

Safety Education in the Curriculum of Construction Programs

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Abstract: Construction safety education will continue to attract the interests of construction educators, researchers, and industry professionals due to its immense influence on accident reduction and prevention. A well-educated workforce with a thorough understanding of safety requirements and procedures is needed to develop and apply effective safety and health programs as well as devise strategic means of preventing injuries, illnesses, and fatalities on construction projects. The objective of this research is to evaluate construction safety education in the curriculum of construction programs in the United States. An analysis of construction safety courses across accredited construction programs in the U.S. is conducted to synthesize important details and common themes. A nationwide characterization of the safety courses presented followed by an assessment selected a few programs as a pilot study. Critical elements of the courses such as course titles, course year, credit hours, topics covered, and alignment with professional certification or outreach training courses are characterized. Findings from the study reveal the similarities and variations that exist among safety courses taught in different construction programs in the U.S. These findings could result from several influencing factors, which could be the subject of further investigations geared toward improving safety education in construction programs.

Keywords: Accreditation, certification, construction safety, education curriculum, OSHA, outreach training.

1. INTRODUCTION

The global construction output has been predicted to increase by 3.6% per year for the next five years, reaching \$12.9 trillion by 2022. This represents an increase of almost 20% from \$10.8 trillion as of the end of 2017 [1]. The construction industry is in a constant state of change because of globalization, the adoption of new technologies, competing economics, competitive market forces, and ever-increasing regulations [2]. The Bureau of Labor Statistics [3] predicts a 13% increase (790,400 new jobs), in the construction industry from 2014 to 2024. The employment of construction managers specifically is projected to grow by 5% through 2024 [3]. This equates to 1,780 additional construction managers every year, not including the replacement of existing construction professionals who leave the industry. To meet this projected increase, construction

management (CM) programs must continuously produce an adequate amount of graduates [4]. There has been increasing pressure on academia to produce highly knowledgeable and job-ready graduates [2]. Continuous integration of new knowledge into the existing curricula is one of the strategies to meet construction industry expectations [5]. Construction education programs must be able to predict the competencies required for successful future construction professionals and enhance academic curriculums to best prepare students for the construction work of the future. The success of a project and construction business is highly influenced by the skills applied by construction managers which are acquired through education and training. Therefore, it is very critical to continuously improve construction programs to address the education needs of the students and the construction industry.

In 2019, the construction industry accounted for 1,061 out of 5,333 total worker fatalities in the private industry [6]. This is attributed to the hazardous nature of construction tasks and the work environment. Despite the adoption of safety procedures and programs, such as those developed and required by the Occupational Safety and Health Administration (OSHA), the rates of injuries, illnesses, and fatalities in construction have been rising within the past decade. This trend in incident statistics has elevated awareness and concerns about construction safety demonstrated by the rise in the development of safety-related materials, training courses, and workshops, among others. OSHA, the agency primarily charged with regulating U.S. workplace safety authorizes individuals and organizations to provide training programs to increase knowledge about safety and health in construction [7]. Safety education and training have been shown to benefit safety performance on construction jobsites. Improvements in safety performance can be gained when project employees have adequate knowledge of the potential construction site hazards and the appropriate means to mitigate the hazards [8]. When construction managers are hired to join construction organizations, they bring core values and standards that influence organizational culture. Safety awareness and the development of the ability to apply safety management skills on the construction site can begin in the construction manager's formal education. If the importance of construction safety and safety management is recognized and included in the educational programs of the managers, an improved safety culture will be created. The relationship between safety education and organizational performance has been reported in a few studies [9,10,11].

The structure, content, and approach of teaching construction safety courses vary to some extent from one university to another due to several factors including program accreditation requirements, university policies and resources, faculty resources and expertise, student enrollments, and industry needs [12] [8]. Some of the construction programs align their safety course with the OSHA 10-hour, OSHA 30-hour, or other certifications and issue a course completion card/certificate upon completion while others do not. This could therefore generate some variations in the amount and type of topics students are exposed to across different universities. Of particular importance are the accreditation requirements (influential drivers of a program's curriculum) which set the standards to be achieved by a program [8]. Given that educational environments must maintain some semblance to the real-life industry practices, harmonizing the curriculum with the needs of the industry is a crucial task taking into account that the construction industry is experiencing speedy transformation [13]. If best practices are incorporated into construction safety education, construction education will be setting the pace rather than keeping the pace with the industry. Azhar et al. [5] argued that construction safety education should be adaptable, and structured to evolve to address present and future challenges. The integration of best industry practices into construction curricula can be used to advance the knowledge base of construction graduates and better prepare them to effectively respond to industry challenges. This study provides an analysis of safety education in construction programs to synthesize important details and common themes that can

potentially be used to identify and implement best practices for effectiveness and continuous improvement.

2. CONSTRUCTION EDUCATION

Construction managers play a crucial role in modeling the industry's success and efficacy. They interact with not only all stakeholders (such as consultants, contractors, subcontractors, vendors, and clients) involved in the construction business [14], but also with fieldworkers (including superintendents, foremen, tradesmen, and laborers). In line with this reasoning, courses in the construction curriculum should be designed to meet the growing demand for construction managers with professional and technical backgrounds [14]. Due to the crucial need for competent and adequately skilled managers, construction programs would be increasingly called upon to produce candidates suitable to undertake these services for the industry [15]. The present pedagogic approach of co-operative education followed by universities of technology embodies the notion that both education and training are equally essential [16]. Several authors have highlighted that apart from course content relevant to job-related situations, there is the need for an appropriate teaching approach that bridges the perceived lacuna between formal academic instruction and on-the-job training [17].

The curriculum in construction programs can sometimes be constrained by the requirements of the accreditation body and the university's curriculum conditions [18]. As a result, academic programs are often forced to retain a large number of traditional courses and sometimes jettison the incorporation of new courses based on innovative management principles and skills. This often results in a large gap between current industry practices and those taught in the construction curricula [19]. This gap can be alleviated through academia-industry collaboration because higher education institutions are observed to provide basic knowledge and skills, whereas the industry can provide additional training and expertise in the management discipline [20]. Studies have supported and emphasized the need for critical learning from practice in construction education [21]. Hence, the integration of best industry practices into construction curriculums should be regarded as an opportunity to produce graduates that can meet industry expectations and become productive from their first day on the job [5].

3. CONSTRUCTION SAFETY EDUCATION AND TRAINING

Accident prevention through education and training has proven to be effective over the years. According to Awolusi et al. [22], it is necessary to make a distinction between education and training to draw out the likely impact of each on safety performance. Education imparts high-level knowledge and skills that are transferable to different situations while training, on the other hand, is more context-specific, dealing with procedures or rules for undertaking particular tasks or activities [23]. Training should strongly focus on developing the safety-critical position holders' ability to recognize and proactively manage hazards as well as providing a greater understanding of the reasons for conducting certain safety activities [24]. OSHA is charged with regulating U.S. workplace safety through which they provide enforcement and promote training. OSHA authorizes individuals and organizations to conduct outreach training programs (OSHA 10-hour and OSHA 30-hour) which provide workers with basic and more advanced training about common safety and health hazards on jobsites. While these forms of information transfer help to address problems, there are still areas where additional effort is needed. In 2004, Massachusetts became the first of seven states to legislate mandated OSHA 10-hour training for construction workers on most public projects. Studies have shown that occupational safety training has beneficial effects on knowledge gain and improved behavior but there is weak evidence for improved safety outcomes [25].

The safety course, which has been taught for several years in different construction programs, is still evolving with industry needs and expectations. According to Banik [12], it is important to attempt to answer some critical questions such as “what are students learning from the course?,” “should the course include only OSHA 10-hour or 30-hour requirements or any other certification or with additional materials?” The inputs of the construction industry practitioners and their guidance on the appropriate content of the course could be very useful in providing practical and impactful answers to these questions. Course evaluation by the industry is a necessity in order to develop such a course with the increasingly stringent rules of OSHA. Their suggestions and requirements would need to be incorporated into the curriculum so that the course achieves desired objectives.

4. RESEARCH METHOD

A background review of research and industry findings on safety education in the construction industry was conducted. A comprehensive online search was also conducted to identify the demography of construction programs in the U.S., the agencies responsible for the accreditation of the programs, the construction safety courses taught as part of the curriculum, and other pertinent information required to achieve the objectives of this study. The construction programs that were considered for this study were those accredited by the American Council for Construction Education (ACCE) and the Accreditation Board for Engineering and Technology (ABET). The current lists of these accredited construction programs were obtained from ACCE and ABET websites. Using these lists, a further online search was conducted to explore more incisively the safety courses in the curriculum of each construction program. Thereafter, the course description and/or syllabi of the courses were carefully reviewed to extract critical elements such as course titles, course year, credit hours, topics covered, and alignment with certification or outreach training courses such as OSHA 10-hour or 30-hour, etc.

5. DATA ANALYSIS AND RESULTS

Data was mined from one hundred and twenty-three (123) construction programs in one hundred and fifteen (115) universities across forty-five (45) states in the United States. Figure 1(a) shows the number of construction programs in different regions of the U.S. According to the data, the states with the highest number of construction programs are California (9), Texas (9), Indiana (8), Florida (7), and Ohio (7). A review of the statistics of the value of state and local construction projects put in place in the U.S. in 2019, by state shows California with (\$39.57 billion), Texas (\$36.54 billion), New York (\$24.05 billion), Florida (\$14.90 billion), Washington (\$12.01 billion) and Ohio (\$9.71 billion) were the top six. This shows a reasonable distribution in the sense that states with an active construction industry have a good number of construction programs churning out graduates for the construction industry. The Bureau of Labor Statistics (BLS) report also indicates high fatality counts in these states with Texas recording 469 fatalities, California (463), New York (223), Florida (275), Georgia (193), and Indiana (158). The fatality counts in these states correlate to the (value) volume of construction projects. The high fatality counts in the Nation and these states reemphasize the need to improve construction safety education to equip construction managers with the requisite knowledge/skills to surmount the challenges. An analysis of the administrative units (college, school, or department) under which the construction programs are housed indicates that most of the construction programs are housed within the college/school of engineering, college/school of architecture, college/school of technology, school/department of construction, and college/school of business. These administrative units could impact the safety education in terms of the focus, which may in turn influence the content and topics covered.

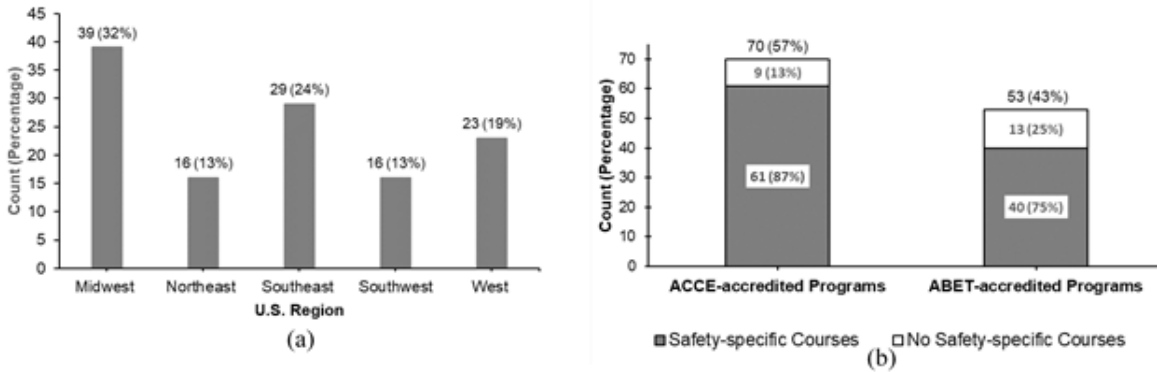


Figure 1. (a) Number of Construction Programs in U.S. Regions (b) Construction Programs and Safety Courses Based on Accreditation

As of the time of this analysis and information available to the research team, a total of seventy (i.e., 57%) of the construction programs were accredited by the American Council for Construction Education (ACCE) while fifty-three (43%) were accredited by the Accreditation Board for Engineering and Technology (ABET). One hundred and one (101) safety courses were identified across construction programs in the U.S. Sixty-one (approximately 60%) of the safety courses were found in ACCE accredited construction programs while forty (i.e., 40%) were found in ABET-accredited construction programs. Thus, as shown in Figure 1(b) ACCE-accredited construction programs are more likely to include safety-specific courses in their curriculum than ABET, with eighty-seven percent (87%) in ACCE-accredited construction programs versus seventy-five percent (75%) in ABET-accredited construction programs.

Table 1. Characteristics of Construction Programs and Safety Courses

Characteristic	Count	Percentage
<i>Most Common Names of the Construction Programs</i>		
Construction Management	65	53%
Construction Engineering Technology	18	15%
Construction Engineering	15	12%
Construction Science and Management	4	3%
Building Construction	3	2%
Construction Science	3	2%
Construction Management Technology	2	2%
Others	13	11%
<i>Most Common Safety Courses Titles</i>		
Construction Safety	58	57%
Construction Safety Management	14	14%
Construction Safety and Health	4	4%
Others	25	25%

Table 1 shows the characteristics of construction programs in the U.S. and respective safety courses in terms of names, the course title, course year, and credit hours. Results of the analysis show the top seven most common names of the construction programs with “*Construction Management*” occurring most (53%), followed by “*Construction Engineering Technology*”, and “*Construction Engineering*”. The top three most common names of the safety courses are “*Construction Safety*,” “*Construction Safety Management*,” and “*Construction Safety and Health*”

as shown in Table 1. Additionally, under the assumption that the first digit of the course number indicates the year in which the course is taken by the students, most of the safety courses (38%) are third-year level courses. Eighty-four percent (84%) of the safety courses are three (3) credit hours. According to the information obtained from the course webpages, thirty-six (36) safety courses cover OSHA content with five (5) aligned only with OSHA 10-hour, corresponding to fourteen percent (14%), while thirty (30) of them are aligned with only with OSHA 30-hour corresponding to eighty-three percent (83%), and one (1) aligned with both OSHA 10-hour and 30-hour corresponding to three percent (3%).

6. PILOT ASSESSMENT OF SYLLABI OF SELECTED SAFETY COURSES

To further assess the content of safety education in the curriculum of construction programs in the U.S., the syllabi of seven safety courses from seven different universities were downloaded from publicly available repositories of the respective universities. Six (6) out of these courses are from ACCE-accredited programs with only one (1) from an ABET-accredited program. Five (5) of these courses are 4th-year courses while the remaining two (2) are 3rd-year courses. As obtained in the nationwide analysis presented previously, four (4) of the courses have their titles as “*Construction Safety*,” and one (1) each as “*Safety in Building Construction*,” “*Safety Engineering*,” and “*Construction Safety Management*.”

Table 2. Occurrence of Most Common Topics in Safety Courses

Topics	Overall		Aligned with OSHA 30-hour		Not Aligned with OSHA 30-hour	
	Count (7 Total)	Percent	Count (4 Total)	Percent	Count (3 Total)	Percent
Falls	6	86%	4	100%	2	67%
Electrocution	6	86%	4	100%	2	67%
Struck-by	6	86%	4	100%	2	67%
Caught in-between	6	86%	4	100%	2	67%
PPE	6	86%	4	100%	2	67%
Introduction to OSHA	5	71%	4	100%	1	33%
Health Hazards in Construction	5	71%	4	100%	1	33%
Safety and Health Program	5	71%	4	100%	1	33%

Four (4) out of these seven (7) courses are aligned with the OSHA 30-hour outreach course while the remaining three (3) are not. The syllabi/topics of the four (4) construction safety courses aligned with OSHA 30-hour and three (3) courses not aligned with OSHA 30-hour were analyzed. The courses aligned with OSHA 30-hour had less variability in the topics covered, averaging only 8.3 different topics as opposed to 21.7 average different topics in the syllabi of safety courses not aligned with OSHA 30-hour. The five (5) topics with the most occurrence in both sets of syllabi were “*Falls*,” “*Electrocution*,” “*Struck-by*,” “*Caught in-between*,” and “*Personal Protective Equipment (PPE)*.” Other common topics observed included “*Introduction to OSHA*,” “*Health Hazards in Construction*,” and “*Safety and Health Program*” as shown in Table 2. Although this pilot assessment revealed certain details about the content of safety courses in the construction programs considered, there is a need to conduct a nationwide analysis of the safety courses and investigation of the perception of faculty and industry practitioners to gain additional insights into these courses and generate critical findings that can potentially be used to harmonize and improve safety education in construction programs.

7. CONCLUSION

The continuous increase in construction employment as estimated by the U.S. BLS means that there would be many new and young workers entering the construction industry. These new and young workers are at greater risk of injury, as they enter this high-hazard construction industry. Additionally, the implementation of safety and health programs on construction projects requires an educated workforce that is knowledgeable in safety requirements and procedures. In this study, an analysis of safety courses in accredited construction programs in the U.S. was conducted to synthesize important details and common themes. The analysis conducted in this study led to the characterization of the safety courses to draw out important details/variables such as the most common administrative units of the university under which the construction programs are housed, the agencies responsible for the accreditation of construction programs, the names/titles and number of construction programs and safety courses, course year and credit hours. Findings from the study reveal the similarities and variations that exist among safety courses taught across different construction programs in the U.S. These similarities and variations could be caused by several influencing factors or variables that need to be investigated in further studies for the improvement of safety education in construction programs.

The significance of this study is that it serves as a starting point for further studies to critically explore the safety education provided by construction programs in institutions of higher learning in the U.S. It opens up opportunities for additional investigation much beyond what was conducted in this study to gain greater insights into the courses and generate critical findings on best practices that can be implemented to harmonize and enhance the safety education that new and young construction managers receive before employment. An immediate extension of the study will involve the assessment of a more representative sample of the safety courses in construction programs throughout the Nation to characterize critical details upon which further appraisal can be conducted. In addition, future studies will investigate the perception of faculty and industry professionals about safety education in construction programs. This survey will help generate pertinent information about the status of and need for the alignment of safety courses with professional certification or outreach training courses, internal and external factors or variables that influence pedagogical content and approaches, and best practices that can be deployed to standardize and improve safety education in construction programs in the U.S.

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