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Construction Education Needs Derived from Industry Evaluations of Students and Academic Research Publications

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ABSTRACT

In recent years, the American Council for Construction Education (ACCE) has shifted to outcomes-based accreditation standards for higher education construction programs, allowing greater customization of educational strategies. Past research efforts have analyzed the demands of industry and strategies used in academia, but these studies occurred before the shift to outcomes-based accreditation. This paper presents an updated analysis of construction industry needs and academic priorities and aims to provide insight into the status of industry and academia in the context of this outcomes-based focus. Thematic analysis of five years of direct evaluations of student performance during industry internships provides insight into industry demands. Parallel analysis of construction education research publications from a corresponding time period is leveraged to understand developments within the academic research community. Results suggest that both sectors recognize the need for experiential learning and software competencies among construction graduates. However, differences in trends were observed with a greater industry focus on personal attributes and a greater academic emphasis on sustainability learning competencies. The contribution of this paper is in providing an up-to-date evaluation of industry and academic trends in order to guide subsequent developments in construction education while addressing the needs of industry.

KEYWORDS

Construction education; curriculum development; internship programs; student learning outcomes

Introduction

Professionals have historically developed construction expertise through years of experience in the industry. Unfortunately, the construction industry is rapidly approaching a major labor shortage, which will mean that much of the collective expertise in the industry will exit as the current generation of experienced professionals retire, leading to "faster-than-average employment growth" for the next several years, according to the Bureau of Labor Statistics (Torpey, 2018). Additionally, while the full effects of COVID-19 are yet to be seen, the pandemic has had a much greater impact on older members of the community, with many

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wary of returning to work (Eisenberg, 2020). For the construction industry, this may further emphasize the need to more effectively prepare the future workforce to efficiently develop the same skills and expertise as those who exit the industry due to this pandemic.

In recognition of the need to evolve the way that construction management (CM) and construction engineering management (CE) students are educated, the American Council for Construction Education (ACCE) began a shift in the mid-2010s to adopt outcomes-based learning for accreditation. The requirements to become an accredited program traditionally included a prescriptive list of courses in various subjects, such as math and science, construction skills, and communication. This shift toward outcomes-based learning enables universities to define their own strategies for educating their students, allowing programs to "emphasize specialties" as they see fit (American Council for Construction Education (ACCE), 2013). The ACCE specifically states that this approach may enable universities to "respond to emerging subject matter areas" (American Council for Construction Education (ACCE), 2013). When considered in conjunction with the impending labor shortage, the shift to outcomes-based learning places universities in an ideal setting to leverage innovative technologies and teaching strategies to provide new formats of education that may provide better learning experiences for their students.

While construction education researchers have been exploring innovative teaching strategies for many years, the critical workplace competencies related to knowledge, skills, and abilities (subsequently referred to as industry "needs" or "demands") have not always been considered when defining high-impact practices for educating construction students. This work explores recent trends in the key competencies targeted by academic research and the key competencies reported most frequently by the construction industry. More specifically, it addresses the following research questions:

- What learning outcomes have been most frequently demanded by the industry in recent years?
- What learning outcomes have been targeted most frequently in recent years by academic research publications?
- How would the comparison between the two sets of high-priority learning outcomes inform better and more aligned practices in enhancing college CM/CE students' career preparedness?

The results addressing these three questions provide evidence to illustrate trends related to the learning outcomes demanded by the industry that are already being targeted by researchers and also the learning outcomes for which there is an opportunity for researchers to address emerging needs reported by industry. The contribution of this conceptual review is in systematically documenting these trends to illustrate current learning needs and strategies to support near-term learning gains, as well as documenting needs for which there is a demand for researchers to improve construction education in the future. This understanding will guide educational researchers to better prepare their students to meet the evolving demands of the construction industry.

Background

This paper provides an up-to-date review of trends in educational research and in professional competencies that are expected from CM and CE college graduates. Analysis of industry needs has precedent in publications from the last several decades. For example, in the 1980s, Warszawski (1984) reviewed the competencies relevant to construction management personnel. Later, others took a more holistic approach, focusing not only on managerial qualities, but also other relevant technical competencies, personal attributes, or interpersonal skills. For example, in 1998, a research team interviewed engineering professionals to see what expectations the industry had for engineering graduates (Back & Sanders, 1998). There is also a precedent of comparative analysis between industry and academic learning initiatives. For example, in 2012, researchers surveyed the industry to find out the key competencies that were most desirable and, using the old ACCE requirements, drew comparisons to how well these traits were being emphasized and found several instances of differences between industry and academic foci (Ahn et al., 2012). This prior work generally found that academics focused more on imparting technical skills, while industry sources frequently sought professional skills, such as 'interpersonal skills.' Around the same time, researchers in the Midwest and Mid-Atlantic regions of the United States compared student and industry perceptions of what skills graduates needed to succeed in the industry (Bhattacharjee et al., 2013). They found that a general understanding of required skills was shared between industry and students, but the two groups often ranked the items differently in order of importance.

While there are some similarities in the conclusions drawn by these types of comparative analyses, they also illustrate some differences that may be based on the needs of the industry at the time of their analyses. An updated version of this type of comparative analysis research has not been published since 2013. This current understanding of educational trends is especially necessary because accreditation agencies shifted to outcomes-based learning objectives, which could impact how universities prepare their students. Concurrently, changing construction workforce needs that have been recognized in the past few years (Construction Industry Institute (CII), 2018; Torpey, 2018) may also impact the human resource demands of the industry. This paper contributes to the body of knowledge by providing an updated analysis of recent trends in academic research and industry perspectives that illustrate how industry demands for students are changing, and how academic researchers are evolving to meet these shifting needs.

Methods

Data were collected from industry and academic sources to develop an understanding of the expectations of industry and the emerging strategies used in academia to equip construction graduates with skills needed for career success. Student internship evaluations were analyzed from industry, and educational research publications were collected and analyzed from academia. The following subsections describe the specific methods used for conducting these analyses.

Data Collection and Analysis – Industry Reviews

First, to gather information regarding the current status of construction industry workforce demands, information was collected directly from practicing industry professionals in the form of feedback on student internship evaluations. Researchers have historically used various methods to gather information regarding industry opinions about what they want to see from graduates of higher education construction programs. For example, some studies surveyed owners, contractors, and other project personnel (Ahmed et al., 2014; Arain, 2010; Bhattacharjee et al., 2013; Love et al., 2001), and others have focused on surveying recruitment specialists from U.S. construction companies (Ahn et al., 2012). Typically, these personnel rated significant skills, often referred to as “key competencies” (Ahn et al., 2012), on Likert scales according to importance. These studies presented key competencies to industry members and asked them to draw on their general knowledge and experience and conceptually rank the skills.

By contrast, the method implemented in this work aggregates and analyzes internship evaluations based on in-depth work experiences that industry practitioners have had with specific students for three or more months. This method presents distinct benefits and a unique perspective. First, similar to previous literature, it illustrates the opinions of current industry practitioners; by nature, those who complete the evaluations are industry practitioners. However, this work stands apart from most literature in that those completing the evaluations hold direct supervisory roles to the interns, making these evaluations based directly on specific student performance rather than hypotheticals. The large number of reviews allows the desires and opinions reflected by industry to be compiled in an informative and detailed dataset and considered in aggregate. The trends that emerge through this analysis provide insights into the current status of the industry’s direct evaluation of student performance.

Most construction engineering and management programs encourage their students to complete an internship during their academic matriculation. Often, after students complete these internships, employers complete evaluation forms for students to assess their performance. A large sample of these evaluations was obtained from internships completed by students at Arizona State University’s Del E. Webb School of Construction. The portion of the form that provides the basis for this analysis is an open-ended section where the employers are asked to reply to the following two prompts (for analysis of the numerical ranking portion of this form, see El Asmar et al., 2020, November):

- Please identify three (3) areas in which the student intern is most improved.
- Please identify three (3) areas in which the student is in greatest need of skill development.

While these questions are aimed at eliciting feedback about strengths developed and areas where further skills are needed, both questions ultimately provide data about the learning needs demanded by industry. This form of open-ended question has been used in other research that aims to elicit emerging topics reported by a population without limiting their responses to indicate one or more pre-determined outcomes (Allen, 2017). Furthermore, when a sample of responses to this type of open-ended response question is analyzed, it offers insights into the trends where there is the greatest frequency of needs reported by a population (Weller et al., 2018). These questions provide an ideal source of data to not only illustrate what learning needs are demanded by industry based on an in-depth knowledge of a specific student, but also the broader trends that emerge to illustrate common learning needs demanded by industry.

These industry evaluations from 2015 to 2019 were digitized, and the content of these two write-in categories was thematically analyzed. Student names were removed from the data per the Institutional Review Board (IRB) requirements. The years of data chosen correspond with the implementation of ACCE's shift to outcomes-based learning in 2015 (American Council for Construction Education (ACCE), 2015) and a five-year period following. The process for obtaining and filtering this data is found in Figure 1. From this dataset, the industry responses were analyzed and coded based on themes founded in previous literature and refined by the data. In particular, the organizational structure proposed by Ahmed et al. (2014) was used as a guide, as it aimed to "identify the key skill set and categories required by today's construction industry from graduating construction management undergraduate students." This research combined an extensive literature analysis with an industry survey to identify seven major categories for demanded skills and attributes: Personal Attributes, Professional Attributes, Technical Skills, Managerial Skills, Industry & Business Skills, People Skills (Interpersonal Skills), and Legal & Contractual Skills. Each of these categories contains a list of subcategories delineating different components of the group. For example, the *Personal Attributes* category includes characteristics like *dependability*, *time management* and *willingness to learn*, among others. A total of 95 subcategories fall within each of these major categories. This prior work (Ahmed et al., 2014) provided a starting point for organizing the new findings generated in this current paper (see Table 1).

A descriptive qualitative analysis was conducted where emergent themes were observed by a thorough reading of each of the evaluations. This resulted in an additional three categories to the 95 categories defined by Ahmed et al. (2014). Table 1 lists these categories, many in abbreviated form (for expanded descriptions, see Ahmed et al., 2014). These 98 themes were quantitatively supported by performing a textual analysis using the text search function in 'The R Project for Statistical Computing' (R), an open source software environment used for statistical analyses. A custom script was authored using the grepl() function with a set of descriptors for each of the subcategories. This function performs a comprehensive keyword-based search of a textual database, in this case the digitized reviews. The custom script used this function for each of the categories and searched to see if any were included in either subsection of each evaluation. If any of the keywords were present, the search would return a value of TRUE for that category. This process was iterated for each of the 98 categories. Figure 3 presents this process in graphical format. The results of the analysis produced a table where each of these categories contained a count for the number of times the concept was mentioned in the internship reviews. The data are presented as a percentage, representing the number of reviews in which the concept emerged in proportion to the total number of reviews. Additionally, the data were separated into the two categories guided by the open-ended questions: 'Greatest need of improvement' (Needs) or 'Most improved' (Improved) categories. After the findings were organized according to the previously defined and emergent categories, they were compared to those observed in recent publications from educational researchers, a process defined subsequently.Figure 3.

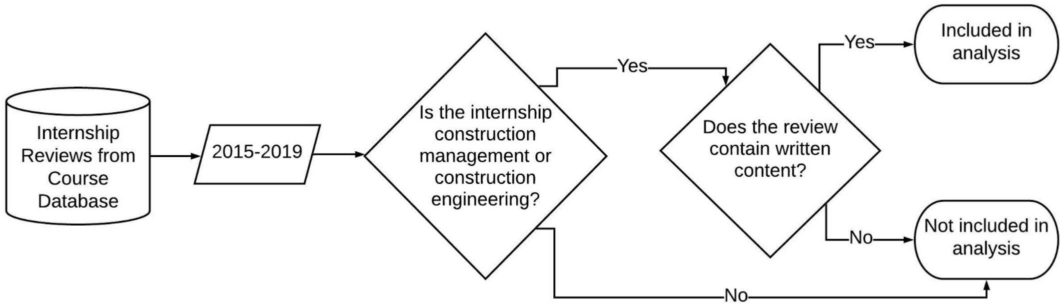

Figure 1. Flowchart outlining the steps taken to collect industry evaluations for the analysis.

Data Collection and Analysis – Academic Research

The learning outcomes most frequently targeted by educational researchers were identified by surveying research publications regarding teaching and learning within construction education. By analyzing a representative selection of literature, this review considers the procedural and technological innovations explored within academia, with special attention to the key competencies that these advancements target. The authors acknowledge that not all educators actively publish research, and some are solely focused on teaching, so this paper does not claim to represent the opinion of all higher education instructors. Additionally, this paper does not seek to provide a detailed review of CM curricula, as it is assumed that the programs that receive accreditation provide coursework that meets each of the student learning outcomes (SLOs) required for accreditation. In light of this, academic research publications are targeted in this analysis to understand where researchers see a need for development and areas of interest or focus that emerge above and beyond traditional curricula. Trend analysis of these publications provides insights on both the strategies used to enhance construction education and the underlying learning topics most frequently targeted by educational researchers. Literature from the Associated Schools of Construction (ASC), the American Society of Civil Engineers (ASCE), and the American Society for Engineering Education (ASEE) were searched to produce a representative sample of literature dealing specifically with construction education. ASC and ASCE publications alone account for more than 75% of the construction education research in the past several decades (Zheng et al., 2019). Additionally, research from the International Journal of Engineering Education (IJEE) and Journal of Information Technology in Construction (ITCON) was included in the search, as these venues regularly include publications relevant to innovative construction education strategies. These databases and journals were searched using the term ‘construction education’ or, where possible, using the Boolean AND search with the terms ‘construction’ and ‘education’ in the title to produce a representative sample of research within the targeted scope of this review, as shown in Figure 2.

From the repositories of each of these organizations, construction education articles were filtered to include research only from the past five years (2015–2019). The resultant list of publications from this time period aligns with ACCE’s shift to outcomes-based learning and also with the internship data collected from the industry, in order to support the comparison of data. To filter relevant literature, the abstracts were manually sorted based on the

Table 1. List of construction industry attributes and skills based on prior work by Ahmed et al. (2014) and emergent categories in this study.

List of construction industry attributes and skills based on prior work by Ahmed et al., 2014 *and emergent categories in this study*

Personal Attributes	**Professional Attributes**	**Technical Skills**	**Managerial Skills**
Listening ability*	Hands-on experience	Plans/Blueprints/ Drawings	Health/safety mgt.
Attention to details*	Teamwork capabilities	Knowledge of operations	Quality assurance
Time Management	Values/ Work ethics	Computer proficiency	Quality control
Dependability	Planning and goal setting	IT/ software	Organizational
Adaptability/Flexibility	Long term commitment	Sustainability/LEED	Document control
Desire to learn	Problem solving	Scheduling	Project management
Assertive attitude	Result orientation	Closeout and handover	Cost control
Promptness in actions	Critical path thinking	Estimating	Leadership
Comprehension ability	Decision making skills	Cost accounting	Team building
Ability to learn	Forecasting	Materials knowledge	Site planning and mgt.
Innovative/Creativity	Ability to follow up	Equipment knowledge	Personnel/ resource mgt.
Willingness to travel	Risk taking	Economic/financial analysis	Risk planning, control
Taking initiative[‡]	Multi-tasking	Knowledge of design	Productivity mgt.
Attitude (general)[‡]		Constructability review	Managing labor issues
		Scope review	Knowledge/info. mgt.
		Bldg. Inf. Mod. (BIM)[‡]	Financial management
Industry/Business Skills	**People Skills**	**Legal/ Contractual Skills**	
Health/safety regulations	Communication (overall)[†]	Interpreting contract docs.	
Bldg. codes/regulations	Written communication	Law and legal environment	
Environment impact	Verbal communication	Contract administration	
Client relations	Diversity	Bidding knowledge	
Permitting knowledge	Trade coordination	Dispute avoid./ resolution	
Trade knowledge	Multilingual	Project delivery/ Contracting	
Procedural issues	Meetings	Change management	
Cultural issues	Relationships/ Collab.	Understanding labor laws	
Other fields/disciplines	Motivation capabilities	Claims prep/ presentation	
Awareness of ind. trends	Negotiations/ Conflict res.	Claims defense skills	
Con. supply chain	Coaching		
Geographical issues	Mentoring		
Business Management			

(*Continued*)

Table 1. (Continued).

List of construction industry attributes and skills based on prior work by Ahmed et al., 2014 *and emergent categories in this study* Personal Attributes	Professional Attributes	Technical Skills	Managerial Skills
Entrepreneurship			
Partnering			
Global con. environment			
Lean culture			

*these two items were originally listed as a single category but split into two distinct categories for this study
†the written and verbal categories were also analyzed in an aggregate 'communication' category that was not explicitly included in the original list
‡these three categories were added to this study

following question: Does this article address a development in, or commentary on, teaching or learning in a construction-related domain? If the answer was no, such as an article on the construction of higher education buildings, the publication would not be included. If the answer was yes, then the next filter was applied: Is the article a literature review or compilation? If the answer was no, then the article was included. Literature reviews were not included to avoid duplicate articles and to reach construction education research at the primary source.

A review of these abstracts provided information about which key competencies were targeted. These abstracts were compiled into a database that was manually thematically analyzed to extract relevant patterns. It was also searched with the same text analysis function as the industry data. The same 95 categories defined by Ahmed et al. (2014) and three emergent categories that were used for organizing the industry data were applied and themes were extracted. The data resulted in percentages of reports for each category. This consistent method of data organization supported the comparison of the industry evaluation data to the reports from academia, presented in

Results and Analysis

Description of the Data

From the internship evaluations between 2015 and 2019, inclusive, a total of 993 evaluations were included in the dataset shown by year and semester in Table 2. These evaluations included students enrolled in the undergraduate sophomore construction management (CM) internship class (48%), the undergraduate junior CM internship class (37%), the undergraduate junior Construction Engineering (CE) internship class (8%), and the graduate CM internship course (7%). Typically, the enrolled course indicates the student's year in school (sophomore, junior/senior, or graduate) and their major (construction engineering or construction management). While demographic information was not solicited on the internship evaluations that form the dataset, parallel data regarding the general demographic makeup of the students is available through the university based on enrollment in construction internships. This dataset (n = 1122) includes a data point for each internship completed during this time period, regardless of whether an evaluation was completed, and can be reasonably expected to represent the demographic distribution of population of interest. The dataset includes a gender distribution of 87% male and 13% female and

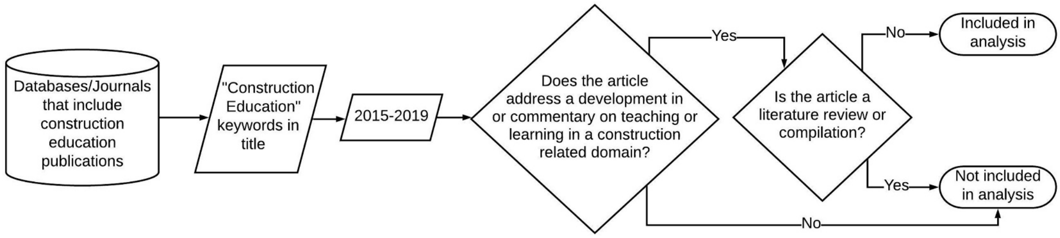

Figure 2. Flowchart outlining the steps taken to collect articles for the review.

representation from a variety of racial and ethnic backgrounds, including American Indian/ Alaska Native (2%), Asian (2%), Black or African American (1%), Hispanic/Latino (24%), White (58%), Two or More Races (2%), and Other or Not Reported (11%).

The evaluators came from a variety of industry sectors and leadership roles within their company. Data on the project role of each evaluator and the industry sector for each evaluation was collected from 2017 to 2019. Exact titles and roles within a company varied greatly, so in order to present a coalesced and meaningful description of the supervisor roles, the most frequently occurring words or word combinations within the title description were compiled to illustrate trends. The resultant data included evaluations from individuals with the following titles (and percentage of responses): Senior Manager (13%); Manager (35%); Assistant Manager (2%); Superintendent (9%), Assistant Superintendent (1%); President (3%); Vice President (3%); Director (7%); and Estimator (5%). The students reviewed in this work completed internships in various types of companies, including Sector analysis of the companies involved revealed a high percentage of reviews coming from the commercial sector (55%), followed by heavy civil (15%), subcontractors (11%), residential (8%), owners (4%), engineering (2%), consulting (1%), and 3% in other categories or unknown.

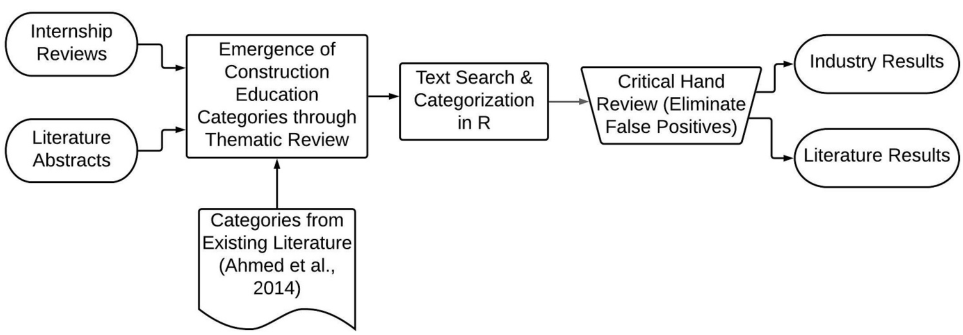

Figure 3. Process for categorizing and processing the data from both the industry internship evaluations and the literature sourced from academic research.

Table 2. Number of industry evaluations collected by semester and year.

Number of industry evaluations collected by semester and year	2015	2016	2017	2018	2019	2015–2019
Fall	10	10	16	6	13	55
Spring	9	30	16	4	8	67
Summer	111	139	154	241	226	871
Total	130	179	186	251	247	993

Table 3. Number of articles included in the literature analysis from each publisher/journal.

Number of articles included in the literature analysis from each publisher/journal	Source	#
Journals	International Journal of Construction Education and Research	18
	Journal of Civil Engineering Education (formerly: Journal of Professional Issues in Engineering Education and Practice)	10
	International Journal of Engineering Education	4
	Journal of Computing in Civil Engineering	3
	Advances in Engineering Education	1
	Journal of Information Technology in Construction	1
Conferences	ASCE Proceedings (various years and conferences)	10
	ASC Proceedings (various years and conferences)	9
Books	ASCE Book Chapters from: Transforming Engineering Education: Innovative Computer-Mediated Learning Technologies	3
	Total	**59**

In order to understand the topics most frequently mentioned in academic literature regarding construction education, a search for construction education-related journals, conference proceedings, and books is presented here. The breakdown of documents after applying the filters described in the methodology is presented in Table 3.

Emergent Themes

Figures 4, 5, and 6 summarize the frequency with which each skill or attribute was mentioned in industry evaluations or academic literature. Within the extensive collection of internship evaluations, nearly all construction-related skills and attributes were mentioned at least once. A higher frequency of skills or attributes in these reviews suggests broader recognition of the need for these learning concepts among employers. Similarly, a higher frequency of research reports targeting specific learning outcomes illustrates a broader interest in specific educational improvements. Of the 98 categories used to organize the data, only those that met a threshold of 10% or higher in at least one category (Greatest Needs, Most Improved, Total Mentions, or Literature Results) were considered. This enabled the researchers to focus their discussion on the topics for which there were common reports on the need for a specific learning category from industry and academia.

The frequency results generated from the R scripts were manually reviewed to limit false-positive categorizations. For example, the attribute of 'results orientation' produced an overinflated count in the academic literature count since most articles will state that they present research 'results,' even if these are unrelated to the 'results orientation' of their

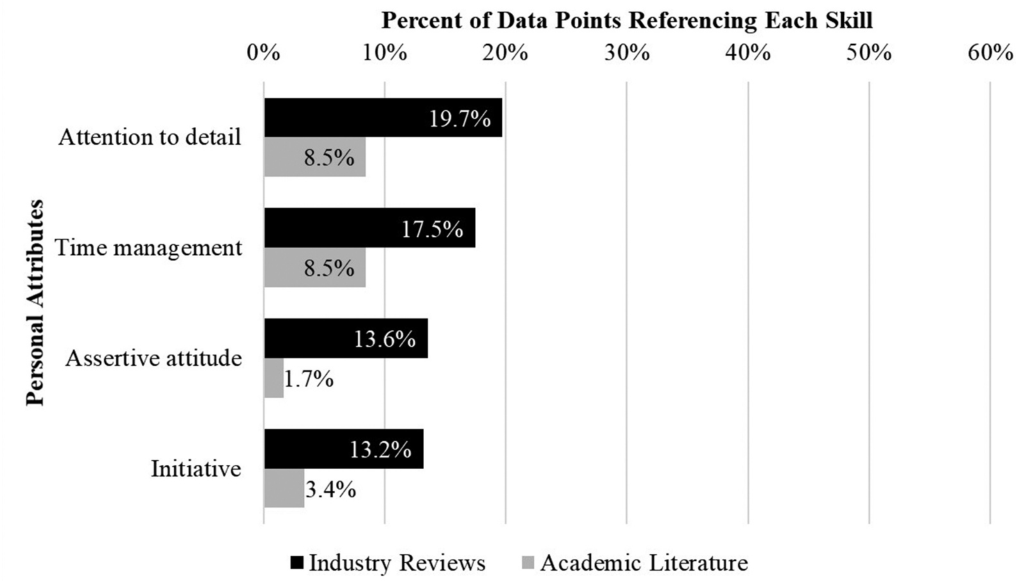

Figure 4. Bar graph comparing the frequency of personal attributes mentioned in internship reviews to the frequency of mention in academic literature. A range from 0% to 60% was selected to scale the image for comparison with other categories.

students. After the data were collected and cleaned, they were compiled for analysis. What follows is a discussion of emergent themes, categorized by three groupings: Personal Attributes, Technical Skills, and Professional Skills.

For the discussion of industry results, the 'Overall Mentions' category will be emphasized. In the industry reviews, it was observed that many skills or attributes were mentioned in both the 'Greatest Needs' and 'Most Improved' categories, sometimes even within the same review. For example, one review explained that a student had 'Most Improved' in "communication skills ... when tasked with scheduling a subcontractor," and that their 'Greatest Need' was "communication skills between more than one subcontractor." The researchers noted that the two categories seemed to be presenting the same information, so a correlational analysis was performed to understand the statistical difference between the two categories. The Pearson correlation coefficient was produced for the two categories with the unit of analysis being the number of reviews mentioning a specific construction skill or competency within the category, with n = 98 skills/competencies. The results of this analysis indicated that the two categories were indeed highly related (Pearson's $r(97) = 0.911$, $p < .001$), indicating that neither category presents unique information relative to the other and that both vary together. The average difference in percentage between the two categories was 1.7%. For example, 12.3% of reviewers mentioned scheduling as a greatest need and 11.9% mentioned scheduling in the 'Most Improved' category. Of the categories presented here for analysis, the one with the greatest difference – and the only with a difference above 10%–was Experience/Hands-on, with 36.7% of reviewers mentioning this as a 'Greatest Need' and 24.9% mentioning it as a 'Most Improved' skill. Because of the strong correlation between the two categories, only the overall mentions are discussed, in depth, with percentages presented in Figures 4,5,and 6.

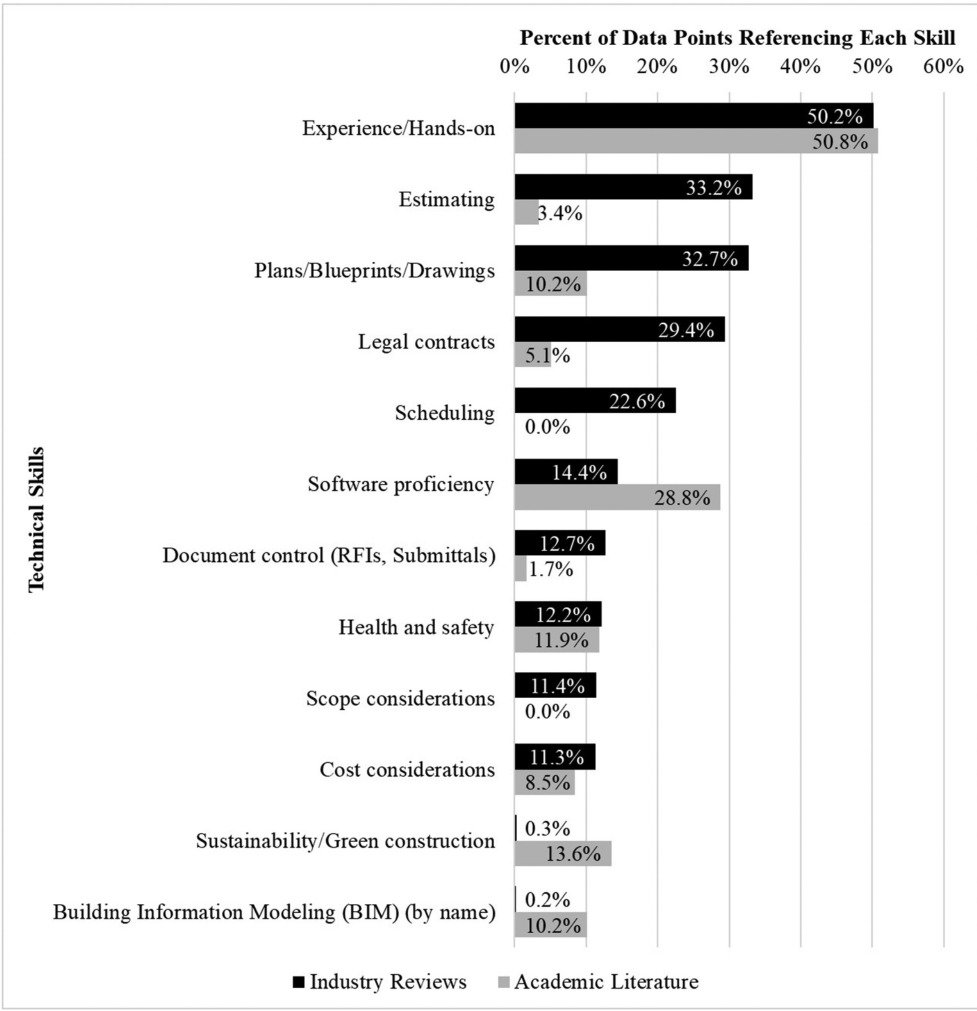

Figure 5. Bar graph comparing the frequency of technical skills mentioned in internship reviews to the frequency of mention in academic literature.

Within the industry evaluations, a variety of personal attributes appeared in the reviews, with attention to detail (19.7%) and time management (17%) leading in mentions. While these may seem like small percentages, the fact that more than 1 in 6 employers mentioned these characteristics in an open-ended response is notable. Examples of content from the reviews regarding each personal attribute above the 10% threshold are included below:

- *attention to detail*: the intern "could use work maintaining attention to fine details in highly repetitive tasks."
- *time management*: the student "needs to learn to prioritize tasks and improve focus on tasks at hand."
- *assertive attitude*: the intern "will have to be assertive with their peers during their career to ensure that other people's actions do not impact their quality of work"

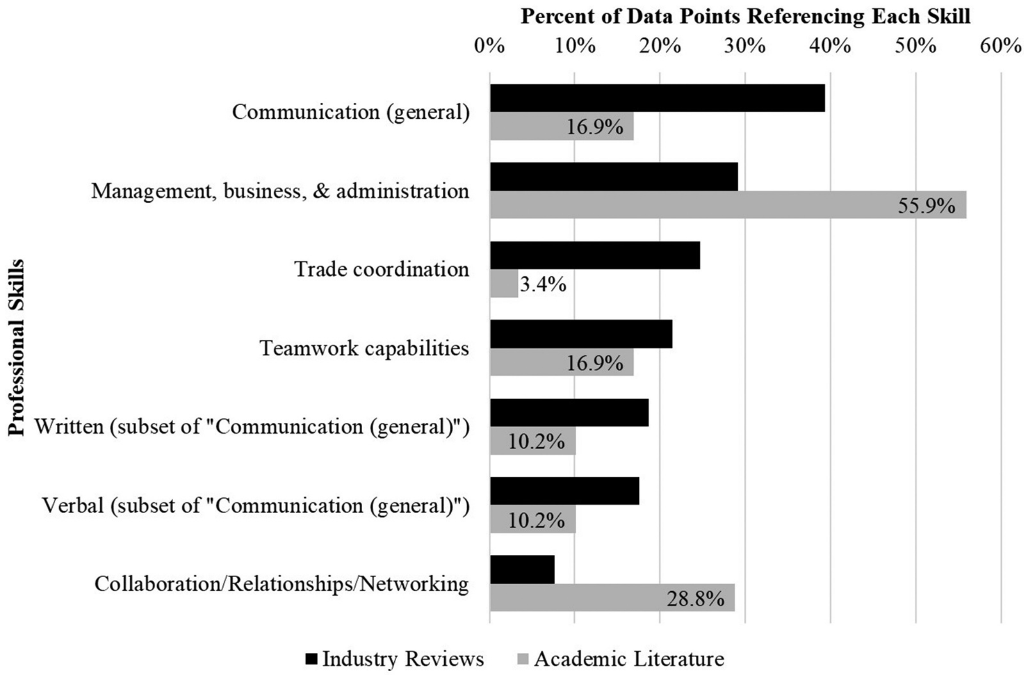

Figure 6. Bar graph comparing the frequency of professional skills mentioned in internship reviews to the frequency of mention in academic literature.

- *initiative*: "I appreciated [the intern]'s initiative to check in with me frequently on their assignments, even when I was out of the office."

In general, there were many personal attributes that industry evaluators noticed and wanted to see in interns.

Overall, personal attributes were much less frequently mentioned with granularity in academic literature, but some reports suggested that students develop positive attributes in general. For example, one article suggested that a collaboration between the Design-Build Institute of America (DBIA) and ASC would help cultivate student attributes, both in personal and in interpersonal capacities (Washington, 2015). Another article referenced a personal attribute development when talking about developing the whole student through global stewardship and service-learning (Songer et al., 2018). While these examples illustrate some level of interest among academic researchers in supporting the development of these skills, very few articles focused specifically on these skills with enough granularity to organize them into specific categories.

Industry demands for the development of personal attributes outweighed the academic emphasis in each specific attribute category. However, it should be noted that it is common for an educational innovation or approach to discuss the possibility of personal attribute development in the general sense while not detailing specific attributes or skills. Therefore, rather than drawing conclusions about academia not meeting industry demands for personal attribute development, it would be more appropriate to conclude that this evidence indicates the potential for greater focus on specific attributes and skills that may be more in demand than others. Researchers using technology or curriculum design to improve the student experience can specifically target personal attributes that are most in-demand, like attention to detail and time management. These two attributes have appeared in high demand in past literature about industry needs (Ahmed et al., 2014). Many educators may be practicing these concepts already, but presenting them here provides a broadly applicable, and industry-backed, reasoning for emphasizing these skills and highlights the importance of reporting on the effectiveness of novel teaching strategies that support the development of these skills.

Regarding the relevance of these findings to the ACCE student learning outcomes (SLOs), most SLOs do not specifically cite personal attributes, except for possibly one – SLO 6: *Analyze professional decisions based on ethical principles*. This particular SLO could be considered a personal attribute (ethical behavior), but does not touch on individual work ethic and related principles, such as attention to detail, time management, assertive attitude, and initiative. Here is an opportunity for the academic realm to innovate and find creative ways to address industry demands, while exceeding accreditation requirements. For example, teaching strategies that have been studied in the business domain such as self-analysis, student-conducted interviews, or inviting guest speakers (Anthony & Garner, 2016) could be replicated in the construction domain to address the needs reported by the industry. As educational researchers explore novel ways to target and measure students' development of these personal attributes, it will enable construction educators to address accreditation SLOs, while enhancing their students' industry preparedness.

Experience/Hands-on – By far, the most common industry reports were that the intern should have more "in-field" or "onsite" experience or simply "experience" in general, with nearly half of the reviews (47.6%) mentioned that the intern either needed some kind of experience or that they had improved in this area during the internship. For example, one employer stated that a student's greatest need was, "experience – being so young, [the intern] just needs to gain experience in construction but [he or she] seems to have a passion for it and is willing to learn." Correspondingly, academic construction education literature places a high emphasis on experiential learning, including hands-on experiences in the construction field, with half the articles mentioning experience in at least a general sense. For example, researchers have been exploring the viability of providing a site visit experience through virtual reality (Pham et al., 2018). With COVID restrictions on universities and a shift to remote experiences, this topic bears relevance to recent situations and likely great relevance to the new normal – which may include a blend of in-person and virtual elements – that will follow as institutions ease out of the pandemic crisis. Overall, there is a prevailing theme in this sample that experiential learning is a critical success factor that can deliver desirable skills. As one of the most prominent themes, special attention should be given to this category.

Software proficiency and BIM – Employers would frequently refer to software and technology in their responses (14.4%). Comments ranged from mentioning software skills in general to specific, well-known software producers such as Autodesk, to company-specific software applications that are proprietary to specific companies. Correspondingly, much of the literature (28.8%) mentioned software in general or specific software by name. Notably, more than 10% of the articles discussed building information modeling (BIM), a term that relates to many of the software applications mentioned, but "BIM" was far less commonly found by name in the internship reviews (<1%). Much of the academic research in the past few years has focused on the implementation of BIM in the classroom as it has become more ubiquitous in the industry. Several researchers have proposed methodologies for incorporating BIM into the classroom through intentional curriculum design (Ghosh et al., 2015; Lucas, 2017; Zhang et al., 2019). Additionally, researchers recognize the utility of BIM not only as an end itself, but also as a facilitator to learning other concepts such as safety education (Clevenger et al., 2015) or contract management (Zhang & Gao, 2019). The strong presence of software and BIM in the academic literature indicates an understanding of its importance and of the need to educate students on its use. While academic reports list BIM far more frequently than industry, this is likely due to the granularity with which industry employers discuss BIM concepts, with many stating specific software skills as desirable, such as Revit, instead of discussing BIM as a general concept. On the other hand, in the academic realm, educators must prepare students for a wide range of experiences, necessitating more generalizable terms. In summary, findings indicate that industry and academia use different terms, but both broadly recognize the necessity of technology competencies within the construction industry. This recognition aligns closely with ACCE's SLO 10: *Apply electronic-based technology to manage the construction process*. This indicates a need for continued exploration of novel strategies and best practices for preparing students with these skills to meet high industry demands. For example, in addition to teaching basic technologies to students, the evidence collected in this work would suggest value for educators to focus on processes related to this implementation (i.e. 3D coordination) to improve the professional value of achieving these ACCE student learning outcomes. While this work does not suggest specific new methods for educators, the findings may guide future research, based on the current technical skill needs of industry.

General construction skills – The ability to work with plans, blueprints, or drawings was heavily emphasized in the internship reviews (32.7%), with employers stating their appreciation of an intern's "ability to read and understand construction drawings" or that the intern "needs to improve their understanding of drawings and how they relate to field conditions." Other general construction skills were mentioned throughout the reviews such as estimating (33.2%), scheduling (22.6%), and legal and contractual competencies (29.4%). Additionally, document control (12.7%), scope considerations (11.4%), and cost considerations (11.3%) were mentioned in a significant amount of the reviews. Overall, nearly all construction competencies were mentioned somewhere in the reviews and this section presents those that fell above a 10% threshold of frequency of mention. It is likely that these specific reports came from individuals who are focused on these specific topics in their work based on the nature of the data collected. While this in-depth knowledge may be necessary by practitioners fulfilling related roles, most of these skills received infrequent mentions in the sample of construction education literature. Despite the comparatively low reports on these basic technical construction skills in academic research publications, these skills are encompassed within several ACCE SLOs, which suggest that academic institutions that adhere to ACCE accreditation requirements are indeed targeting them. For example, ACCE SLOs include: SLO 4: *Create construction project cost estimates*; SLO 5: *Create construction project schedules*; and SLO 17: *Understand the legal implications of contract, common, and regulatory law to manage a construction project*. Because these topics are covered by ACCE accredited institutions, this could indicate an opportunity for increased focus and innovative teaching strategies by academia to more thoroughly target these technical skills to address the nuanced skills demanded by industry; however, it may also simply indicate a limitation of academic environments that aim to prepare all students to be capable of growing into any construction role. In other words, to accomplish the breadth of teaching construction topics to all students, the depth of understanding of specific technical competencies that may be of particular interest to certain construction positions may be limited. To avoid drawing speculative conclusions about how all educators should evolve in their teaching, the authors recommend that future educators consider these findings in conjunction with their own curricula to determine if they can add educational experiences to support more technical development without compromising other topics that are being covered effectively.

Sustainability – Academic literature had a much higher emphasis on sustainability than the industry reports. The prominence of the sustainability agenda in academic research is consistent with the results found by Zheng et al. (2019), who, after performing an extensive bibliometric analysis of construction education research from 1982 to 2017, found that sustainability (and building information modeling) have emerged prominently as hot topics since 2006. These findings indicate that academic researchers are actively exploring innovative strategies to support their students' education on sustainability topics. However, the frequency of mention is much lower in the industry reviews. This disparity may be due in part to the barriers that the construction industry faces to implementing sustainable design and construction, such as profit, demand, and procedural barriers (Häkkinen & Belloni, 2011). However, as these barriers evolve and ideally diminish over time, the authors envision a continued need for the kind of education that is happening regarding sustainability in conjunction with SLO 18: *Understand the basic principles of sustainable construction*.

Health and safety – Safety is mentioned in a significant portion of industry reviews (12.2%) as well as in much of the recently published construction education research literature (11.9%). This has been especially evident in research aimed at advancing safety education through technologies like serious games (Din & Gibson, 2018) or virtual reality (Pedro et al., 2016). In addition to the academic reports on novel safety education strategies, this learning content is also directly targeted in ACCE's SLO 3: *Creating a construction project safety plan*. This offers further evidence that academic institutions are already targeting this learning content with some success. For a learning topic where poor decisions can lead to catastrophic life consequences, there may always be a need to improve in how students are prepared with this skill until injuries and fatalities are no longer a part of the construction field. This sentiment was indicated by an industry response that stated a need for continued improvement to safety education for students "no matter how good they are." While other responses worded this sentiment differently, this was a common type of response. Similarly, in many of the academic publications targeting this learning topic, authors would often recognize the improvements that have been made regarding construction safety, but also the continued problems that persist to motivate the work of emerging researchers. Therefore, the findings related to this topic suggest that continued work should be pursued related to safety education, as it is highly demanded by industry and still relevant based on the construction safety incidents that continue to be recorded.

Communication – One of the most ubiquitous skills mentioned in the dataset was the need for improved communication, with 39.4% of reviews mentioning communication skills in some form. The content of the comments about communication included a call for improved communication in general as well as the subcategories of written communication and oral communication. Within these two categories, reviewers mentioned both formal and informal contexts, such as formal report writing, formal oral presentation, informal e-mail writing, or information phone conversations. For example, one evaluator addressed informal, written communication in the form of e-mails to clients, stating that the student "writes technical information correctly, but could work on [his/her] 'voice' when emails will interface with clients." Many emphasized the importance of students being able to recognize their areas of inexperience and articulate questions they have to enable them to improve. Overall, communication is broadly recognized to be a critical success factor in the industry reviews. While not as ubiquitous as in the industry reviews, communication was still mentioned frequently in academic literature (39.4%), suggesting a clear emphasis. For example, some researchers explored BIM as a vehicle for developing communication skills (Zhao et al., 2015). Others explored how to use coursework, such as capstone projects, to foster communication (Zhang et al., 2017). Within the ACCE SLOs, the first two address communication, both written and oral – SLO 1: *Create written communications appropriate to the construction discipline* and SLO 2: *Create oral presentations appropriate to the construction discipline*. These two SLOs define specific skills that were brought up several times by the industry reviewers. One form of written communication that may be overlooked in an academic setting is informal written communication, such as e-mails. This form of communication is certainly "appropriate to the construction discipline" and for many roles more common than formal reports. Effectively and earnestly incorporating something seemingly simple into the course curriculum could require creativity but ultimately would benefit students, many of whom need guidance on digital communication in a more professional setting. For targeting SLO 2 regarding oral presentations, many professors organically involve oral presentations in their class, providing a valuable opportunity for public speaking experience. In addition to formal settings, educators can consider the opportunity of teaching students appropriate verbal communication in professional settings. For example, many industry reviewers indicated that they wished students asked more questions, fewer questions, or simply better questions. Others wished for more effective phone communication from their interns. Developing effective verbal communication in both of these informal settings are certainly appropriate to the construction discipline and would benefit from creative application in the academic realm.

Trade coordination – While communication, in general, was acknowledged by both industry and academia, one specific area that emerged more strongly in industry results was trade coordination. This topic was not mentioned by name in most of the academic literature while more than 1 in every 5 industry reviewers cited working with "subs," "subcontractors," or "trade partners" in various forms as a crucial part of the job expectation for the student interns. The strong emphasis placed on this concept by industry suggests that academic researchers and curriculum developers can use this need to craft student experiences that meet SLO 9: *Understand construction management skills as a member of a multidisciplinary team* through the lens of integrating building systems with various specialty contractors and design professionals in order to prepare students for those interactions in the field. While this SLO is undergoing a wording shift from "apply" to "understand," effectively lowering the student expectation by one level on Bloom's taxonomy, educators can still consider ways to implement collaboration strategies in the classroom in novel ways since working with others is critical to daily work in industry. This is an area where advancements in novel teaching strategies could offer near-term value to students entering the industry.

Collaboration and teamwork – Collaboration was strongly represented in the recent construction education literature (28.8%), often in conjunction with the aforementioned communication skill. For example, researchers have addressed collaboration within interdisciplinary teams and with problem-based learning tasks (Scott & Ghosh, 2016). The intersection of several topics with teamwork, such as sustainability (Valdes-Vasquez & Clevenger, 2015) and BIM (Zhao et al., 2015) presents itself in recent academic literature in the field. Researchers have also explored barriers to collaboration and the effectiveness of incentives to fostering teamwork (MacLaren et al., 2017). Overall, within the recent body of academic work within the construction education fields, there is a general understanding of the importance of collaboration and a desire to improve the way this concept is delivered to students. While the concepts of collaboration and networking did not appear as frequently in the industry reviews, several employers mentioned these qualities (7.2%), showing a general understanding of the importance of collaborative skills in industry. Teamwork was also highly represented in literature (16.9%) and also in the industry reviews (21.5%). Semantically, some may argue that these two categories are inseparable. The topic group with collaboration includes networking and relationships and seems to imply a longer-term investment in some sort of interpersonal interaction while the teamwork category is more task-based. Despite the difference, the two terms are often used interchangeably in the literature, so differences in frequency should not be used to decisively conclude that one term or type of relationships is preferred over the other. Both collaboration and teamwork are recognized across industry and academia as critical success factors.

Limitations

It is recognized that the factors that motivate a direct evaluation of a specific student may differ from the factors that motivate peer-reviewed publications. For example, company needs and culture may motivate a student evaluation, while topics more likely to attract funding or to be accepted by the peer-review process may motivate publications. Therefore, the focus of this work is on offering qualitative insights into similarities or differences between the types of topics explored, as opposed to suggesting this as evidence to illustrate how academia is or is not failing to address the needs of the industry.

The authors aimed to identify trends reported about the skills and attributes of students at an ACCE-accredited institution in recent years. Due to the data collection and cleaning processes involved, the authors were not able to define sub-trends specifically based on demographic information of individuals included in this study. It is theoretically possible that some trends may have emerged based on demographic group, but since this was not a focus of this study and was not facilitated by the data, all reported trends and claims are not stated based on specific demographic group relationships.

In pursuing this research, the aim was to understand the trends in the U.S. construction industry on what skills construction institutions should focus on fostering in their students. The authors recognize that their set of industry data came from evaluations of students attending a university in one region (i.e., the American Southwest), which could theoretically create a geographic bias to the responses. Even so, the students enrolled at this institution complete internships across the country. Furthermore, the authors were careful to avoid including comments that explicitly refer to skills associated with only one particular region. For example, while the Southwest may require construction with sun-resistant materials and the Northwest region may require more water-resistant materials, professionals in both regions need to use estimating tools and concepts to predict the cost of constructing with these materials. As a result, the authors maintain that their results can be generalized to apply across the U.S. construction industry, but how future researchers use these results may need to be tailored to their specific regional needs.

Conclusion

The construction industry's need for better-prepared professionals calls for educational improvements. The shift to outcomes-based learning goals in construction education accreditation provides the needed flexibility to implement innovative educational strategies. In order to guide educators to target learning strategies and topics that are frequently demanded by industry, this research coalesced findings related to student learning needs from industry and academia. The major findings provided by this research include a discussion of skills and competencies that are both highly emphasized by industry and academia, including technical skills that result from hands-on experience and software proficiency as well as interpersonal skills such as communication. It was also found that industry more frequently mentioned specific professional skills, such as attention to detail and time management, than academic publications. On the other hand, the concept of sustainability was mentioned much more frequently in academic literature than it was by the industry representatives. Overall, several skills and competencies, involving personal attributes, technical skills, and professional skills, were analyzed for frequency of mention and compared between industry and academic realms.

The contribution of this work is in systematically organizing and comparing recent reports from both industry and academia related to necessary competencies needed for students pursuing construction careers. In the near term, this knowledge will allow future educators to more specifically understand what learning outcomes, and what professional contexts related to those outcomes, are in the highest demand from the industry. This can guide their educational strategies for addressing student learning outcomes required for accreditation. In the longer-term, the analysis approach used in this work offers a repeatable strategy based on a wealth of firsthand industry-to-student direct feedback that would allow future researchers to update and compare findings to this paper in order to identify shifts in demands for new competencies from the industry. These methods use forms of data that are likely to continue being collected and accessible to academic researchers in institutions of higher education.

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