AC 2010-1167: AN OVERVIEW OF TEACHING CONSTRUCTION SAFETY TO CET/CM STUDENTS

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An Overview of Teaching Construction Safety to CET/CM Students

Author A

Author B

Abstract

This paper illustrates the need to teach that construction safety is not intuitive. In our construction program, we start teaching safety principles and practices in the student's junior year and continue to emphasize construction safety throughout the student's junior and senior years, ending in the student's capstone graduating class. The key is to get our students understanding that in construction safety, we are talking about human lives. Many safety laws are dictated based on results from severe accidents or even death (e.g.. OSHA Fatal Facts). Understanding these laws is not easy, especially for a 20 to 22 year old who does not have industry experience. This paper reports the trends in our students' scores on the Constructor's Qualification Examination (CQE) Level I Exam as well as student responses to a locally developed survey relating to safety. The paper also recounts the various means that the program uses to not only teach construction safety principles and practices but to instill the fact that safety is not intuitive and must be learned and practiced.

This paper follows a similar thread to Peterson[1] on student knowledge of and attitude toward safety. Specifically, we wanted to investigate the safety culture of outgoing graduates of our program as the data and literature review show that this age and experience group is twice as likely to become injured onsite. The other concern is that Bureau of Labor Statistics (BLS) data starting in 2003 showed that first-line managers/supervisors of construction trade workers and construction managers were ranked as one of the top eight occupations in the private construction industry for fatalities.

Safety culture is made up of a variety of factors, including attitude; however, a large portion of the safety culture is directly connected to on-the-job work. As faculty, our responsibility is to do our best to prepare our students for this work. Faculty must focus instruction on safety rules and procedures, and we must emphasize the use of communication skills and competency to promote safety in the work environment.

This paper offers an overview of our current approach to teaching construction safety, our plans for the future, and recommendations for safety education for similar programs.

Introduction

The Construction Engineering Technology (CET) program at Montana State University (MSU) is an ABET-TAC accredited program and was founded in 1960 in the Department of Engineering and Agriculture, which is now the College of Engineering, a college that includes five academic departments, including the Department of Civil Engineering, where the CET program resides. Our 2008-09 enrollment of CET undergraduates in the program was 266 with

an average of 45 graduating from the program on an annual basis. The program has two full-time, tenure-track professors and three adjunct instructors. The authors of this paper are the two full-time tenure track professors. Both authors have extensive construction industry professional careers.

Construction Practice, is the first course taught in the construction core curriculum of the program and the initial presentation of construction safety to our junior students. The senior capstone course, Construction Project Management, includes six weeks of intensive safety training in a two-hour lab class setting. We call these two courses the bookends of the program. One starts the path of construction knowledge education and the capstone course ends this education just prior to graduating from the program.

This paper discusses three primary components of safety culture relative to our students:

1. The inherent risk of construction work for graduates, based upon the Occupational Safety and Health Administration (OSHA) and Bureau of Labor Statistics (BLS) data.
2. The Contractor's Qualification Examination (CQE) Level 1/American Institute of Constructors (AIC) Exam results and in-class assessment.
3. Student attitudes towards safety and their belief that safety is common sense, intuitive knowledge.

In addition, the paper offers a brief overview of our current approach to teaching construction safety, our plans for course improvement, and recommendations for safety education for similar programs.

This paper follows a similar thread to Peterson[1] on student knowledge of and attitude toward safety. Specifically, we wanted to investigate the safety culture of outgoing graduates of the program, reflecting the goal of the National Occupational Research Agenda's National Construction Agenda: research goal 8.1.2: Evaluate how safety and health cultures influence key construction industry subgroups. In this case, our focus is upon the new workers, CET/CM graduates who will be leading the construction industry in the future.

We define safety and health culture as "Safety culture…alludes to individual, job, and organizational features that affect and influence health and safety," [2] where safety culture is made up of six factors: "top management commitment, safety rules and procedures, communications, workers' competency, work environment, and workers' involvement." [2] What is interesting is the variability of this definition. Choudhry, et al., attempt to clarify their construction safety culture model, which falls into "three constructs: person, behavior, and environment/situation."[3] As such, the academic definition is still under debate. Our best outline lies specifically per the National Construction Agenda,

> Safety culture is related to safety, health, productivity, and other aspects of the organization of work on a construction site [Sampson et al., 2008]. Whether the worksite is extraordinarily safe or extremely hazardous, there is a resulting safety culture that reflects the management and workers' attitudes and approaches to safety and those hazards. In this respect, safety culture can be viewed as a consequence of the physical and organizational conditions of work. [4]

Safety culture is made up of a variety of factors; however, a large portion of the safety culture is directly connected to on-the-job work. As faculty, our responsibility is to do our best to prepare our students for this work. Following Andi's six factors, faculty must address top management commitment through the ability of our students to become top management personnel. We must continue to focus instruction on safety rules and procedures, and we must emphasize the use of communication skills and competency to promote safety in the work environment. Ultimately, attitude, as per the National Construction Agenda, is the key factor in reflecting a strong safety culture.

Rationale of Data Collection

Part of the pedagogy in the capstone course is to show the students the facts about construction safety. This is done by using the U.S. Department of Labor, Bureau of Labor Statistics and Occupational Safety and Health Administration data. Both of these departments have been collecting data on construction fatalities, but in 2003, new data was collected that showed first-line managers/supervisors of construction trade workers and construction managers were ranked as one of the top eight occupations in the private construction industry for fatalities. Since 2003, the average fatality rate for first-line managers/supervisors of construction trade workers was 7.8% over a five-year period and 6% for construction managers over this same time period. This is distressing news because our students are being trained to enter into the construction industry as first-line managers and supervisors of construction trade workers. As their careers progress, many will become construction managers.

The construction trade fatality data was one indication that we needed to make sure that we were preparing our students properly, in regard to safety, for their future careers. In addition to this indication, we started to pay more attention to student performance on the Contractor's Qualification Examination (CQE) Level 1 from the American Institute of Contructors (AIC) in the section relating to construction safety. We also wanted to gather data directly from our students in regard to their attitudes toward and knowledge of safety procedures.

Data Collection and Discussion

CQE Exam Results

In regard to the CQE Exam results, a trend started to appear. Only capstone graduating seniors take the exam and although MSU's average pass rate on the entire exam from Spring 2005 to Fall 2008 was six percentage points higher than the national average; the fail rate in the construction safety section was roughly 25 percent of the class. These results were particularly distressing because the construction safety lab of the capstone course is taught just prior to the CQE exam. These results prompted a serious look into why the trend was occurring, followed by changes in the curriculum.

The detail of the CQE exam scores is shown in Table I below. Starting with Spring 2005 CQE exam scores, our overall score was 222.71 out of 300 and the national average was 214.14 out of 300. Montana State University's score on the construction safety section of this exam was 17.92 out of 20, and the national average was 16.86 out of 20. That semester, 38 students took the exam and 11 failed the construction safety section of the exam. The next three semesters,

Montana State University's overall exam scores showed similar results but the individual student scores on the construction safety section were inconsistent. For Fall 2005, 19 students took the exam and 8 failed the construction safety section and in Spring 2006, 26 students took the exam and 13 failed the construction safety section. For Fall 2006, the overall exam scores remained the same, but only one of 14 students taking the exam failed the construction safety section. Spring 2007 was slightly higher in overall exam scores as previously stated and showed similar individual construction safety scores, with two students failing out of 29. The Spring 2007 overall scores remained very similar through last Fall 2008 with an average of 7.75 percentage points above the national average, but the individual construction safety scores reverted to the Spring 2005 ratio, with about a quarter of the class failing the construction safety section. This data may show a potential mind set or thought process as to the students' overall attitude toward construction safety. The data could also be interpreted to show that more emphasis on safety, when professors brought their industrial experience to the program, resulted in at least temporary improvement in the exam scores; however, more improvement would be desirable.

Table I. Summary of Montana State University's CQE Level 1 Exam Scores

	Spring 2005	Fall 2005	Spring 2006	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
National Average Overall Score	214.14	212.1	206.35	213.5	216.94	210.19	210.57	211.94
MSU's Average Overall Score	222.71	216.63	214.65	220.57	237.1	228.68	224.81	229.81
MSU's Score over National	0.04	0.02	0.04	0.03	0.09	0.08	0.06	0.08
National Average Safety Score	16.85	17.57	16.96	18.14	18.22	15.60	15.39	15.55
MSU's Average Safety Score	17.92	17.53	16.27	18.86	19.62	16.16	16.22	16.09
MSU's Score over National	0.06	-0.002	-0.04	0.04	0.07	0.03	0.05	0.03
Students Fail Safety Exam	11 fail/38	8 fail/19	13 fail/26	1 fail/14	2 fail/29	5 fail/19	6 fail/27	7 fail/32

As a result of the CQE Exam data, in Spring 2008, a separate safety mid-term was introduced to reinforce the idea that construction safety is about human life and that students will be responsible for not only their lives but several others whom they supervise. With three semesters of exam scores, the assessment results fare no better than the overall CQE Level 1 exam scores in regard to safety. The average class grade for Spring and Fall 2008 was 140 out of 200 points; Spring 2009 scores were significantly lower, with an average class score of 127 out of 200 points. Reviewing this data and the CQE Level 1 scores, it was decided to find out more about student perceptions and attitudes about safety, both from the Spring 2009 graduating seniors and the juniors.

Survey of Current Students

The capstone course had 27 seniors enrolled who graduated May 2009. All 27 of those students completed the survey. The Construction Practice course had 30 construction and 44 civil engineering students. Twenty seven of the construction students completed the survey. Respondents were asked to answer two open-ended questions about their perception of

construction safety and two "yes" or "no" questions that they could elaborate upon. In their level of agreement, Disagreement or a "No" response was valued at 1, "Maybe" was valued at 3, and an Agreement or "Yes" response was valued at 5. Table II shows the average of the responses for both the junior and senior students.

Table II. Summary of Responses to Survey

Question	Average of all students n=54	Average of Seniors n=27	Average of Juniors n=27
Do you believe that construction safety is common sense?	3.91	4.54	3.30
Minimum safety requirements for new employees include one hour of safety orientation. Is one hour sufficient?	2.36	1.92	2.78
You will be working towards a PM or Supt. Position, what do you visualize as your responsibilities, who are you responsible for?	Self and others		
What is your previous construction experience?	Mixed responses		

The first question was: "Do you believe that construction safety is common sense?" Out of the 27 seniors, 24 stated that, to them, construction safety was common sense. Out of the 27 juniors, 18 felt that construction safety was common sense as well. The second question was: "Minimum safety requirements for new employees include one hour of safety orientation--is one hour enough?" Out of the 27 seniors, 2l stated that the one-hour safety orientation was NOT enough for new hires. Out of the 27 juniors, 15 juniors said "no," that one hour of new hire safety orientation was not enough.

This data response shows a disconnect in their logic. If the majority of seniors (88%) and the majority of juniors (67%) feel that construction safety is common sense, then why do 78% of seniors and 56% of juniors feel that one hour of new hire safety orientation is not enough? If construction safety is common sense, there should be no need for new hire safety orientation. The majority of both sets of students have minimal field experience, with an average of two summer internships. Out of each set of students, three students have a family history of construction business and five of those six students answered that construction safety is common sense and one hour of new hire safety orientation training was acceptable.

The third question that was asked related to whom they will be responsible for on a construction jobsite. Only two out of the entire group of students surveyed said they would be responsible for only themselves; all other students replied that they would be responsible for themselves and others. Again, this shows a further disconnect. If they realize they are responsible for their own safety and the lives of others and that one hour of new hire safety training orientation is NOT enough, then why do they assume that construction safety is common sense? In essence, the safety culture revealed through the survey of these upper-division construction students is that of complacency.

Related Literature

Upon the review of research begun by McCabe[5] in comparing safety attitudes of construction workers with demographic information, a few trends emerged. First, there was a trend that as age and time in the industry increase, the belief that being more proactive about safety increases safety performance. Second, as age increases, the belief that safety interferes with work decreases. Third, as age and experience increase, the belief that safety and production are non-compatible goals decreases. According to their research, "experience and age positively impact attitudes."[5] This realization prompted additional research, resulting in the evidence that the number of incidents (accidents) vs. age was 0.57 for the under-30 age group and it spiked to 2.41 for the 30-37 age group. Alternatively, the number of incidents (accidents) vs. experience resulted in 1.98 for under-5 years of construction experience and it dropped to 0.88 for 5-14 years experience.

If we base these three trends of safety attitudes and perceptions strictly on industry experience, we can directly relate the data to that of our current students. The average age of a student is 22, and upon graduation from the program, they will accept a construction job and begin on-the-job training. So, to correlate McCabe's data, the graduating student's rate of accidents will be double that of their co-workers with 5 years or more experience. To go even further using McCabe's data relative to attitude, the students as new workers may believe that (1) Their safety attitude (proactive or otherwise) will not impact safety performance, (2) Safety interferes with the work to be completed, and (3) Safety and production are not compatible on the construction worksite. The evidence is clear that although age positively impacts safety attitudes (and thereby safety culture) the greater impact is based upon the time spent working in construction. This literature indicates that field experience will change our students' attitude toward safety.

Recommendations

As the present rate of accidents and injury occurrence in the construction industry is higher than other industries, and the rate of first-line managers/supervisors of construction trade workers and construction managers averages 7.8% fatalities per year, we cannot ignore the implication of potential injury to our student graduates. In our own zeal for these students to succeed, we must impart that their own personal safety is at risk once they set foot onto a construction jobsite. And although recent research reveals that it is field experience that develops a worker's positive attitude towards safety, we as educators have an additional responsibility to impart to our students the current data. The curriculum must also reflect the safety culture that is necessary to prevent fatalities, injuries, and illnesses.

Because of the importance of safety to our students and their apparent complacency to learning about safety, we have committed to some changes in our program 'bookend' courses. In the capstone course, we will (1) match a safety final to parallel the safety mid-term exam, (2) continue the existing safety lessons, and (3) add a survey matching that of the Peterson[1] study at the end of the term. The survey would be a beneficial point to better reflect the understanding of the safety portion of the midterm and final exams, thereby relating the student's perspective back to the data collected and the research reviewed. This survey includes student rating of their attendance at lectures and tutorials, rating the usefulness of the class materials, and rating the effectiveness of feedback mechanisms.

In addition, the Construction Practice course will be modified to offer a stronger safety component. The Peterson survey will be added to the curriculum after the final exam. Another recommendation that will be implemented is Peterson's 'zero tolerance assessment' strategy in the course, where work is not accepted from the student until it reaches a high technical level and that the issues of safety and health are no longer compromised. Per Reynolds[6], the zero tolerance assessment strategy is based on professional practice, allowing for the student to become more familiar with risk management concepts. This in turn requires the student to accept a safety culture by performing the work, and that, even though additional work is involved, the end product is something of greater value once it has evolved. One current term-long assignment used in the Construction Practice course is weekly journaling of a construction project. This activity mirrors that of preparing a daily log and a daily work journal in the time frame of 30 minutes per week. Bringing safety into this activity would require additional instruction about safety elements at the beginning of the term; however, it would develop the tools the student will need to evaluate a construction site and determine if the work is safe. Evolution of the journal will include the 'zero tolerance assessment' through periodic review and assessment.

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