



An Example from Construction Safety: Professional Certifications as Potential Drivers of Degree Program Enhancements

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Abstract

The American Road and Transportation Builders Association (ARTBA) recently launched a “Safety Certification for Transportation Project ProfessionalsTM” (SCTPP) program that targets a wide range of road construction occupations to include engineers as well as construction managers and supervisors. The certification development process documented industry demand for safety-specific competencies. The objective of this paper is to determine to what extent the industry-driven safety competencies identified in the SCTPP certification development process are currently being covered at the degree level in construction engineering, construction engineering technology, construction management, and civil engineering programs. This paper documents results of a survey of civil engineering and construction degree programs.

Analysis of survey responses from 110 institutions of higher education across the United States indicates that construction safety content is typically embedded in general coursework and/or offered in a separate course. Fifty-eight percent of responding institutions offer full courses devoted to construction safety. Safety content focuses primarily on workplace safety standards and enforcement (e.g. OSHA), followed by recognizing project site hazards and preventing personal injury. The vast majority of responding programs reported having at least some course content devoted to these topics. Survey responses on what construction engineering and management students would be expected to know upon graduation reflect this emphasis. Respondents expected most or all graduates to be able to: identify and assess safety risks (88%); communicate the importance of safety to a broader audience (80%); identify and implement regulatory safety requirements (71%); develop a safety plan (66%); implement a safety plan (63%); and assess the effectiveness of safety measures (59%). These skillsets map back to competencies outlined in the ARTBA certification exam blueprint and reveal that some topics gain more emphasis at the degree level than others.

The authors utilize survey results to develop recommendations on how professional certifications in general can be used by education providers as “industry benchmarks” to drive curriculum development. In addition, safety certifications may provide a catalyst for expanding opportunities for experiential learning and other industry-education partnerships that ensure students are gaining the full range of competencies that reflect industry demand.

Introduction

The U.S. Department of Transportation Federal Highway Administration (FHWA) launched a National Transportation Career Pathways Initiative in 2016 with the goal of assisting technical schools, universities, and employers to establish structured education, training, and experiential learning programs that foster the placement, retention, and advancement of individuals in high-

demand occupations and careers. The national initiative focuses on five transportation discipline areas with the West Region Transportation Workforce Center (WRTWC) at Montana State University leading the career pathway development process for the safety discipline. The WRTWC worked with a national advisory group of subject matter experts to identify priority safety occupations, key competencies required for safety professionals in these occupations, and the current state of the practice for safety-related training and education. Highway construction was identified as an important focus area for this effort; and a representative from the American Road and Transportation Builders Association (ARTBA) was involved in the process as an advisory group member.

ARTBA's participation in the career pathway development process was particularly relevant as the association recently launched a "Safety Certification for Transportation Project ProfessionalsTM" (SCTPP) program. The initial conceptual framework for the proposed credential was to certify the safety directors and other professionals who oversee occupational health and safety at job sites. The original targeted occupations changed, however, in response to feedback from industry representatives serving as subject matter experts for the certification development process who identified a wider range of target road construction occupations. The industry advisory group consensus was that the real demand for enhanced safety knowledge and skills was for occupations like project engineers, construction managers and site supervisors, who are not currently labeled as "safety professionals" but play an important role in ensuring safety on project sites. Feedback from industry representatives highlighted concerns about an observed lack of safety knowledge on the part of engineers and construction supervisors as well as trepidation over a lack of standards for basic project safety competencies. It was generally recognized that project safety cannot be the sole responsibility of the safety director, and that a wider range of transportation project workers needs to be able to identify and mitigate risks [1].

ARTBA's stated goals for the SCTPP certification program are to provide a mechanism for industry to "identify and reward" professionals with demonstrated safety competencies and to "create a 'safety benchmark' for all future civil engineering and construction management program graduates who are interested in employment with industry-leading firms [1]." Because the SCTPP certification development process documented industry demand for specific transportation construction safety competencies, the WRTWC was interested in determining to what extent these industry-driven safety competencies are currently being covered at the degree level. The research objective was to determine if current safety topic coverage in degree-granting programs coincides with in-demand industry safety competencies, what safety topic areas could receive more attention or focus, and to what extent education institutions currently provide experiential learning opportunities focused on safety. The paper documents the results of survey responses from 110 civil engineering and construction two and four-year degree programs.

Literature Review

The safety career pathways initiative studied current education practices related to promoting a systems approach to safety. A systems approach incorporates a comprehensive safety

management methodology that encompasses policies, procedures, planning, monitoring, and assessing safety outcomes with the goal of achieving continuous improvement [2]. This approach, which includes efforts to improve safety awareness, culture, and behaviors, has produced significant safety improvements in the construction industry [2]. However, observers note that the traditional approach to safety training as well as on-the-job construction safety practice is often focused on a passive approach, which measures safety performance based on reactive measures like number of injuries or accidents [2], [3]. Proactive safety management approaches may include implementation of new technologies that facilitate real-time monitoring and information sharing as well as enhancing the role of designers to integrate construction safety into the design phase [3], [4], [5]. One barrier to integrating construction safety into design is the fact that civil engineering students may lack experience or coursework in construction [5], [6], [7]. ABET, for instance, does not require civil engineering programs to expose students to the fundamentals of construction safety [5].

A study on safety emphasis in university civil engineering and construction degree programs was undertaken by Gambatese in 2003 [8]. The survey asked about course content in three areas: OSHA standards, safety management, and safety in design; and found OSHA regulations received the bulk of course time. Gambatese's survey also highlighted differences between civil engineering and construction programs. While 90% of construction programs offered a separate safety course, no engineering programs offered a separate course on construction safety. His study included a review of various accreditation requirements and found accreditation standards to be influential in driving curricular content.

Previous studies of university course content may be outdated due to periodic changes in accreditation standards related to construction safety. For example, the American Council for Construction Engineering (ACCE), which primarily accredits construction management, construction technology, and construction science programs at the Bachelors and Associates degree level, implemented outcomes-based standards in 2016. The standards are defined by student learning outcomes rather than course credit hour requirements [9]. The new process replaces a previous minimum safety course requirement with a student learning objective focused on creating a construction project safety plan.

There is ongoing debate on the best approach to safety content coverage in degree programs. A mandate for separate safety courses ensures that safety receives at least some attention during degree attainment. On the other hand, safety is embedded in a variety of activities and processes in the real world, and safety education should likewise be integrated into a wider range of courses covering different construction methods and processes [10].

Literature on construction safety education focuses on several additional factors. Existing pedagogical approaches to construction safety training have been criticized for failing to adequately engage and motivate learners [4], [10]. Experiential learning through on-site visits has been deemed a useful educational tool for applying and retaining theoretical knowledge and promoting student interest in safety [11]. Onsite safety concerns, however, create barriers to

widespread implementation of this learning tool [10], [11]. Emerging technology platforms like virtual and augmented reality, provide new opportunities to overcome barriers to site visits by providing for interactive and collaborative safety experiential learning in safe environments [12]. While new educational platforms based on these technologies are being developed and tested, they are not yet widely implemented by faculty in the classroom [11].

Methodology

This paper documents research to determine to what extent degree programs in construction technology, civil and construction engineering, and construction management cover safety topics through coursework and work-based or experiential learning. For the purposes of the safety career pathways development process for highway construction, the West Region Transportation Workforce Center was additionally interested in learning what role industry engagement and experiential learning plays in the educational process during degree attainment. An online survey instrument was created using Qualtrics. The survey queried university and community college representatives regarding what construction specialization areas were covered, at what level, and how much time was devoted to specific safety topics for each responding institution. Respondents were asked about competencies students would be expected to master by time of graduation, as well as institutional expectations regarding work-based and experiential learning experiences obtained by students during program enrollment. Respondents were additionally asked to provide information on any courses fully devoted to safety topics and to email copies of syllabi for safety courses to the researchers. Syllabi received were reviewed to identify common course themes and topic areas.

The online survey link and an invitation to participate in the survey were distributed to degree program contacts at 401 universities and colleges across all 50 states and Puerto Rico. Construction degree program contacts were gathered in a variety of ways to ensure full national coverage. Lists of accredited programs were gathered from two accreditation bodies. Ninety-six programs were identified from the American Council for Construction Education (ACCE) list of accredited construction degree programs. Forty-nine programs were identified from the ABET list of accredited Bachelors degree programs in Construction Engineering as well as Bachelors and Associates degree programs in Construction Engineering Technology. Further review of ABET lists identified an additional 149 ABET accredited civil engineering programs with construction-related components. Another 111 programs were identified from the WRTWC's online compendium of transportation two and four-year degree programs offered within its ten-state region, requests for survey distribution assistance through the other four regional transportation workforce centers established by the FHWA nationwide, and via online search engines.

Findings

After removing incomplete or duplicate responses, 118 unique responses were obtained to the survey (a 29% response rate). Eight of the four-year university respondents reported that their

institutions did not offer construction-related topics within their degree program and so did not answer any additional questions. Of the remaining 110 complete survey responses from civil engineering and construction programs, 29% (or 32 institutions) represented two-year degree programs and 71% (or 78 institutions) represented four-year universities. Responses provided good geographical representation for all regions in the United States as shown in Figure 1, which provides data on the number of survey responses from each state and Puerto Rico.

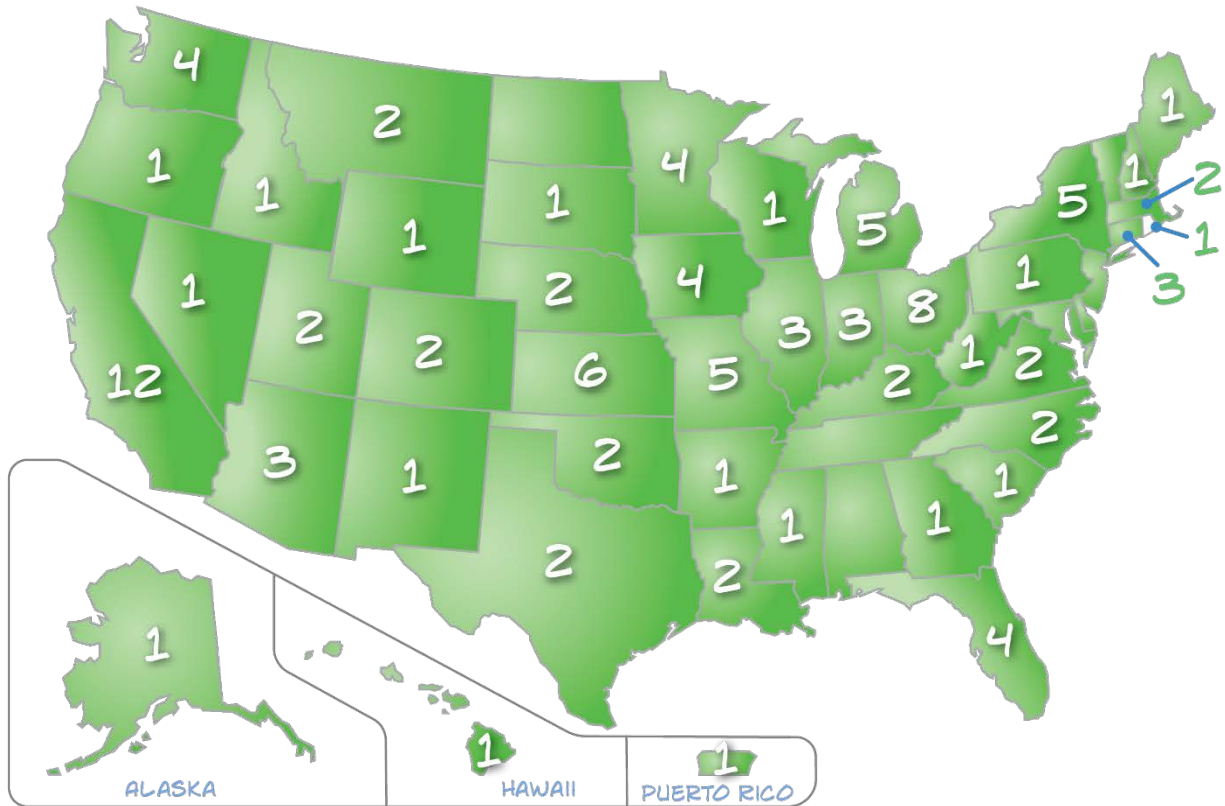


Figure 1: Geographic Representation of Survey Responses

Survey respondents were asked to select all construction topic areas in which their institution offered a degree or certificate program from a drop-down list. The majority of two-year institutions offered construction programs focused on Construction Management (59%) or Residential Construction (56%). Eight institutions (25% of sample) covered highway construction topics and an additional five programs (16% of sample) addressed heavy construction. Four-year institutions concentrated more heavily on Construction Management (82%). Heavy construction and highway construction also received greater attention at four-year institutions, each topic representing approximately 28% of the sample respectively, with less attention devoted to residential construction (13%). Thirty-nine institutions at both levels reported offering Construction Management as the sole degree program topic area covered. Most of the respondents selecting “other” indicated that their program fell under civil engineering, civil engineering technology, construction engineering, or construction engineering

technology. Other topics covered included surveying, architectural engineering or technology, construction inspection, construction materials and facilities management.

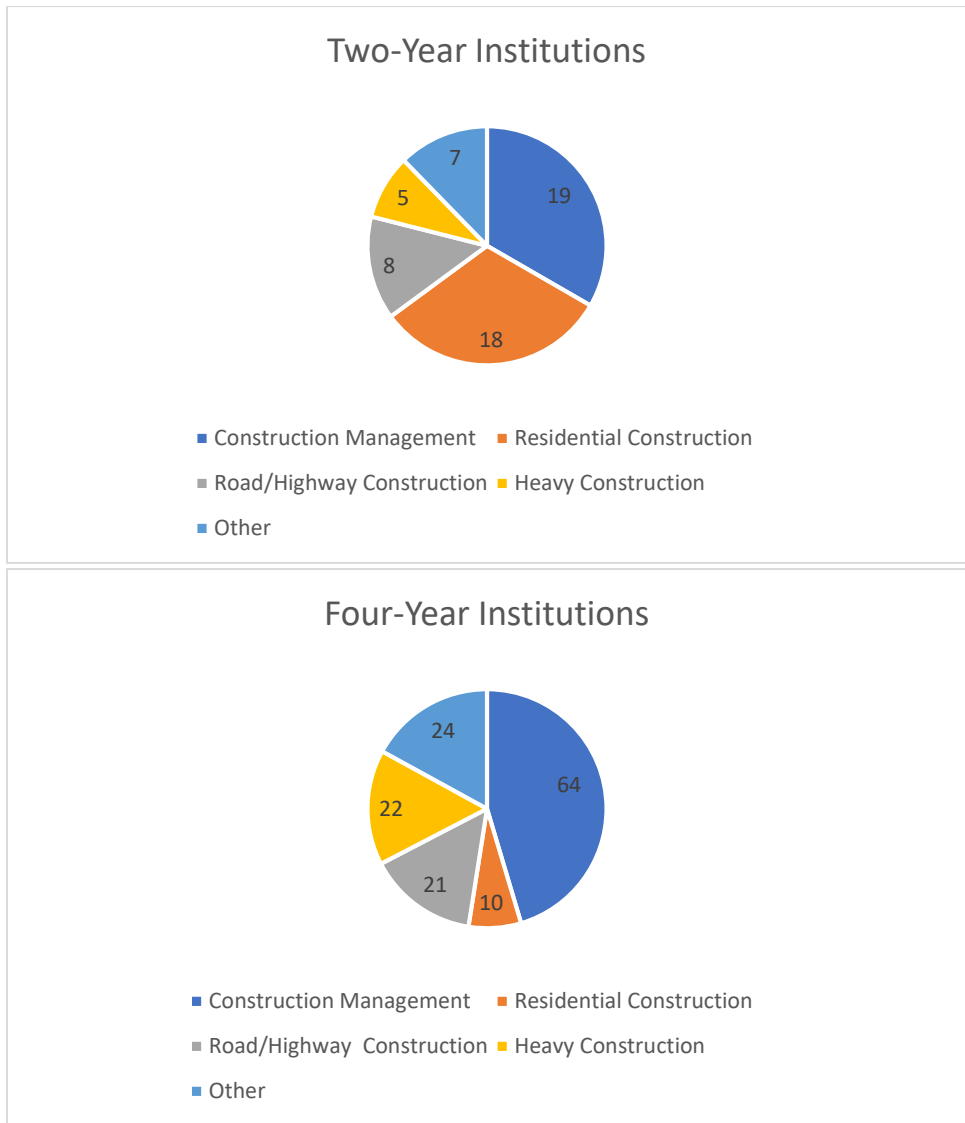


Figure 2: Predominant Construction Degree or Certificate Program Areas Covered by Surveyed Institutions

Most institutions (68%) reported offering construction content at the Bachelors degree level; 34% offered Associates degree content; and 34% offered graduate level (Masters or PhD) content. Thirty-four programs at both the two-year and four-year levels reported offering specialized certificates in a construction content area.

To gauge the overall safety-focused outcomes for construction program graduates, survey respondents were asked to indicate the extent to which graduates of the institution’s construction or construction management programs would be expected to understand: 1) the importance of safety, 2) safety management principles, and 3) the safety planning process. Responses indicate

that over 90% of all construction program graduates would be expected to understand the importance of safety, and 64% of all graduates would be expected to understand safety management principles. Only a handful of programs reported not exposing students to these two topics. On the other hand, while 52% of institutions expected all graduates to understand the safety planning process, survey responses indicate that 10% of construction programs do not expose students to this topic.

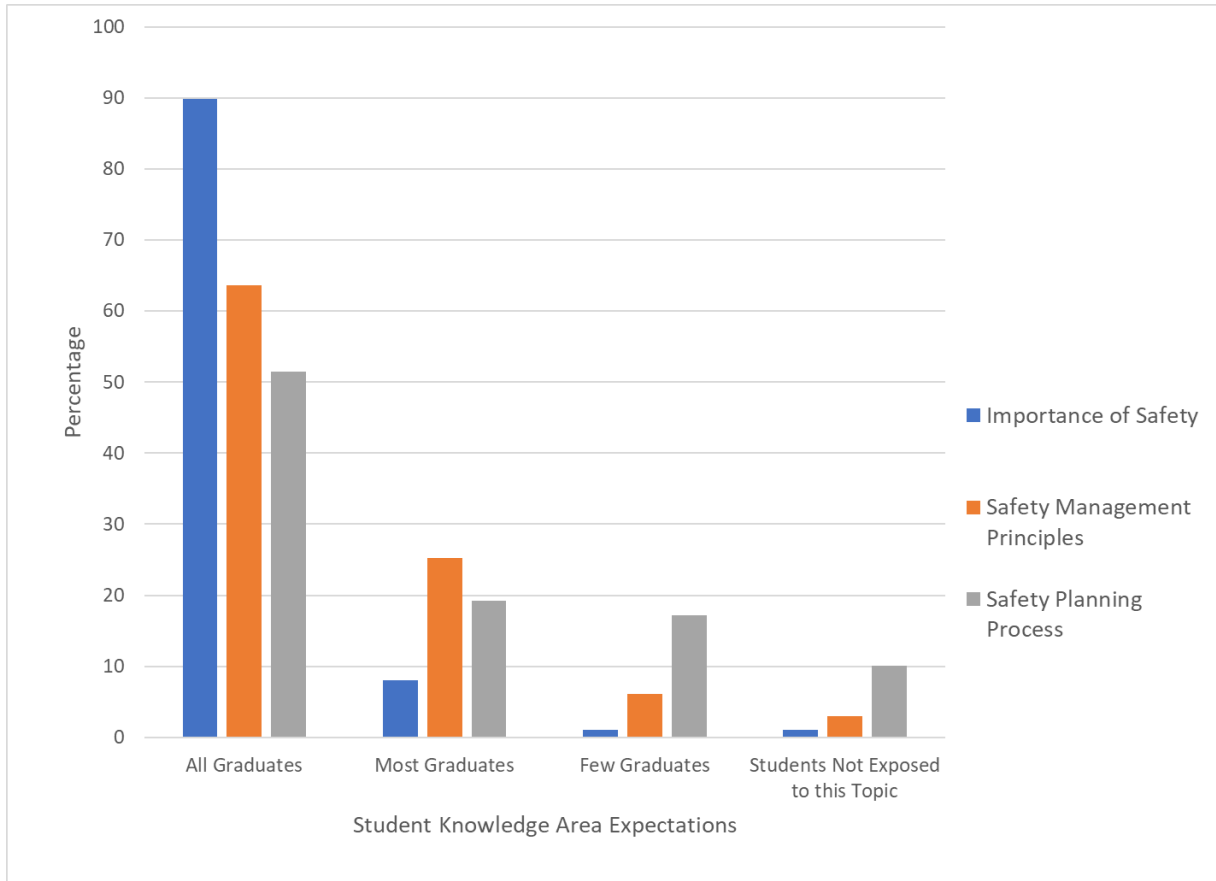


Figure 3: Student Knowledge Area Expectations Upon Graduation

Regarding amount of time spent on safety topics in construction coursework, sixty-three program respondents (or 58% of the sample) indicated that their program offers an entire course or courses devoted to safety, 44 of which represented four-year institutions. No respondents at two or four-year institutions reported a complete absence of safety course content and only one respondent indicated that safety was only briefly mentioned. Fifteen percent of respondents indicated that “safety is covered in a significant portion of the coursework,” and 27% indicated that “some portion of the coursework is devoted to a discussion of safety.”

Survey respondents were asked to rank the extent to which specific safety content areas are covered in construction coursework. Figure 4 presents the results. The safety topics receiving the most content coverage were related to safety standards and enforcement (e.g. OSHA), followed by recognition of project site hazards and personal injury prevention. Only 4% of respondents reported spending no time on OSHA topics, and 18% reported that all safety content

coverage was devoted solely to this topic. Similarly, 93% reported spending at least some class time on the topic of hazard recognition and injury prevention. On the other hand, behavioral factors, systems safety, and risk mitigation topics presented a more mixed picture. A third of respondents reported spending little to no class time on the topic of systems safety and the interaction of multiple risk factors, while nearly a quarter of the institutions reported spending considerable time on this topic. A similar pattern is observed for content on effective countermeasures, with 8% reporting no course content coverage, and 27% reporting considerable time spent on the topic. Behavioral risk factors also received comparatively less coverage, although 67% of the programs responding to the survey reported spending at least some time on the topic.

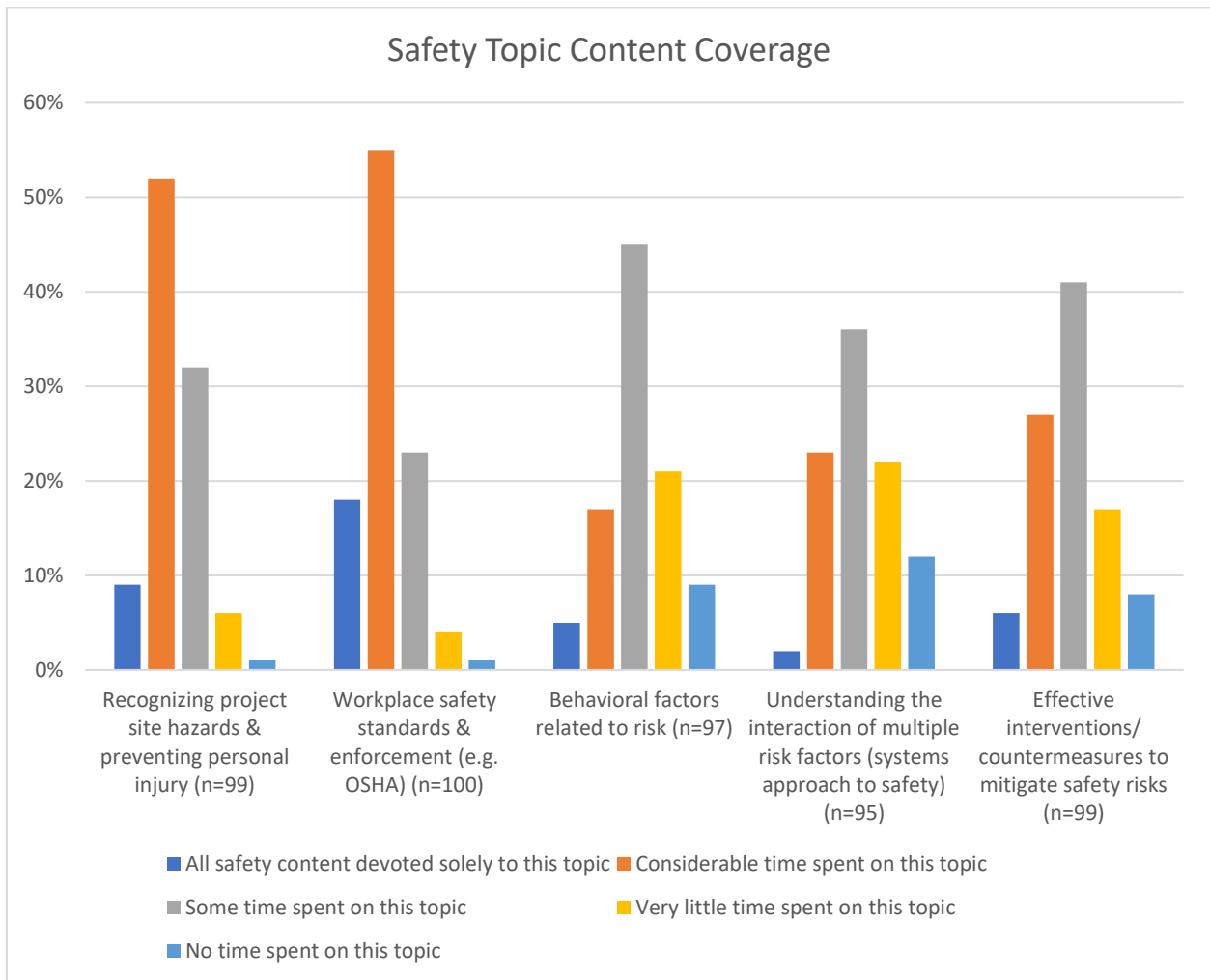


Figure 4: Course content coverage by safety topic

Eleven respondents selected “Other” when asked about safety content areas. The topics reported included OSHA 10 and OSHA 30 training cards, safety planning, statistical models for accident investigations, job hazard analysis, and media communications.

Three safety content areas addressed in the survey related directly to roadway work zone safety. In recognition of the fact that residential construction programs, for example, would be less likely to provide coverage on these topics, response rates for all respondents (n=96) were compared to response rates for programs reporting a road or highway construction focus (n=29) as shown in Figure 5. As expected, programs with an emphasis in transportation infrastructure reported spending more course time covering work zone safety topics.

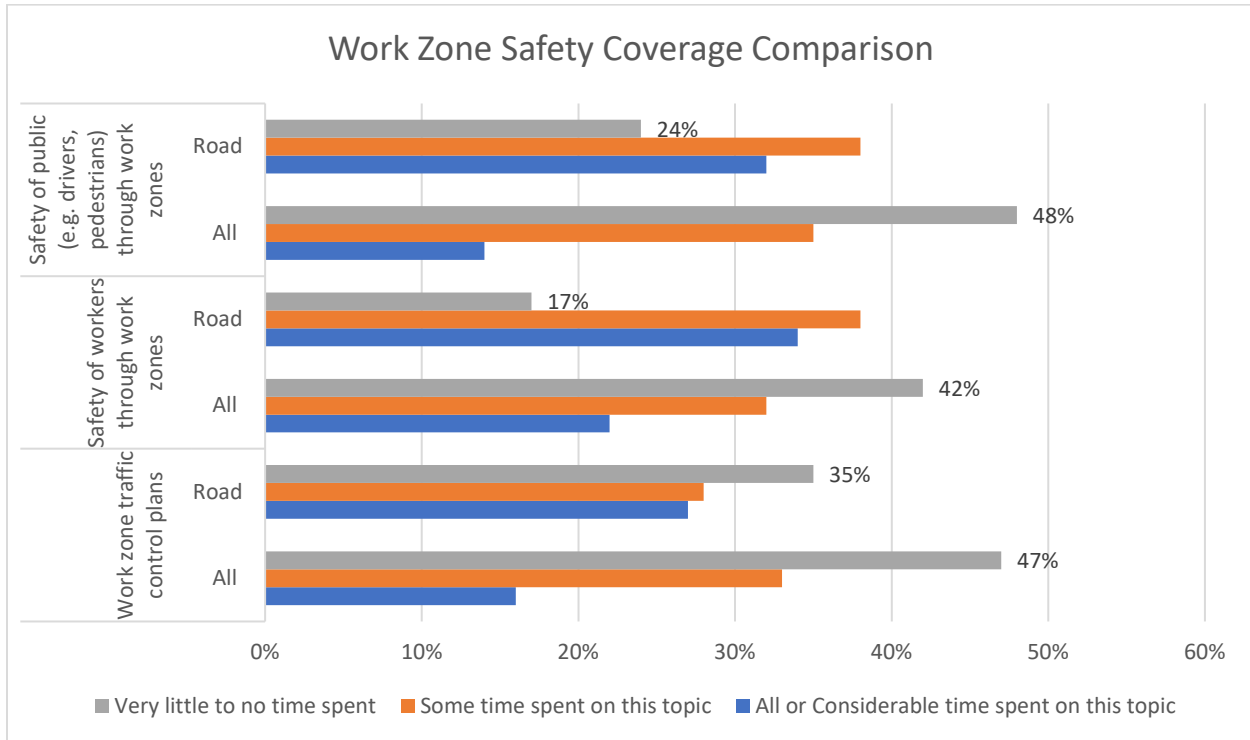


Figure 5: Work Zone Safety Coverage for all Respondents and for Programs with a Road Construction Emphasis

Nevertheless, programs reporting an emphasis in highway construction spent the most class time on the topic of worker safety through work zones. Only five of the twenty-nine programs reported spending little to no time on this topic. Work zone traffic control plans received less attention, with ten of the twenty-nine programs reporting little to no time spent on the topic. Finally, public safety through work zones received the least course time coverage. These results are in line with the observation of more course time spent on worker health and safety topics with less emphasis paid to systems safety, as was previously noted in the descriptions of other course content areas.

To map construction program expectations back to the “safety benchmark” established by the SCTPP certification exam and the core safety competencies identified by the safety career pathways advisory group, survey respondents were asked to indicate the extent to which program graduates would be expected to be able to:

- Communicate the importance of safety to a broader audience;
- Identify and assess safety risks;

- Identify appropriate countermeasures to mitigate risks;
- Develop a safety plan;
- Implement a safety plan;
- Assess the effectiveness of safety measures; and
- Identify and implement regulatory safety requirements.

Survey respondents were asked to select whether the expectation for students in each competency area applied to: 1) all graduates, 2) most graduates, or 3) few graduates; or they could select 4) students not exposed to this topic. Most programs expected all graduates to be able to identify and assess safety risks. Forty-five percent of programs expected all graduates to be able to develop a safety plan and 42% expected all graduates to be able to identify appropriate countermeasures to mitigate risks. The ability to communicate the importance of safety to a broader audience was also expected of most construction program graduates, although 7% of the respondents indicated that their students received no exposure to this topic. Students received the least exposure to the topic of assessing safety measure effectiveness. Competency areas with the word “implement” also received less exposure, perhaps due to the fact that these skills are learned by doing and more appropriately applied and learned on the job rather than in a classroom environment.

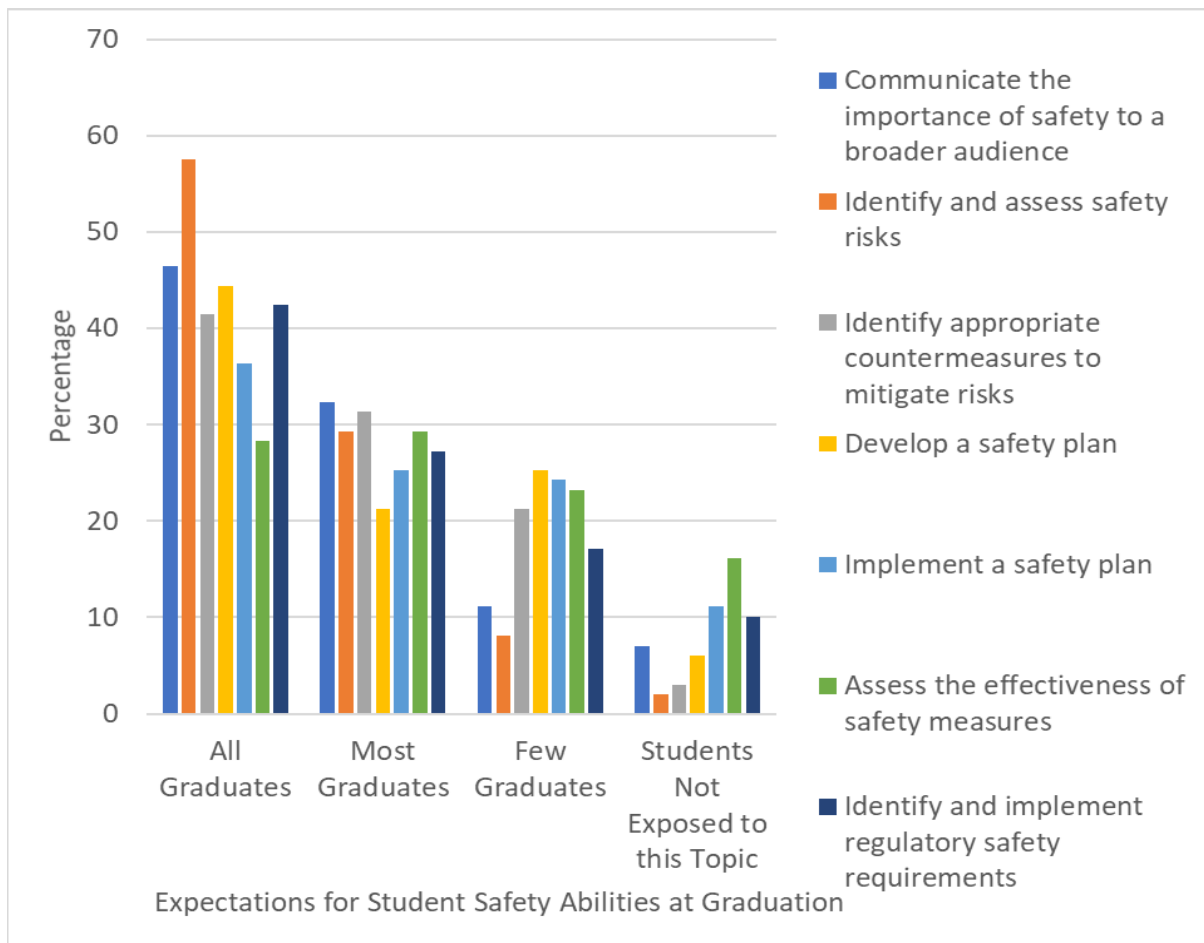


Figure 6: Abilities Expected of Construction Program Graduates

Beyond coursework, researchers were interested in learning to what extent institutions expected their students to participate in work-based learning experiences like internships or co-ops while enrolled in construction degree programs. The responses demonstrate that construction programs widely support work-based learning opportunities of this nature. Thirty-seven respondents (38% of sample) require work-based learning experiences for their enrollees while an additional 45% encourage and support such experiences. Four-year degree programs were slightly more likely to require work-based learning than two-year institutions; 33% of two-year institutions reported having this requirement as compared to 41% of four-year institutions.

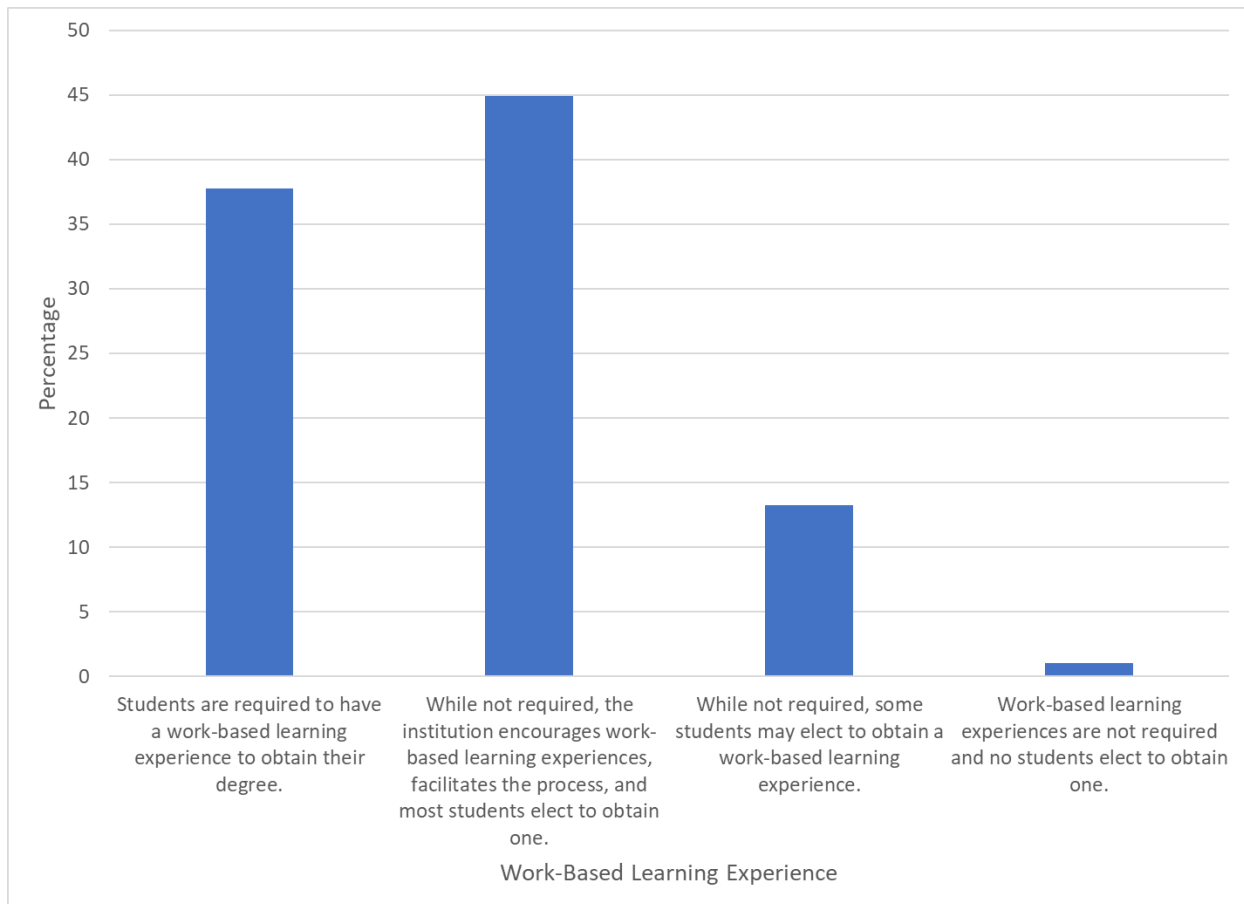


Figure 7: Work-Based Learning Expectations

Expectations and institutional support for work-based learning experiences are borne out by self-reported estimates of the proportion of students who obtain such experiences. Institutions that did not require work-based learning experiences estimated that, on average, 71% of students obtain these experiences during their degree program.

Work-based experiences like internships and co-ops are one mechanism for students to gain real-world project experience. Another mechanism is through in-class experiences. Experiential learning can take a variety of forms such as a senior design course, an industry-led challenge project, or a service learning project. Survey respondents were asked about experiential learning opportunities offered to degree-seeking students in construction or construction management. Of

the ninety-seven institutions that provided feedback to this question, 54% reported that all students are required to have an experiential learning experience; 37% reported that experiential learning opportunities are offered to students through the institution, although they are not required; and only 9% of survey respondents indicated that no opportunities of this kind were offered to students at their institutions. Eighty-one percent of the respondents citing experiential learning requirements represented four-year institutions.

Of the 96 institutions that reported offering work-based or experiential learning opportunities, 29 reported that at least some of these experiences were specifically focused on safety, 44 reported that they were not safety focused, and 23 were unsure. Twenty-three respondents provided narrative descriptions of safety-focused work-based or experiential learning opportunities. Descriptions of specific work-based learning opportunities included: the availability of safety-focused internships for students interested in safety; opportunities to intern as a compliance assistance specialist for a local OSHA office; opportunities for internships with a safety management component; work opportunities with company safety programs; as well as opportunities to intern with safety engineers or directors at various construction firms. One respondent indicated that the institution required students to log daily reports on job site safety as part of their internship requirement as well as to lead a safety meeting. Several respondents noted that safety competencies developed through coursework led to greater work-based learning opportunities in safety. For example, one respondent noted that students earn their 30-hour OSHA cards in class, so when they are placed in their required internship, the company often places them into positions that include safety oversight. Another respondent noted that because students earn their 30-hour OSHA cards before they co-op, some companies have the students perform basic safety inspections and toolbox talks while on the job.

In-class safety experiences included coursework with requirements to complete a safety review, to demonstrate safe practices and procedures in the lab, and to develop safety plans. Several respondents mentioned courses that led to OSHA 10 or OSHA 30 certifications. Some capstone courses or final projects included safety components like safety program analysis, conducting a jobsite audit, writing a safety plan, or on-campus safety projects or research. One respondent noted a student competition that involved developing project-specific safety plans. Other experiential learning opportunities included job site visits and other field trips.

Researchers received seven course syllabi for construction safety courses. The courses represented a mix of departments, to include Construction Management, Civil Engineering, Construction Engineering Technology, and Architectural Engineering; but most had a common “Construction Safety” title. Two came from two-year institutions. Five of the courses resulted in eligibility for either OSHA 10-hour or OSHA 30-hour certifications. Common themes in the learning outcomes and topics described in the syllabi are listed in Table 1 in order of highest frequency cited in syllabi.

Table 1: Common Learning Objectives for “Construction Safety” courses

Learning Outcomes:	Number of Courses
Understand and apply OSHA's construction standards and corresponding safety practices .	7
Identify potential hazards and develop procedures to mitigate them.	6
Create a construction project safety management plan .	5
Understand accident investigation , reporting and record keeping processes.	5
Understand the importance , costs, and history of safety in the construction industry.	3
Communicate and promote safety strategies.	3
Understand relationship between ethics and job safety.	2

Additional knowledge areas mentioned by at least one course syllabus included analysis of incident statistics, analyzing construction documents for safety planning, and emergency response plans.

Thirty-three survey respondents provided open-ended feedback on the topic of safety within construction and construction management curricula. Some respondents provided information on successful educational practices at their institutions. For example, one respondent described the variety of safety tasks students were required to complete during their program, which included creating a safety program, and conducting an accident investigation, a safety audit, and a safety meeting. Another noted that students learn well from experiential learning as compared to regulation-based coursework. As a result, the instructor is working to integrate more hands-on projects and experiences into safety coursework. Several noted that safety is integrated into a variety of courses and is not limited to courses solely dedicated to this topic. One respondent highlighted the institution’s engagement with an advisory committee, Associated General Contractors (AGC), and OSHA as an effective process to focus course content on industry-driven safety issues. Another respondent pointed to opportunities for cross-disciplinary safety coursework and certifications offered by other engineering departments.

Some respondents pointed to perceived deficiency areas. Deficiencies included lack of coverage on emerging technologies (such as virtual reality, drones, laser scanning) that could be used to ensure construction safety in the field; as well as lack of coverage in how to protect pedestrians and other non-workers passing through construction sites. Finally, a few respondents mentioned the need to meet ACCE requirements regarding incorporating project specific safety plans into student learning objectives. These comments highlight the importance of accreditation requirements for driving curriculum development.

Conclusions

The research methodology aimed to capture what safety competencies employers can generally expect to observe in recent construction degree program graduates. Career pathways for construction occupations that are critical to achieving safety outcomes are diverse, and include construction and project engineers, construction managers, and project workers and on-site supervisors. Equally diverse are the “supply-side” education providers responsible for preparing many of these workers; these providers represent a mixture of two and four-year institutions, many of which adhere to different accreditation or other administrative requirements. As has been demonstrated by other research, accreditation standards are important drivers of curricular content. However, even among similarly accredited programs, safety content coverage and approach to safety topics can differ markedly.

Given the diversity of construction education providers, the researchers were interested in identifying additional mechanisms for driving safety content at degree-granting institutions, and especially for communicating the most current in-demand industry safety competencies. The research highlights how professional certifications, developed through consultation with industry representatives, might be used to identify deficiencies in student learning outcomes. Using the example of ARTBA’s Safety Certification for Transportation Project Professionals™, the authors map current construction programs’ learning expectations back to the “safety benchmark” of the SCTPP exam blueprint.

Analysis of survey responses from two and four-year institutions of higher education indicates that most construction programs offer a separate safety course and all programs integrate at least some aspect of safety into course content. Most construction programs expose students to topics related to personal and job site safety. Only 4% of survey respondents reported spending no time covering topics related to OSHA. Institutional expectations of program graduates are correspondingly high in these topic areas, with respondents expecting most or all graduates to be able to: identify and assess safety risks (88%); communicate the importance of safety to a broader audience (80%); and identify and implement regulatory safety requirements (71%). Program respondents reported devoting less class time to risk mitigation measures and systems safety; and expectations regarding abilities of program graduates were correspondingly lower in these areas. Over a third of survey respondents expected few or no program graduates to be able to develop or implement a safety plan, and 39% expected few or no graduates to be able to assess the effectiveness of safety measures. The process of mapping course content coverage and program learning expectations back to certification competencies informed by industry input highlights opportunities for educators to enhance curricula components related to systems safety and risk mitigation and analysis.

Research results also underscore opportunities for industry to foster experiential learning opportunities for students to implement classroom knowledge in real-world scenarios and to develop in-demand safety competencies. Construction programs express broad support for work-based and experiential learning as evidenced by survey responses on these two topics. This support provides opportunities for industry employers to become directly involved in influencing student learning outcomes by encouraging and offering a greater variety of safety-focused

activities to students. Industry involvement in offering internships as well as in shaping capstone courses, senior design projects, or project site visits to emphasize safety processes and outcomes can overcome noted barriers to adding new content into existing coursework or requiring new courses. Enhanced industry-led experiential learning in safety has the added benefit of engaging and motivating students to a greater extent than regulations-based coursework.

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