O: Understand** construction accounting and cost control.
12	**J: Apply** electronic-based technology to manage the construction process.	11	**T: Understand** the basic principles of mech., elect. and piping systems.
13	**N: Understand** construction accounting and cost control.	13	**N: Understand** construction quality assurance and control.
13	**P: Understand** construction project control processes.	14	**M: Understand** construction risk management.
15	**H: Analyze** methods, materials, and equipment used to construct projects.	15	**E: Create** construction project schedules.
16	**C: Create** a construction project safety plan.	16	**B: Create** oral presentations appropriate to the construction discipline.

17	**S: Understand** the basic principles of structural behavior.	17	**S: Understand** the basic principles of structural behavior.
18	**R: Understand** the basic principles of sustainable construction.	18	**C: Create** a construction project safety plan.
18	**T: Understand** the basic principles of mechanical, electrical and piping systems.	19	**R: Understand** the basic principles of sustainable construction.
20	**K: Apply** basic surveying techniques for construction layout and control.	20	**K: Apply** basic surveying techniques for construction layout and control.

The two IABs ranked four competencies equally, namely "Create written communications appropriate to the construction discipline," (1); "Analyze professional decisions based on ethical principles," (6); "Understand the basic principles of structural behavior," (17); and "Apply basic surveying techniques for construction layout and control," (20). Interestingly, while rankings tended to shift in the middle ranking learning outcomes, the IABs agreed on the most important "written communication," and least important, "survey techniques" competencies. The importance of "written communication" may come as surprise to many students who may, falsely, believe that writing is not important in technical and applied fields such as construction.

The relative mean and deviation based on 95% confidence level of the survey responses from the two IABs are summarized and shown in Figure 3. The statistical significance for the collected data from the two IABs are summarized in Table 2. The null hypothesis for the analysis is "there is no significant difference between the importance of competence levels as suggested by CU Denver's CEM IAB and Fresno State's CM IAB members." It should be noted that the 95% confidence interval was calculated based on a normal distribution, however a few of the learning outcomes such as A, B, I, M, have skewed distribution and, accordingly, had upper limits of confident interval exceeding the maximum of five.

Discussion

Findings based on the results of the survey are primarily descriptive rather than statistically significant, due in large part to small sample sizes, and may or may not represent the construction industry opinion or construction education as a whole. Nevertheless, findings support patterns and potential differences between industry executives as represented by IAB members serving either CEM or CM academic programs. High-level findings can be summarized as follows: CU Denver CEM IAB members generally placed greater importance on the ACCE learning outcomes compared to Fresno State CM IAB members with five exceptions. Such a finding initially appears somewhat counter-intuitive since the ACCE learning outcomes primarily target construction management rather than construction engineering and management programs. The five learning outcomes that Fresno State CM IAB members assigned higher priority to than did CU Denver CEM IAB members include:

- Analyze construction documents for planning and management of construction processes.
- Analyze methods, materials, and equipment used to construct projects.
- Apply electronic-based technology to manage the construction process.
- Understand construction project control processes.
- Understand the basic principles of mechanical, electrical and piping systems.

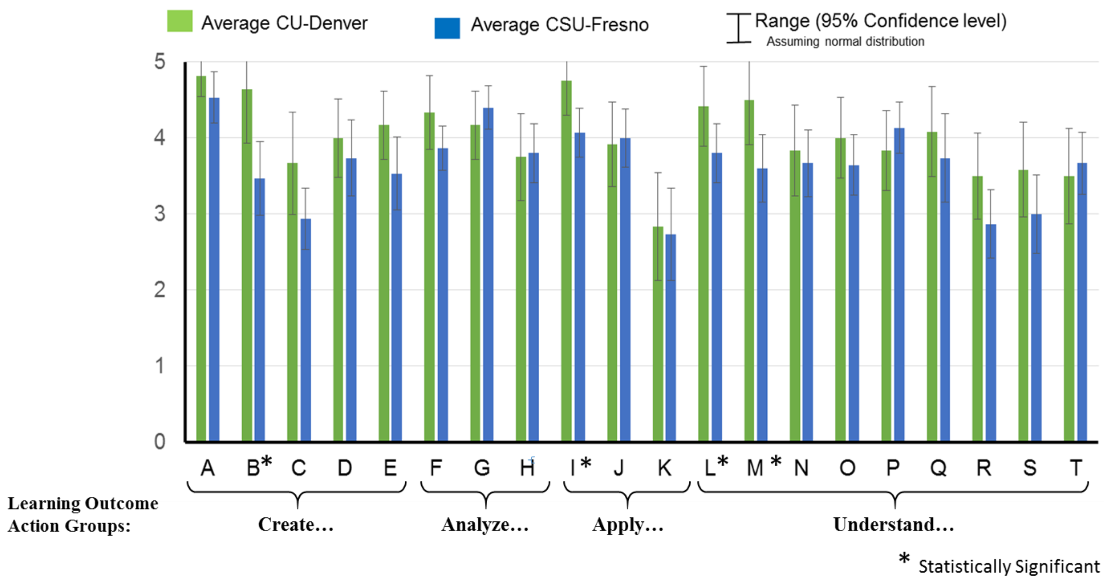

Figure 3: Mean and standard deviations by Learning Outcome for the two Industry Advisory Boards.

Table 2: Data by Learning Outcome for the two Industry Advisory Boards and statistical analysis.

Competency	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Denver CEM Average	4.82	4.64	3.67	4.00	4.17	4.33	4.17	3.75	4.75	3.92	2.83	4.42	4.50	3.83	4.00	3.83	4.08	3.50	3.58	3.50
Denver CEM Variance	0.16	0.45	1.33	0.73	0.70	0.79	0.52	0.57	0.20	0.81	1.79	0.45	0.64	1.06	0.91	1.06	0.81	1.00	1.17	1.00
Fresno CM Average	4.53	3.47	2.93	3.73	3.53	3.87	4.40	3.80	4.07	4.00	2.73	3.80	3.60	3.67	3.64	4.13	3.73	2.87	3.00	3.67
Fresno CM Variance	0.55	1.12	0.78	1.21	1.12	0.41	0.40	0.74	0.50	0.71	1.78	0.74	0.97	0.95	0.71	0.55	1.64	0.98	1.29	0.81
T Stat	1.25	3.43	1.82	0.71	1.74	1.53	(0.88)	(0.16)	3.05	(0.25)	0.19	2.09	2.62	0.43	1.00	(0.85)	0.83	1.64	1.36	(0.45)
t Critical two-tail	2.07	2.06	2.09	2.06	2.06	2.09	2.07	2.06	2.06	2.07	2.06	2.06	2.06	2.07	2.07	2.09	2.06	2.06	2.06	2.07
Statistically Different?	No	**Yes**	No	No	No	No	No	No	**Yes**	No	No	**Yes**	**Yes**	No	No	No	No	No	No	No

All five of these outcomes involve actions that promote lower level learning outcomes, as suggested by Bloom's Taxonomy of Learning, which ascends from Remember, Understand, Apply, Analyze to Evaluate and Create (Krathwohl, 2002). Additionally, comparison of importance placed by the two IABs on learning outcomes A-E suggests that CEM programs put greater emphasis on achieving learning outcomes related to "creating," since large deltas in opinion occur across these learning outcomes. Such findings are consistent with the general educational charter that CEM programs should provide technical skills necessary to make design and planning decisions related to construction. It may also be correlated to the fact the CEM is a graduate program whereas the CM program is undergraduate. Traditionally, by design, CM programs are more focused on the fundamentals of plan reading, project management, and basic coordination. Overall, however, it is important to note that both IABs view the large majority of learning outcomes as important (a mean of greater than three on the Likert scale).
Exceptions where IAB members of Fresno State CM program weighted learning outcomes as less valuable include:

- Create a construction project safety plan.
- Apply basic surveying techniques for construction layout and control.
- Understand the basic principles of sustainable construction.

While the exception where IAB members of CU Denver CEM program weighted a learning outcomes as less valuable includes only:

- Apply basic surveying techniques for construction layout and control.

Notably, "Apply basic surveying techniques for construction layout and control," was reported with the least value by both groups. This may be a result of the fact that industry technology and processes have evolved faster than academic content and material, making current instruction surrounding tradition surveying techniques somewhat obsolete. Finally, analysis identified four cases where opinions regarding the importance of individual ACCE learning outcomes differed between CEM and CM IAB members and were statistically significant. These include:

- Create oral presentations appropriate to the construction discipline.
- Apply construction management skills as member of a multi-disciplinary team.
- Understand different methods of project delivery and the roles and responsibilities of all constituencies involved in the design and construction process.
- Understand construction risk management.

In all four cases, CU Denver CEM IAB thought the learning outcomes were significantly more important than did Fresno State CM IAB. The first two of the statistically significant learning outcomes underscore the increasing role of soft-skills in the construction industry. The second two potentially highlight the evolving nature of project delivery as well as uncertainty and risk typically associated with new contractual arrangements and industry partnerships. As such, these differences may be the result of undertaking more technically complex projects. While it is not possible to draw strong conclusions based on the data available, it may also be that regional differences account for differing construction practices and complexity, and therefore, also contribute to differences in opinion. It should be noted that, during CU Denver CEM IAB meeting, board members were informally asked to identify skills they seek in new construction employees. Anecdotally, the following list of competencies or skills emerged as themes. In order of frequency: social skills, communication; collaboration / teamwork; passion, innovation; lean construction, alternative delivery methods; and risk management. CEM IAB members stressed the importance of presentation and public speaking skills, going as far as to suggest that all students should participate in "toast-masters" or a similar type program. The big take-away was that technical or hard-skills are assumed, and, as a result, an employer is looking for soft skills and business acumen, largely to succeed in winning proposals and to hire individuals who will eventually be prepared to succeed in executive management.

Conclusions and Future Work

While it is not possible to generalize the findings of this study due to the sample size, survey results suggest that there is consensus across two regionally, and academically distinct IABs that ACCE's learning outcomes have value in today's industry. Results were collected across two academic program that were determinately distinct in 1) location 2) graduate versus undergraduate 2) CM versus CEM curricula. Nevertheless several patterns emerged and, therefore, results can be used to inform construction education as well as illuminate its relationship to industry in general and at a high level. For example, both IABs most highly valued written communication. Furthermore, both IABs assessed the learning outcome to "Apply basic surveying techniques for construction layout and control," as having the least value. This is likely a result of the fact that industry technology and processes have evolved faster than academic content and material, making current instruction surrounding tradition surveying techniques somewhat obsolete. Furthermore, to a greater or lesser extent, much of this work may be sub-contracted out by certain firms to specialty trades. In either case, identifying a learning outcome as potentially declining in value as a result of fast-paced evolution of industry highlights the need for ACCE defined learning outcomes to be a "living," revisable list, one that changes overtime and adapts to progress within industry. An additional example, may be the general absence of technology and graphical communication in ACCE's current learning outcomes. As the use of technology continues to advance in construction, it is recommended that ACCE adjust its learning outcomes to align with competencies desired by industry. Finally, although the two IABs surveyed for this research primarily form a convenience sample, it is certainly possible that regional construction differences could start to impact the relative importance of competencies, and should be studied further. Additional opportunities for research include comparing and contrasting industry opinion regarding ACCE learning outcomes and ASCE outcomes. Various and larger comparisons could be drawn across construction populations, and similar research could be performed regarding industry's opinions of various certifications.

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