ASSE ACADEMICS PRACTICE SPECIALTY

VOLUME 7, ISSUE 1 • 2011

Journal of Safety, Health & Environmental Research

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Understanding the Link Between Construction Safety & Productivity: An Active Learning Simulation Exercise

By Matthew Hallowell

Abstract

The relationship between construction safety and productivity is extremely complex and very difficult to convey through traditional pedagogy. Nevertheless, it is vital for construction engineering and management students and construction managers to understand how safety and productivity are interrelated. To create a rich learning experience, an active simulation exercise was created that exposes the relationship between safety and productivity. The objectives of this paper are to: 1) describe the design and implementation of the exercise; 2) present the results of three years of implementation with more than 300 students; and 3) discuss the achievement of predefined learning objectives.

The exercise was designed to be implemented in an outdoor setting using a 5 ft by 8 ft tarp, ten tennis balls, a stopwatch and a set of simple instructions. Through multiple rounds, students were exposed to the factors that affect both safety and productivity, including teamwork, communication, hazard volume, predictability of hazards and learning. Post-implementation assessments indicate that there is quantitative and qualitative evidence that, when compared to traditional lecture, the simulation exercise yields a greater achievement of desired learning objectives.

For example, students are more capable of identifying and designing management strategies that effectively promote both safety and productivity. Residual benefits of the activity include teambuilding, leadership, promotion of lifelong learning and increased engagement. It is expected that this exercise can be used as an effective alternative to traditional lecture in both academic and professional settings.

Keywords
Safety, productivity, education, simulation

Introduction

To successfully complete a modern construction project, managers must ensure that the facility is delivered on time and under budget while meeting specified quality requirements and acceptable safety standards. Frequently, cost, schedule, quality and safety are in conflict and require strategic management to meet project objectives. For example, the budget may be compromised if too many resources are allocated to quality and safety, but if quality and safety are not adequately managed, the overall cost of the project is likely be compromised due to increased rework, injuries and delays. University researchers and educators strive to better understand the interrelationships of these factors and to convey the salient knowledge to their construction, engineering and management students.

One of the most difficult topics to describe using traditional pedagogy is the safety-productivity relationship as it is relatively complex and is affected by numerous confounding factors. For example, some factors, such as distractions in the work environment and human error, have a negative impact on safety and productivity while other factors, such as planning, communication and teamwork, have a positive impact on both safety and productivity. Additionally, some key factors, such as focus on the task, productivity pressure and time spent installing barricades, have mixed impacts, which further complicate the relationship.

Until recently, many representatives of the construction industry viewed safety management as an additional expense that hinders productivity. Industry representatives believed that traditional safety management strategies do not add value to production and compliance requires significant effort and resources (Mitrolpoulos, et al., 2005). Though some aspects of this belief remain true, recent researchers have found that some safety management strategies improve productivity through reductions in delays and distractions, increased teamwork, cleaner and more orderly worksites and improved ergonomics. A challenge for professors and instructors is to demonstrate how safety and productivity are intrinsically related and the management strategies that can be used to simultaneously promote both aspects of project performance.

This paper presents three years of research on the use of an educational simulation exercise that was designed to increase the ability of construction management students to identify, analyze and respond to factors that affect safety and productivity. Included is a thorough description of the instructions for the simulation exercise and the results from three years of implementation with more than 300 undergraduate civil

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engineering students. Special attention is paid to presenting the statistical validity, reliability and stability of the exercise; the ability of the exercise to achieve desired learning objectives; and representative feedback from student participants.

The results of this research set a foundation for the application of simulation teaching techniques to construction safety education. Since a thorough literature review reveals no publications that study such simulations, the structure of the exercise, learning objectives and assessment strategies may be used as a primary resource for future educators who wish to apply simulation to construction safety education. Additionally, the techniques may be applied by practicing professionals who want to train their workforce in new and engaging ways.

Background

To provide context for the simulation exercise, salient literature related to the relationship between safety and productivity was explored. As will be shown, the findings of studies that focus on the safety-productivity relationship are equivocal. Not surprisingly, publications in this arena tend to focus primarily on how safe work practices enhance productivity. Nevertheless, the author found a significant body of literature that discusses both the benefits and drawbacks of safety management from a productivity standpoint. The results of this literature review are summarized in this section and are used to build theory about the safety-productivity relationship. This evidence was also used to inform and structure the simulation exercise that is the focus of this paper.

Mutual Achievement of Safety & Productivity

Researchers often attempt to show a positive relationship between a safety intervention and the productivity of a work crew using long-term analyses. For example, Hare and Duff (2006) conducted a study for the U.K. Health and Safety Executive and found that losses in productivity were higher with safety violations than with preventive safety. Hinze and Applegate (1991) found similar evidence concluding that safety management has a positive influence on productivity because injuries reduce task achievement to zero for the entire crew for several hours, there is a long-term decrease in productivity of the injured worker, there is often associated damage to equipment and materials and time must be spent on required record-keeping, accident investigation and training. Building on this work, Shikdar and Sawaqed (2003) and McLain and Jarrell (2007) studied the relationship between safety and productivity from a management perspective and concluded that companies with more safety problems consistently resulted in lower rates of productivity.

Hinze (2006) provides additional theoretical support for the direct relationship between safety and productivity with his Distraction Theory, which postulates that a worker will have a higher rate of task achievement if the distractions from a known hazard are minimal and the rate of task achievement is minimal when there is a high level of focus on the distractions posed by the hazards. This theory points out that productivity is compromised when the distraction due to hazards is high and that safety risk must be mitigated in order for safety and productivity to be simultaneously improved.

In addition to the relatively large body of literature that argues how safety and productivity are positively related, some literature discusses the tradeoffs. In their study of managers' perceptions, Choudhry and Fang (2008) found that managers believe that there is not enough time to perform work safely and that safe work practices decrease productivity. Similarly, Evans, et al. (2005) studied employees' perception of productivity climate and found that workers who perceived a stronger climate for productivity reported higher numbers of accidents. Of the 526 surveys more than half of the respondents believed that productivity and safety should be viewed as tradeoffs because emphasis on productivity increases risky behavior. The impacts of schedule pressure have been studied by others as well. Hinze and Parker (1978) concluded that schedule pressure increases injury rate, and Probst, et al. (2007) found that workers would often cut corners on safety performance in order to be more productive for fear of losing their jobs.

Choi, et al. (2006) systematically demonstrated the amount of lost productivity that occurs when workers use a personal fall arrest system in residential roofing operations. Researchers observed twelve properly trained male volunteers and tracked productivity before and after the initiation of fall protection systems. Once the fall protection systems were instituted, productivity reduced dramatically. The subjects used up 6.8%, 9.1% and 11.2% of their 2-hour production time for adjusting the lanyards at 18°, 26° and 34° slopes, respectively. A large amount of time was also spent on adjusting the personal fall arrest lanyard, which translates into a decrease in effective work and an increase in essential contributory work (i.e., lost productivity).

Only one study tracked the short-term and long-term productivity impacts of a safety intervention.

Maudgalya, et al. (2008) studied the impacts of instituting a multifaceted safety program on productivity, quality and cost performance. The study found that there was a strong negative correlation between safety and productivity when new strategies were first implemented. Over time, however, the correlation became positive and, after several months of using the new safety strategies, there was a 66% increase in productivity and a 44% increase in quality. They also found that companies that have a formal process for building safety into new projects at the design stage, during installation and at start-up discover both safety and productivity improvements more quickly. The safety efforts with the greatest short-term productivity gains are housekeeping improvements, safety orientation and training and PPE.

To summarize, the major findings from literature are as follows:

- The introduction of a safety intervention generally results in short-term decreases in productivity resulting from time associated with performing the safety management tasks or using PPE and long-term increases in productivity resulting from fewer distractions and delays due to injuries.
- The fewer distractions on site, the higher the productivity.
- The more attention paid to productivity, the higher the potential for an injury.

•The more attention paid to a hazard, the lower the potential for an injury.

•Organizational learning, communication and teamwork increase both safety and productivity when efforts are focused on improving existing procedures.

To enhance learning in an undergraduate Civil Engineering course, a simulation exercise was created, which includes a hands-on experience that effectively demonstrates the relationship between safety and productivity. Simulation exercises are highly effective for enhancing psychomotor, professional and social skills in a consequence-free environment (Boehrer & Linsky, 1990; Christensen, 1991). The exercise was created to specifically highlight the salient findings from literature and is designed to be completed in one and a half 50-minute class periods (approximately 75 minutes of class time). The following sections describe the learning objectives of the exercise, the preparation requirements, instructions, discussion points, results and ability to meet desired learning objectives.

Learning Objectives

As a result of the activity and the associated discussion, students shall be able to:

1) Analyze the relationship between safety and productivity.

2.)Identify and communicate factors that influence safety and productivity performance during a construction task.

3) Identify and communicate factors that influence productivity.

4) Manage a group of individuals to achieve desired cost, schedule, safety and quality outcomes.

Instructions for the Simulation Exercise

Overview

The appropriate student-to-instructor ratio for this exercise is 1:10. However, successful initial implementation occurred in classes with up to 50 students. Instructors may accommodate more students by involving teaching assistants, graduate research assistants, industry representatives or other experienced individuals. The instructors' role in any application of this exercise is to explain the rules, to monitor the exercise and keep students focused, to lead the subsequent discussion and to assess the achievement of the learning objectives. The framework for implementation of this exercise is provided as Figure 1.

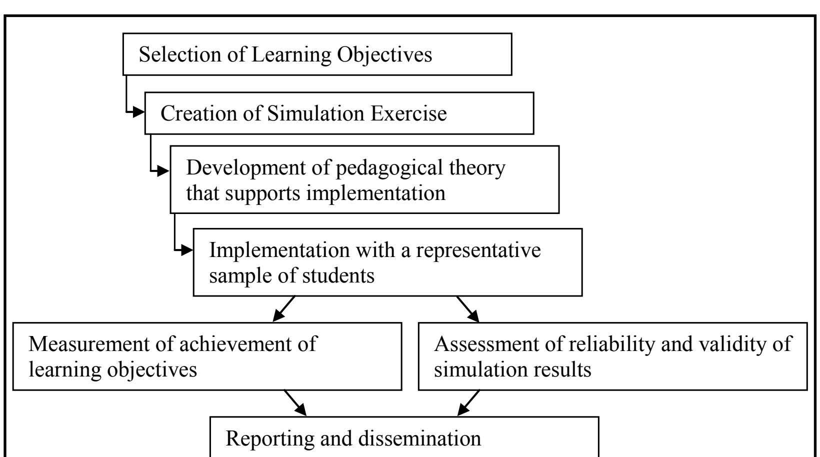

Figure 1. Research Framework

Preparation

The author suggests reviewing the importance of construction safety with the students prior to the exercise. Alerting the students to the relative frequency, magnitude and costs associated with construction industries can be enlightening, especially for students with little to no construction experience. Understanding the importance of construction safety is essential for students in introductory courses because some students tend to view safety management as a superfluous topic. The following statistics generally catch the attention of students who aspire to be project managers and project engineers:

•The construction industry accounts for a fatality rate that is five times greater than the all-industry average (NSC, 2006),

•The fatality rate is as high as 13 per 100,000 workers in the European Union (Carter & Smith, 2006).

•In 2004, there were 1,194 fatalities in the U.S. and the average direct cost of each of these fatalities was approximately $1,150,000 (NSC, 2006).

•Construction injuries account for more than $15.6 billion in lost revenue each year in the U.S. alone (NSC, 2006).

•The total cost associated with construction accidents accounts for 7.9% to 15% of the cost of new, nonresidential projects (Everett & Frank, 1996), and the average workers' compensation costs are estimated to be about 3.5% of the total project cost (Coble & Hinze, 2000).

In addition to covering this material in the classroom and providing real-life example of the impacts of injuries on workers, families and companies, the instructor must hold a brief conference with any other instructors who will be involved and assemble the required materials for the exercise.

Materials Needed

The materials required to implement the exercise are readily available and relatively inexpensive. For every 20 students, an instructor will need: (2) 10 ft x 15 ft tarps, 8 tennis balls, 2 stopwatches, 2 pens and recording sheets with randomized team assignments.

Instructions

Every 20 students should be randomly organized into five groups of four. Teams are then paired and each pair is given one 10 ft x 15 ft tarp, four tennis balls, a stopwatch and a recording notebook that includes written instructions and a worksheet for recording the results of the exercise. A sample form is provided in the appendix of this paper (p. 9). To prepare for the exercise, the pairs are instructed to lay the tarp out flat and stretched out. Once the pairs have their materials, one of the teams in each pair is assigned as the "work" team and the other as the "hazard" team. These roles alternate so that each team serves as the hazard team and the work team once in each round.

During each round, the work team is instructed to stand on the tarp. The instructor must inform the work team that their task is to flip the tarp and have all five members of the team standing on the other side as quickly as possible without having any member step off of the tarp. If a member steps off of the tarp and touches the ground, the team must freeze for 20 seconds. This is a relatively challenging task that may take teams up to two minutes to achieve. The objective of flipping the tarp and the associated penalty for touching the ground remains constant throughout the eight rounds. During each subsequent round, a new rule or condition is introduced. The purpose of these successive rounds is to produce an experience for the students that illustrates the importance of communication, planning, learning, hazard predictability and risk leveling. The specific rules and conditions of each round are discussed below and are summarized in Table 1.

Round	Directions
1	No hazards
2	4 hazards randomly lobbed
3	4 hazards randomly lobbed; no communication among work team members
4	8 hazards (hazard team members can throw their ball twice)
5	8 hazards, no communication
6	4 hazards, lobbed at predefined intervals
7	4 hazards, lobbed at predefined intervals from known locations
8	No hazards

Table 1. Rules

Round 1

For the first round, the work team must meet the general objective of flipping the tarp while the hazard team records the time of the work team and learns from the other team's mistakes. This round serves as the baseline to which the results and experiences from subsequent rounds are compared. Once the work team has successfully achieved their task, the teams switch roles and repeat the exercise.

Round 2

After both teams have implemented one round, "hazards" are introduced to the exercise. For the second round, the work team is informed that there will be four "hazards" on site represented by the four tennis balls held by the hazard team. The task for the work team remains the same as the first round; however, the hazard team is now instructed to lob the balls toward the tarp while the work team is attempting to achieve their task. Four of the five hazard team members are instructed to lob the tennis balls while the fifth member records the number of failed catches and the time taken by the work team to achieve their task. The throwing members of the hazard team surround the tarp with one member at each edge and may lob their ball at any time. Once a ball has been thrown, it cannot be thrown again. If the work team is able to catch the balls, there is no penalty. If the work team fails to catch a ball that is lobbed, they must all freeze in place for 20 seconds. It is important for the validity of the exercise that the hazard team makes their throws catchable. This can be difficult for the instructor to manage when students are overzealous.

Round 3

The instructions for round three are the same as for round two with one notable exception: the members of the work team are not allowed to speak to one another during play. Speaking during play results in a 20-second penalty added at the end of the round.

Rounds 4 & 5

In the fourth round, the instructions are the same as for round two except that the hazard team is allowed to lob eight balls toward the tarp during the exercise (each member may throw his or her ball twice). Again, the balls may be thrown by the hazard team members at any time during the round. The fifth round is the same as the fourth, but the work team is not allowed to communicate during the fifth round.

Round 6

The sixth round involves a different relationship between the work team and the hazard team. In this round, there are four hazards (i.e., the hazard team members can only throw their balls once), and they can only throw a ball once every 15 seconds. The timekeeper informs all team members when the time interval has been reached, and the hazard team member assigned to that interval throws their ball. The work team is informed of this interval but not of the location from which the ball will be thrown.

Round 7

The seventh round is the same as the sixth with the exception that the balls must be thrown in counterclockwise order by the hazard team at 15-second intervals. During this round, the hazard team members must stand on their assigned edge of the tarp and behave predictably.

Round 8

The eighth and final round is the same as the first round as there are no balls thrown, and the work team is encouraged to communicate freely. This round serves as a comparison round that demonstrates the level of learning from the beginning to the end of the exercise.

Discussion Points

The eight rounds generally take 30 to 40 total minutes. Following the exercise, the class should be asked to brainstorm parallels between the construction work and the exercise. Identifying these parallels is an essential aspect of the activity as it enlightens the students and encourages learning and internalization of the experience. Immediately following the exercise, the author asked the student teams to brainstorm the various elements of construction sites that the activity simulates. Dur-

Exercise Element	Simulated Aspect of the Construction Environment
Rate at which the tarp is flipped	Productivity
Thrown ball	Dynamic hazard
Number of times balls that hit the tarp	Number of accidents
Catching the ball	Near miss
Predictability of the balls	Predictable hazards and effective management
Concentration of the balls	Concentration of construction hazards
Time spent discussing strategy	Planning
Time spent watching other teams	Learning
Communication on tarp	Communication among workers

Table 2. Parallels to Actual Construction Environments

ing these discussions, students should identify the parallels to the "real world" listed in Table 2.

The instructor should use his or her professional experience to add rich examples to the discussion. The author has also found that involving a guest speaker from industry to assist with the implementation of the exercise and subsequent discussion adds significantly to the quality of the exercise. In the class period immediately following the day of the exercise, students should be assessed to determine the level of achievement of the learning objectives. The following section of this paper presents the results from implementation of this exercise with more than 300 students.

Results From Implementation

To assess the achievement of the learning objectives, three different assessment strategies were implemented over the course of three years of implementation. In the first year, students were given an unannounced quiz two days following the exercise. To recall, students participated in the exercise and were asked to draw parallels between the exercise and the industry. In this quiz, students were asked to describe how safety and productivity are related and the various factors that affect the complex relationship. Students were directed to provide at least three examples that they learned from the simulation exercise. This method of assessment specifically addresses the first learning objective, which is appropriate for introductory-level construction courses for students with little to no construction experience.

In year two, the group of 110 students was divided into two groups of 50 students. In one class, the safety and productivity simulation exercise was implemented and in the second section, a traditional lecture format was used. To assess the difference in achievement of learning objectives between the two modes, pairs of students in both sections were asked to identify as many of the following as possible in three minutes: 1) factors that affect safety; 2) factors that affect productivity; and 3) strategies that influence both safety and productivity. The results were then statistically compared using a Wilcoxon Rank Sum test. The final assessment strategy involved traditional student ratings where the students were asked to rate the ability of the exercise to meet the stated learning objectives and to rate the value derived from the exercise. These three methods of assessment were triangulated to provide a holistic view of the efficacy of the simulation as an alternative to traditional lecture.

Achievement of Learning Objectives

The most important measure of success of the activity is its ability to achieve the desired learning objectives. As previously indicated, the achievement of the learning objectives was assessed in three different modes. The first, which was conducted after the exercise had been implemented with 76 students, involved an unannounced quiz. The results of the quiz indicate that the learning objectives were achieved. Fifty-one of 76 students (81%) provided at least three examples that met the learning objectives. The average number of examples per student was 3.17. The students adequately described the impact of communication (86%), planning (47%), learning (34%), increase in hazards (55%), predictability of hazards (74%) and risk leveling (21%) on the safety-productivity relationship.

Though the initial learning assessment provided moderate evidence of success, the author desired to evaluate the difference in achievement between the simulation exercise and traditional lecture. As discussed, a statistical comparison between two delivery modes, lecture and simulation, were tested. In total, 42 student pairs (i.e., 84 students) participated. The results, presented in Table 3, indicate that, on average, student pairs whom we taught the safety-productivity relationship with the simulation exercise were able to identify and describe 1.25 (31%) more strategies that affect both safety and productivity ($p = 0.08$). With respect to identifying individual safety and productivity factors, there was no statistically significant difference in the sample means, which indicates that the simulation exercise is as effective as the traditional lecture mode for the delivery of this material. In summary, the statistical analysis indicates that the simulation exercise outperformed or was comparable to the traditional lecture mode for each major learning objective.

Delivery	n	Safety Factors	Productivity Factors	Safety & Productivity Strategies
Traditional Lecture	20	6.50	4.05	2.75
Simulation Exercise	22	6.18	4.32	4.00
p-value		0.64	0.78	0.08

Table 3. Statistical Comparison of Factor Identification

The third and final assessment of learning objectives was performed using student ratings. Much research has shown that student ratings of learning achievement correlate well with actual achievement of learning objectives. In the third year of implementation, 95 students were asked to complete an assessment survey within the three days following the survey. Eighty-one surveys were returned resulting in a response rate of 85%. The results, presented in Table 4, indicate that the overwhelming percentage (77%) of students either agreed or strongly agreed that the learning objectives were achieved with the simulation exercise. The only learning objective that received a neutral rating was the ability of students to manage groups of individuals to achieve desired outcomes. This is not surprising since the activity is rather abstract and involves only

Achievement of Learning Objectives	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This exercise increased my ability to analyze the relationship between safety and productivity.	0%	0%	4%	77%	20%
This exercise increased my ability to identify and communicate factors that influence safety performance during a construction task.	0%	4%	15%	55%	27%
This exercise increased my ability to identify and communicate factors that influence safety and productivity performance during a construction task.	0%	1%	16%	54%	29%
This exercise increased my ability to manage a group of individuals to achieve desired cost, schedule, safety and quality outcomes.	1%	10%	42%	41%	6%

Table 4. Student Ratings of Learning Achievement

theoretical parallels.

In addition to assessment of learning objectives, students were asked to rate several indicators of the value and quality of the activity. As one can see from Table 5, more than two thirds of the students strongly agreed or agreed that the exercise made learning about safety interesting, helped with retention, increased interest in the subject matter, increased knowledge of the subject matter and contributed to the completeness of their education. Additionally, 83% of students indicated that they would prefer the simulation exercise over traditional lecture.

Validity, Reliability & Stability of the Simulation

Though there was strong evidence for the achievement of learning objectives, it is also very important to recognize the importance of the validity, reliability and stability of the exercise. If the simulation does not accurately simulate a construction environment, the quality of the simulation would be compromised. To analyze the outcomes of the activities over the course of over 40 iterations, several items were recorded for each round (see Appendix 1 for recording form). With these data, several statistical tests could be performed and significant results were obtained.

First, T-tests were used to test for differences in sample means as the data were approximately normal, the F-tests confirmed equal variance and the data were independent. When teams were allowed to talk, they were 20% more productive (i.e., took 20% less time to flip the tarp) and had 4 fewer "accidents" ($p < 0.05$). When hazards were predictable (i.e., the balls came from prespecified locations at known intervals), teams were 12% more productive and had 288% fewer accidents ($p < 0.01$) and when hazards were spread out in regular intervals, teams were 53% more productive ($p < 0.05$) and had three times fewer injuries ($p < 0.05$). Finally, the trends in productivity were positive and the number of accidents was negative as subsequent groups participated in the activity indicating that subsequent groups were learning. Though these results are not essential to the activity, the stability indicates that the activity is reliable when conducted as described.

Value Derived	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This exercise made learning about safety interesting.	0%	1%	6%	22%	70%
This exercise will help me remember safety and productivity concepts after graduation.	0%	1%	15%	40%	44%
This exercise increased my interest in the subject.	1%	2%	28%	44%	24%
As a result of this exercise, I feel knowledgeable about the subject matter.	0%	5%	13%	61%	21%
This exercise contributes to the completeness of my education.	0%	2%	9%	48%	41%
I would rather have learned this material through traditional lecture.	44%	39%	5%	6%	6%

Table 5. Student Ratings of Learning Achievement

Student Feedback

The final component of each year's simulation exercise involved obtaining feedback from student participants through an open-ended question. First, students were asked to comment on the aspects of the activity that they found to enhance the learning experience. These commendations were obtained anonymously so as not to bias the feedback and were collected via an online survey. Representative commendations are provided for reference in Table 6. As one can see from these comments, there are residual benefits from the activity, including team-building, engagement and encouragement for lifelong learning. All statements provided in Table 6 are direct quotations from actual students.

In addition to commendations for the activity, students were also asked for criticisms and recommendations for improvement as a part of the online survey. Sample feedback is provided in Table 7. The criticisms and associated recommendations generally involved class size (with a smaller class size being preferable), selecting an activity day with better weather, increased introduction prior to the activity, more student-led discussion, allowing student groups to brainstorm and simulate their own selected environments, increased emphasis on leadership, discrimination among hazard types and team continuity. As with Table 6, Table 7 includes only direct quotations from actual students.

Limitations

The limitations associated with this exercise must be recognized. First, the achievement of the learning objectives for this exercise rests largely on the instructor's ability to spur interest in safety and productivity prior to the exercise, to keep the class focused and serious and to lead and enhance the discussions that follow. In the author's experience with the exercise, students may become distracted or lose focus if they are not engaged. For this reason, it is recommended that one instructor supervise no more than two pairs of teams during a class period. This ensures that no students are idle. Second, the technique does not illustrate the impact of an injury to the worker, the worker's family, crew morale, financial stability, etc. The

"It was fun to go outside and participate in an activity, and I paid attention more than I would in a lecture where it is easy to zone out."

"In traditional settings, it is easy to become distracted and to drift away from the material presented. This method, however, keeps students engaged without them really even knowing that they are learning the material, all while having fun and building relationships with their peers."

"The safety and productivity activities were a lot more helpful than learning the required materials in the classroom setting because it forced the people who participated to think about what they had to do in a certain timeframe and allowed for the communication in the groups to flow smoothly. Performing the activities in the groups allowed everyone to communicate and possibly the chance to break out of their shells."

"The activity really got some points across, such as the negative impact of overcrowding and problems connected to lack of strong leadership in a project."

"The activity was much more engaging than a traditional lecture setting. Activities and projects similar to this help me commit these concepts to memory much better than trying to recall information from a text or lecture. I enjoyed it and feel it helped me understand the factors that affect productivity on a worksite."

"I love the fact that we used hands-on techniques to learn about safety and productivity. The activity did a very good job of showing how productivity and safety relate. When worrying about safety, the task at hand was much harder to perform and created an extra challenge for the group. Also communication was a big factor. The groups that had a plan going into it and talked through the process seemed to have better results. This shows that when doing an activity, great planning can go a long way and can improve the productivity and safety of a job site."

"I feel that this activity helped me learn far better than traditional lectures do. Since I learn better by doing rather than by listening and I have a tendency to zone out during traditional lectures, this was very helpful in keeping my attention in what could have been boring subject matter."

"It is a nice change to be able to get out of the classroom and to participate in interactive learning activities. Moving around, away from the typical desk lecture situation, makes it a lot easier to stay awake and interested in the topic. I would definitely enjoy classes more if these types of activities were incorporated by more professors to reinforce material."

"This activity worked because it presented the same scenario in many different circumstances. Each circumstance showed differently the relationship between safety and productivity. It was quite effective."

"This activity allowed me to make my own hypothesis about what the outcome of the different hazard scenarios would be. It was a fun activity, but it also encouraged critical thinking throughout."

"The activity helped me actually want to learn, as it was engaging and required me to think about what was actually happening. By doing and seeing firsthand the different consequences of certain activities, it was made apparent how safety and productivity play their roles on the construction site."

"I thought this activity was very fun while still educational. It was a different approach to teaching safety and productivity. This activity helped me learn the material in a fun way, instead of listening to a boring lecture."

"We could have covered this information in the classroom using the board as most concepts are covered. However, I do not think the information would have made as much of an impact on the students. This activity was involved and effective in teaching this information."

Table 6. Representative Commendations of the Activity (Direct Quotations)

exercise only addresses the relationship between safety and productivity. For this reason, this exercise may not be appropriate when there is little time to address safety in a particular course. Finally, this exercise must be implemented outdoors or in a large open space. If such space is not available or if weather is poor, the exercise may be difficult to implement.

Conclusions & Recommendations

One of the more complex topics to cover in construction engineering and management courses is the relationship between safety and productivity. In addition to the technical challenge, traditional delivery of safety-related material in engineering courses can be superficial, boring and disengaging. Analysis of three years of implementation of the safety and productivity simulation exercise with more than 300 students indicates that the activity is an effective alternative to traditional lecture. Three different learning assessment strategies were used to evaluate the effectiveness of the activity with respect to the achievement of predefined learning objectives. The triangulation of the results indicates that there is strong evidence that the simulation is as good as or better than traditional methods in the courses tested. Finally, student responses to open-ended questions indicate that there are many residual benefits to the simulation and creative recommendations for future improvement.

When integrating this activity into a course, the author suggests preceding the activity with an interactive lecture to develop and spur excitement in the topic. Leading with an engaging lecture on the impact of safety and productivity on business performance and the need for creative professionals who can manage complex and dynamic worksites will ensure that students appreciate the value of the activity. When implementing the activity, the instructor may wish to engage graduate students who have aspirations for academic positions. This strategy is an alternative to the traditional lecture and in-class activities that may encourage new faculty members to consider experiential learning strategies that challenge the traditional pedagogy.

The strong results of this study indicate that simulation can be an excellent alterna-

"Smaller groups might be a good idea to show safety and productivity on a smaller scale."

"Obviously, the weather was a factor out of our control, but it strongly impacted the 'smoothness' of running the activity. I think that it was a good activity that really got the point across, however, it was a little bit repetitive. I think that if there was a way to speed up the activity and to do it in fewer rounds, it would have been just as effective."

"Including one more tarp may have been beneficial so that not as many people would have been just standing around."

"Ask students what is being symbolized through the activities at different points in time."

"Make sure that the activity is done on a good day. The day we had ours, it was extremely windy and hard to communicate to get the whole idea of the activity."

"Allow the students more room to make decisions and for conclusions about how changing the hazards can allow them to get the job done faster. I think established groups (not changing groups), competitiveness between the two groups and a greater focus on the group talking about what factors they could change to get the job done faster would improve this activity."

"It would have been interesting to see how the productivity and safety would have changed when there is a single leader directing people."

"I suggest that a little more work be done in the class before the activity so we can go in thinking about these concepts and how they apply to what we are doing."

"Distinguishing between the different types of hazards could be a little clearer. You could use different colored balls or have something have a larger penalty than another."

"The process was fun and engaging; I think it would work better with a smaller class size so that there are less idle people standing around. Really easy to get distracted or miss the point if you are not directly involved. Basically, it works well if everyone can participate and the group is cooperative and attentive when correlations are drawn between the activity and real life. If people start to get distracted or off track, it is hard for the rest of the group to stay on point."

Table 7. Representative Suggestions for Improvement (All statements are direct quotations from actual students)

tive teaching strategy when implemented properly. The author recommends future research that investigates the use of simulation in other areas of constructions safety education and the application of simulation during orientation or training sessions by practicing professionals. Additionally, pedagogical researchers are encouraged to validate the findings by applying the strategies presented in this paper in new academic environments.

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Acknowledgements

The author would like to acknowledge the students who enthusiastically participated in these exercises and the colleagues who have implemented this activity in their classes and provided feedback.

Round 6
4 hazards, lobbed at 15-second intervals

Team member names

1 ____________________

2 ____________________

3 ____________________

4 ____________________

5 ____________________

Total time to complete (seconds)	
Total number of failed catches	
Total number of mistakes (steps off from the tarp)	

Observations of team performance

Suggestions for improvement

Appendix 1. Example Recording Form

Externally Reported Occupational Health & Safety Data Among U.S. Manufacturing Firms

By Michael Behm & Arthur Schneller

Abstract

Occupational health and safety (OHS) metrics, a component reported in sustainability's social dimension, have largely been ignored in peer-reviewed literature. We evaluated the externally reported OHS metrics from the top 50 manufacturing firms from IndustryWeek's Top 500 firm list in 2009. The purpose of this research is to explore, describe and quantify the extent that OHS is utilized as an externally reported metric among leading manufacturing firms and to recommend future directions and research within the topic. We find that firms are primarily reporting injury and illness statistics and qualitative information about policy and management systems. The business value of OHS is largely ignored. The public and consumers of externally reported OHS data must be mindful of "worker washing," a parallel concept to "green washing." We introduce this term in this paper for broader consideration and suggest this as a professional ethics issue for OHS professionals. The results of this research will assist organizations to operationalize, measure and report OHS and sustainability metrics. Additionally, consumers of externally reported OHS data will be able to make better decisions about the quality and type of data reported. Areas for future research are recommended.

Keywords

Corporate social responsibility, sustainability, occupational health and safety, metrics, benchmarking

Introduction

Over the past decade, companies have been increasingly capturing and formally reporting sustainability and social responsibility data to external stakeholders in environmental, economic and social aspects. Sustainability reporting is now the norm, not the exception, among the world's largest companies (KPMG, 2008). Several research endeavors have focused on quantifying environmental aspects in sustainability reporting (Cerin, 2002; Williamhurst & Forst, 2000; Beets & Souther, 1999; Hackston & Milne, 1996; Gray, et al., 1995). The investigation of the combination of social and environmental reporting has increased in recent years (for example, see Mitchell & Hill, 2009). However, a small group of researchers has claimed that the sustainability reporting is too narrowly focused on the environment while ignoring important social aspects (Gilding, et al., 2002; Newport, et al., 2003), such as occupational health and safety (OHS).

We find few specific research endeavors that evaluate OHS metrics reported within sustainability or corporate social responsibility (CSR). Some research studies include OHS but only the extent to which injuries and illnesses are reported; we will discuss the limitations of these measures later. Previous research evaluated construction companies' external OHS reporting and found that construction firms are largely ignoring OHS as a metric within CSR and sustainability (Behm & Veltri, 2008). Montero, et al. (2009) provide an exploratory study of the relationship between CSR and OHS by examining common international CSR tools and instruments.

The purpose of this research is to explore, describe and quantify the extent that OHS is utilized as an externally reported metric among the top 50 IndustryWeek manufacturing firms and to recommend future directions and research within the topic. We expect the results to provide an improved understanding of the value of voluntary and transparent sustainability reporting. The results should help organizations as they go about formulating a strategy for sustainability implementation and reporting. Investment firms are also interested in OHS performance. Goldman Sachs (2007) found that Australian investors could have profited using OHS measures as a signal for an investment strategy. This strategy can extend to supply chain relationships, which can be enhanced and assured they are in line with sustainable principles, and can lower the risk of supply chain disruptions due to OHS issues.

Methods

OHS is a component of the social dimension within the construct of sustainability. There is no doubt that concern for the well-being of employees should constitute one of the main aspects in any firm's CSR (Montero, et al., 2009). We found four guidance documents in the literature that specifically provided recommended practices for external OHS reporting.

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OHS Reporting Guidance

The Global Reporting Initiative (GRI) is "a network-based organization that has pioneered the development of the world's most widely used sustainability reporting framework and is committed to its continuous improvement and application worldwide" (GRI website, 2010). "Workplace safety and health is recognized within GRI," notes Kathy Seabrook. "Therefore, we as safety professionals are part of the triple bottom line" (ASSE, 2009). The four performance indicators listed by GRI related to OHS are:

1) Rates of injury, occupational diseases, lost days and absenteeism and total number of work-related fatalities by region.

2) Education, training, counseling, prevention and risk control programs in place to assist workforce members, their families or community members regarding serious diseases.

3) Percentage of total workforce represented in formal joint management-worker health and safety committees that help monitor and advise on OHS programs.

4) Health and safety topics covered in formal agreements with trade unions.

The Australian National Occupational Health and Safety Commission (NOHSC) (2004) and the Royal Society for the Prevention of Accidents (RoSPA) provide guidance documents related to the contents of externally reported OHS metrics. Epstein and Roy (2003) provide an evaluation strategy to determine the extent that OHS is integrated into the core business strategy or the organization. We have utilized these three documents previously and found that the RoSPA guidance was a bit cumbersome to categorize; its general components are also integrated within the Australian NOHSC guidance. We also determined the Australian NOHSC guidance to be inclusive of GRI performance indicators. Therefore, for this research endeavor, we utilized the Epstein and Roy guidance and the Australian NOHSC guidance as the categories to evaluate the contents of externally reported OHS metrics. We also searched for the presence of OHS management systems reported. Management systems, such as ANSI Z10, OHSAS 18001 and OSHA's Voluntary Protection Programs, are increasing in popularity.

Company Selection

Companies were chosen from *IndustryWeek's* U.S. 500 found at http://www.industryweek.com/research/us500/2009/iwus500rank.asp. This is *IndustryWeek's* report on the 500 largest manufacturing companies based on revenue, which are publicly held. The top 50 companies on this list were selected for this research. The types of industries varied; see Table 1 for the list and distribution of the companies on the list. Content analysis was utilized to gather OHS reporting data in annual reports and from company websites relating the content to the details and guidance categories. This form of data collection has been completed previously with environmental reporting in accounting research (Williamhurst & Forst, 2000; Hackston & Milne, 1996; Gray, et al., 1995).

Industry (as classified by *IndustryWeek*)	**N**
Petroleum & Coal Products	10
Computers & Other Electronic Products	7
Pharmaceuticals	4
Chemicals	4
Aerospace & Defense	4
Food	3
Motor Vehicles	2
Metals	2
Machinery	2
Electrical Equipment & Appliances	2
Beverages	2
Publishing & Printing	2
Miscellaneous Manufacturing	2
Tobacco	1
Railcars, Ships & Other Transportation Equipment	1
Paper	1
Communications Equipment	1
Total	50

Table 1. Industries in the *IndustryWeek* Top 50

Results

Australian National Occupational Health & Safety Commission

The Australian NOHSC (2004) provides guidance on specific items organizations should include in their OHS section of a financial, sustainability or social responsibility annual report. Specific recommended items include policy statement, CEO statement, safety statistics, safety goals, how the organization manages OHS, contribution of employees, training, OHS program and initiatives, awards, contribution to industry sector OHS, description of OHS incidents, how OHS is integrated into business planning and any employee health surveillance programs. We utilized all 13 recommendations as guidelines and during the review of the manufacturing firms' websites and annual reports made a yes/no determination whether they were reporting on these criteria. For the 50 companies evaluated across 13 components, there were 650 possibilities for a yes/no designation. One-hundred and fifty-eight (24.3%) yes responses were recorded out of a possible 650. The results, as a ranked order, are shown in Table 2.

Safety statistics and indicators were the most frequently reported metric. Sixty percent of the companies reported safety statistics and 26% reported safety goals or targets. These were injury and illness rates and sometimes fatality numbers or rates. However, consumers of externally reported OHS data should be skeptical of these numbers. The issue of underreporting such statistics has evolved into a national problem with no real solution. In 1988, the U.S. General Accounting Office reported that employers may deliberately underrecord injuries in response to incentives, such as OSHA inspection policies or employer

Component	Yes	No	% Yes
Safety statistics and indicators	30	20	60
OHS policy statement	24	26	48
Description of how firm manages OHS	22	28	44
Description of OHS programs and initiatives	21	29	42
CEO statement on OHS	16	34	32
Description of OHS training	16	34	32
Safety goals or targets	13	37	26
OHS awards	9	41	18
Description of significant OHS incidents	6	44	12
Employee health surveillance programs	1	49	2
Employee contributions to OHS	0	50	0
Contribution to OHS in their industry	0	50	0
How OHS is integrated into the business	0	50	0
Totals	158	492	24.3

Table 2. Results of the 13 Recommended Elements for OHS Reporting (in ranked order)

safety competitions. Further, employers may also misunderstand what needs to be recorded since accurate recordkeeping is not a high priority for many employers (GAO, 1988). Twenty years later nothing had changed with regards to injury and illness underreporting. The U.S. House of Representatives (2008) suggests that underreporting may be between 33% and 69% nationally. The report suggests that employers' incentive to underreport include decreasing the chance of being targeted for an OSHA inspection, decreasing workers' compensation expenses, internal and external business incentives and to look good to shareholders, customers and the local community. This should be of concern to readers of CSR reports. It should also be of concern to organizations that develop social reporting indices.

It is interesting that none of the companies discussed employee contributions to OHS. Montero, et al. (2009) also found few references to workers' rights in their content analysis of CSR principles and codes, certification schemes, reporting frameworks and rating indices. If internal stakeholders (employees) are a customer of externally reported data, firms should consider methods to include employee contributions. Meaningful employee constitutions are a valuable part of organizations' overall safety culture.

We also analyzed the aggregate data on a company basis. Thirteen companies (26%) reported no OHS information; this was the mode. One company reported 9 of 13 possible recommended OHS metrics. The mean number of yes responses per company was 3.16; the median was 3.0. The majority of firms are not reporting OHS metrics to the extent they could. Table 3 summarizes the aggregate sum of yes responses for the 50 companies.

Number of Yes Responses (out of 13 possible)	Frequency	Percentage
0	13	25
1	5	10
2	6	12
3	4	8
4	3	6
5	7	14
6	6	12
7	3	6
8	2	4
9	1	2
Total	50	100.0

Table 3. Summary of Yes Responses per Company

Dow Jones Sustainability Index Companies

The Dow Jones Sustainability Index (DJSI) was the first global index tracking the financial performance of the leading sustainability-driven companies worldwide (DJSI website, 2010). Twenty-five (50%) of the companies in the Industry-Week Top 50 manufacturing firms were DJSI companies. The DJSI questionnaire asks about OHS lagging indicators (injury/illness rates, fatalities and their tracking systems). Issues with these measures were discussed previously. We hypothesized that DJSI companies would be reporting OHS data and performance more so than non-DJSI firms. We find that the mean number of yes responses for companies on the DJSI list was 2.80 yeses, whereas the non-DJSI companies reported OHS elements at an average of 3.52. The difference is not statistically significant (p=0.35), but it is an interesting result. DJSI companies do not externally report OHS metrics to the extent when compared to non-DJSI companies. We infer that OHS is not a highly valued component of sustainability compared to environmental and other social aspects.

Linking OHS Metrics to Business

Epstein and Roy (2003) contend that sustainability measures must be explicitly linked to business performance or they will become meaningless and not integrated as important metrics. They provide guidance on categorizing "levels" of business integration for a variety of sustainability issues, including OHS. Four levels are described and range from "descriptive information not linked to financial performance" to "monetized information fully linked to financial performance." In their research, Epstein and Roy (2003) found that most companies do not make the strategic connection between occupational safety performance and financial performance.

Among the 50 manufacturing firms, 13 (26%) made no references to any OHS information and no level was assigned. Nine companies' (18%) reporting strategy can be classified as Level 1 or descriptive information not linked to financial performance. Twenty-eight companies' (56%) reporting strategy can be classified as Level 2 defined as quantified information not linked to financial performance. No firms could be classified as a Level 3 reporting monetized information partially linked to financial performance and likewise no firms demonstrated Level 4 strategy in their OHS reporting fully linking OHS to financial performance. These results are similar to Epstein's and Roy's.

This struggle to link OHS performance with financial performance is not limited to manufacturing. Colbert (2006) reported that the typical approaches and metrics of OHS professionals are too focused on regulatory aspects and that this minimalist type of philosophy is not congruent with sustainability. Rikhardsson (2004) reported that calculating occupational accident costs can illustrate and visualize the value created by the OHS department by preventing accidents, but that common accounting measures do not include OHS costs. The topic of linking OHS with financial performance, or making a business a case for safety, is becoming increasingly a topic of discussion among safety professionals. ASSE created a Business of Safety Committee with the goal of being a clearinghouse for information on how safety is linked with financial performance and how safety performance can be good for business (http://www.asse.org/bosc).

Reporting Methods

We evaluated whether the 47 firms that reported CSR/sustainability data were in the form of a PDF-style report, web-based data or in some combination. Three of the companies had solely PDF reports, 18 were web-based and 26 utilized a combination of PDF and web-based. The web-based materials could be updated more easily, whereas the PDF reports where annual reports. Rikhardsson, et al. (2003) discussed that the ease and availability of sustainability information is related to its importance; they found that to access social reporting from company webpages required an average of 2.75 clicks. In our sample, the average was 1.85 clicks; 21 (42%) were directly available from the company's webpage. The increased efficiency in the ease to access CSR data over the six-year period from 2003 to 2009 could indicate that webpages are becoming easier to navigate in general or that CSR and sustainability information is given greater importance. We believe that likely both are somewhat true.

Discussion

The data revealed that very few companies are reporting OHS information. When manufacturing firms are reporting, the amount is limited compared to available guidance. However, these guidance documents do not appear to be widely used and are not cited in the peer-reviewed literature or the practical business magazines. It appears that OHS is not an important factor in external sustainability reporting. On the other hand, a recent study of businesses and stakeholders in Hong Kong found that of 15 CSR rubrics, OHS was the number 2 ranked CSR priority next to environmental (Welford, et al., 2008). Either OHS is a stated priority but not practiced or there is a difference between perceptions in Hong Kong and in the U.S. Moreover, there may be a perception that external stakeholders are not interested in OHS, as OHS is an internal issue, rather than an external one. However, there is growing data-based evidence that good OHS performance, management and practices are linked with business value. We mentioned the Goldman Sachs report earlier. If OHS data can truly be used as an investment signal, then investors need valid, reliable and consistent data and firms need to understand how OHS contributes to performance. These are all areas for future research.

The issue of the credibility and quality assurance of externally reported sustainability data is not limited to OHS. Hodge, et al. (2009) describe the potential for transparency and trust-building within externally reports. Fonseca (2010) reports on the lack of attention to quality assurance among large mining companies in their sustainability reports. OHS professionals, and in particular ASSE members, must view their involvement in externally reporting as a matter of professional ethics. As a member of the Society, members shall "issue public statements in a truthful manner and only within the parameters of authority granted" (ASSE, 2010).

Gilding, et al. (2002) and Newport, et al. (2003) posit that sustainability reporting is too narrowly focused on the environment while ignoring important social aspects, such as OHS. Safety is an important component for companies who want to operationalize sustainability; Gilding, et al. (2002) recommend excellence in OHS as a starting point to truly understand sustainability. How can an organization satisfy external social needs in an exemplary fashion if it is not meeting and even surpassing its internal customers' health and safety expectations? Dentchev (2004) goes one step further and contends that OHS is so important that its measures are recommended to be utilized as a proxy for overall CSR performance. If manufacturing firms want to begin or enhance current sustainability initiatives, ensuring excellence in, and the reporting of, OHS is a critical component.

Lagging OHS indicators are those associated with measurements after an accident occurs, such as injury rates, experience modification rates, accident costs, etc. They are reactive measurements. Leading indicators are those measures, which are activity-based and are proactive measures, and, if researched and constructed adequately, are predictive of lagging indicators. The issues of validity and reliability of lagging indicators was described previously with regards to their accuracy in the desire to maintain a perfect safety record (U.S. GAO, 1988; U.S. House, 2008) and can be viewed as corporate rhetoric. Other research recognizing lagging indicators may not accurately reflect a firm's safety performance and can be misleading (O'Brien, 1998). This is due to the rare number of accidents or lagging indicators, which results in a low level of confidence. Toellner (2001) recommends using a combination of leading and lagging indicators as safety performance metrics.

We evaluated each company as to whether they were quantifying and describing OHS leading indicators. Surprisingly, we found none of the companies quantified leading indicators.

Many described activity-based initiatives, such as behavior-based safety and training, for which they received a yes in those categories as described previously. However, they are not quantifying the leading indicators. Compared to the firms, which quantified and tracked lagging measures, we hypothesized that at least some of the companies would be tracking and reporting leading OHS measurements. Developing appropriate, meaningful and valid leading OHS indicators to be quantified in CSR reports is an area of future research.

Recommendations

This formative research sets the foundation for future research regarding external OHS reporting. ASSE recently formed a Sustainability Task Force to assess "how we can advance our role in CSR and sustainability" (Patton, 2010). The results of this research can be utilized by ASSE and the task force as a baseline to measure the advancement of safety reporting within the realms of CSR and sustainability. Additionally, because the guidance documents reviewed are not cited in the peer-reviewed literature or the practical business magazines, this presents an opportunity for an organization such as ASSE to take the lead in developing and instituting clear, measurable and effective external OHS measurements. We recommend this as an area for immediate research and implementation.

Secondly, we recommend that external reporting on OHS within the broader topics of sustainability and corporate social responsibility be investigated more thoroughly. Although there is recent data-based evidence that OHS can have a positive relationship with business value in terms of employee morale (Behm, 2009) and operational measures and quality (Das, et al., 2008), the relationship has not been broadly accepted outside the OHS profession since the claims have been largely anecdotal. OHS is primarily viewed as a compliance-driven function and a cost of doing business. Future research should examine if and how OHS performance and management systems truly matter in terms of affecting business value. Linking OHS performance and data with stock price and other investment data should be investigated in the U.S., as was completed in the Goldman Sachs study in Australia. However, because the Goldman Sachs study did not clearly explain their research methods, we recommend a clear methodological approach be undertaken and fully disclosed so that businesses and readers can interpret the components that matter and so the research can be peer-reviewed.

Finally, firms and consumers must be mindful about forms of "green washing" since there is skepticism about voluntary disclosures and their intent (Ramus & Monteil, 2005). In the OHS realm, we label this "worker washing"; since we have not found this term in other publications, we introduce this new term here for consideration in broader use. Worker washing is exacerbated by the issues surrounding underreporting in injury and illness records discussed earlier. This, however, provides an opportunity for research into quality and auditing of OHS and social external reporting. Moreover, a focus on meaningful employee involvement in OHS would serve as a path forward for firms seeking to legitimize OHS endeavors in the broader social and financial arenas.

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Factors Affecting Grade Variation Between Graduate & Undergraduate Students

By Kimberly Criddle-Straughter & Magdy Akladios

Abstract

Safety and health courses are typically taught by instructors who are keen about the learning processes of their students. Instruction methods are typically the same for both graduate and undergraduate students. However, it has always been the case that graduate students' grades are typically higher than undergraduate students. Causes may be that the instructors are unconsciously teaching the courses differently. Therefore, to avoid inter-instructor variation, and to test other factors, a course was cross-listed with equal populations of graduate and undergraduate students. While the instructor was the same and class was held at the same time, graduate students still seemed to score considerably higher on exams and assignments than their undergraduate counterparts. This paper will analyze factors, such as gender, age and work experience, on the variation of grades. Also, the effects of combining undergraduate and graduate students in group assignments will be tested to determine if the graduate students influence undergraduate students.

Keywords

Grade variation, graduate undergraduate student grades

Introduction

Graduate students are typically expected to outperform undergraduate students. This may be due to the fact that admission requirements for graduate schools are usually higher and more rigorous than admissions into four-year universities. The minimum requirement for students in "good standing" in most graduate programs is to maintain a grade point average (GPA) of 3.0; whereas undergraduate students in good standing at most four-year institutions need a minimum GPA of 2.0. Also, graduate students attended college for four years so they are usually older than undergraduate students and more mature (Korvick, et al., 2008). Even if placed in the same curriculum, degreed students outperformed nondegreed students (Wilkinson, 2004). Kwon (1997) and McSpirit and Jones (1999) studied the correlation between students' age and their GPA, and again, confirmed that student age correlated positively with the noted increase of GPA.

Santos (1999) and Stahl and Paval (1992) defined "traditional" students as those who began their higher education immediately after high school (age range 18 to 24), whereas, nontraditional students are older (>24 years old). These are naturally more mature and tend to be more serious-minded than younger traditional students. Older students are, therefore, considered more focused concerning academics (McSpirit & Jones, 1999; Santos, 1999). However, these nontraditional students usually have other obligations, such as employment and family, whereas, traditional students are usually unemployed and do not have as many family obligations (Stahl & Paval, 1992). These differences may influence the students' values and goals when attending school. Younger students tend to spend more time doing traditional college activities, such as student organizations, partying and socializing with friends, whereas older students are more concerned with work and family responsibilities and are less likely to socialize in school (Santos, 1999).

Note that, however, some studies have shown that nontraditional students in their late 30s and 40s are at an academic disadvantage. Although nontraditional students may bring a unique experience to the classroom, eventually these students reach their plateau primarily due to family and work obligations, combined with out-of-practice study skills and difficulty incorporating new ideas with past experiences (Palmer, 1996).

Work experience is another factor believed to influence academic achievement. Before the mid 1990s, most students interested in a Master's of Business Administration (MBA) program would enter right after completion of college. Later, many universities started to require work experience as a prerequisite to gain entrance into their MBA programs. The assumption was that students with work experience are more likely better prepared for graduate school than those without (Dreher & Ryan, 2000; Sulaiman & Mohezar, 2006). Faculty believe that students with work experience are more likely to see the relevance and applications of the course work (Dreher & Ryan, 2000).

Gender has been a factor complicated by the historical lack of opportunity for women in universities a few decades ago. However, females now attend and graduate college at a higher rate than males. Before the 1960s, women were least likely to earn a college degree compared to men. In the 1980s, more women were enrolled in universities than men (Jacobs, 1995). By the 1990s, women received more university degrees than men (Ntiri, 2001). However, while males have always scored

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higher on standardized tests, females earned higher grades in school (House, 1998; Ntiri, 2001). In fact, historically, girls have outperformed males from grade schools through high schools. This may be due to the fact that girls, at an early age, were more self-disciplined than boys, and they focused and studied harder, and hence, made better grades than boys (Duckworth, et al., 2006). In addition, boys were less likely to seek help if needed, and these study habits transferred to college academics (Sax & Arms, 2008).

After the 1960s, female enrollment increased over male enrollment. This may have been due to the fact that more females entered the job market, a decrease of children in the family household and an increase in the divorce rate (Ntiri, 2001). Historically, academic and career choices for women were restricted due to gender stereotypes. Women with college degrees were more likely to choose "sex-appropriate" majors, such as nursing and education, whereas, men majored in engineering, mathematics and physics (Jacobs, 1995). Interestingly, today women attaining bachelor's degrees in these male-dominated subjects are more likely to continue on to graduate school than men (Sax, 2001).

Race and ethnicity were also factors found to be correlated to grades. Major ethnic groups in the U.S. today typically include Caucasian American (white), African American (black), Hispanic and Asian American. Although the progress of increasing minority students in colleges and graduate schools has been made over the past five decades since outlawing discrimination in schools, black and Hispanic students are still underrepresented in many colleges and universities (Kinzie, et al., 2008; Walpole, et al., 2002). This may be due to the fact that many minorities are first-generation college students or low-income students. These students are usually unfamiliar with college procedures and environment (Pizzolato, et al., 2008). Also, many of these students are ill-equipped or unprepared for college. African-American students at two-year colleges were twice more likely to require developmental courses than White students (Greene, et al., 2008). In addition, underrepresented parents may expect children to perform well academically; however, aspirations for their children may be lower due to perceived social alienation (Walpole, 2008).

However, unlike African Americans and Hispanic Americans, Asian-American students are not underrepresented in the post-secondary education system. In fact, Asians outperformed other groups, including Whites (Pizzolato, et al., 2008). Chinese Americans, for example, statistically outperformed Whites in math and science regardless of whether the student was born in the U.S. (Pearce & Lin, 2007). This suggests that there are cultural and behavioral differences that allow gains of higher academic success than the majority population (Pearce & Lin, 2006; Koa, 1995). However, it must be noted that there are diverse subgroups within the Asian community. In other words, there are Asian ethnic groups that follow the same academic trend as the underrepresented minorities.

In 2001, the number of international college students was about 547,867. Students from Asia made the highest percentage of international students in the U.S., followed by European and Latin American students (Constantine, et al., 2004). Previous studies suggested that mastery of the English language is necessary for academic success and the lack thereof may hinder success. In fact, it takes five to seven years for a non-English-speaking student to master language communication well enough for academic success (Light, et al., 1987). International students whose first language was not English are required to pass the Test of English as a Foreign Language (TOEFL) before being considered for graduate school. It is commonly believed that the international students with higher TOEFL scores will have higher academic performance. Since TOEFL requirements were usually higher for graduate school (550) than undergraduate (500), students tended to perform better (Johnson, 1988; Light, et al., 1987). Also, according to Johnson, prior exposure to the subject matter, experience, motivation, better study skills and cultural adaptation may be better factors of academic success than language proficiency alone.

Given the previously mentioned factors, this research will determine whether graduate students were in fact more academically successful than undergraduates. Then it will determine if graduate students did in fact influence undergraduate students' academic achievement by simply working together.

Materials & Methods

A survey questionnaire (22 questions) was administered to 19 participating volunteers. The survey and material were approved by the Committee for Protection of Human Subjects (CPHS) at the University of Houston-Clear Lake (UHCL). Grades data were also gathered for two cross-listed courses (courses that combined both graduate and undergraduate students), Fall 2008 INDH 4136 and Spring 2009 INDH 4333 semesters. The grades included student scores on coursework, group project, exams, homework and quizzes). The data were analyzed using statistical software, Minitab 15 and Microsoft Excel.

Procedure

A letter of consent and a survey questionnaire were administered to students after approval from UHCL's CPHS. The completed surveys were analyzed using Minitab 15 and Microsoft Excel. Grades collected from the Fall 2008 and Spring 2009 semesters were analyzed. ANOVA general linear model was used to statistically determine whether multiple factors had any significance on the grades earned. Paired t-test was used to analyze the test if there is significant difference in the grades earned by the students before and after the group project. The paired t-test is a statistical analysis used to compare two means of the same population in two different circumstances. Groups consisted of three to five individuals combining graduate and undergraduate students, except for one group, which consisted of only undergraduate students. This last group served as a control group.

Results

The survey group consisted of 19 students in INDH416 Spring 2009 at UHCL. The class was a cross-listed course that included eight graduate students and 11 undergraduate students. Table 1 shows the distribution of student age in the class. Table 2 shows the class distribution by gender. Table 3 shows the class distribution by ethnicity. Table 4 shows the class distribution by experience.

The marital status of the survey group was three divorcees, five married and eleven singles. Two students were divorced with children, two students were married with children and one was a single parent who never married. The nationality of the students and their parents' background was also considered as a factor. Of all 19 students surveyed, only four had parents neither of which were U.S.-born citizens. Five were from families where at least one parent's highest educational level was a high school diploma. Eight participants had parents with at least one holding a bachelor's degree, five had parents holding a master's degree and one did not answer the question.

Students were also asked how many hours per week they spent studying. Two studied only one hour or less per week, eight studied two to three hours per week, six studied four to eight hours per week and three students studied more than eight hours per week. They were also asked how many hours they spent reviewing before a test. One student reviewed only one hour, thirteen reviewed for two to three hours, three reviewed for four to eight hours and only one student reviewed for more than eight hours before a test. When asked about class absenteeism, three students did not miss any days in the past academic year. Five students missed one day, four missed two to three days, two missed four to six days and four students missed more than six days of school during the past academic year.

Regarding consulting with their professors, one student did not consult at all during the past academic school year. Eight consulted two to three times, and five consulted three to five times. In addition, one student did not confer with any students or support group during the academic year. However, four conferred at least one to two times, four conferred three to five times and nine conferred six or more times during the academic year. Among the eight graduate students, only two of the students went directly from undergraduate to graduate school, and two felt that graduate school is more difficult than undergraduate. Among the 11 undergraduate students, six students plan to attend graduate school. It may be noted that all but one minority intends to further their academic career and only one Caucasian American student has plans to attend graduate school.

Survey Statistics

Using ANOVA general linear model, scores from the tests and final grades were used to statistically analyze whether the social factors (surveyed in the questionnaire) were significant to the students' academic performance (Table 5).

Based on the analysis, all p-values were greater than 0.05, with the exception of class level and economic status, indicating a significant effect on the final exam. Furthermore, absenteeism had a significant effect on the overall course grade (p-value <0.05).

The combined data from the INDH4333 Fall semester 2008 and INDH4136 Spring semester 2009 consisted of 32 grades for each test (there are three tests, including a final exam for each course), a project for each course and other assignments and quizzes. ANOVA general linear model was used to determine whether the abovementioned factors statistically affected the scores on the three tests and group project (Table 6). Note that class level for all three tests was a significant factor.

Excel software was also used to compare the mean results of Tests 1, 2 and 3 (final exam). Pearson's correlation and a paired t-test were used. The results showed that the means of Tests 1 and 3 were not significantly different, whereas, the means of Tests 2 and 3 were significantly different.

Also, scores from tests before the group project were compared to those after. The average of Tests 1 and 2 were used as test grades before the group project and were compared to Test 3 (Final Exam) grades after the group project. The results showed a significant improvement in the group project score. Overall performance on four key measures (Tests 1-2, project

Age Group (Years)	Number of Students
<24	2
25-34	11
35-44	2
45-54	3
55-64	1

Table 1. Distribution of Students by Age

	Gender	
	Male	Female
Graduate	2	6
Undergraduate	8	3
Total	10	9

Table 2. Distribution of Students by Gender

	Ethnic Background	Number of Students
Graduate	African American	1
	Caucasian Americans	7
Undergraduate	African American	1
	Caucasian Americans	5
	Asian Americans	2
	Hispanic American	3

Table 3. Distribution of Students by Ethnicity

Experience (Years)	Number of Students
<1	5
2-5	4
6-10	5
10-20	3
>20	2

Table 4. Distribution of Students by Experience

Test	1	2	Final Exam	Course Grade
Factor	***p-value***	***p-value***	***p-value***	***p-value***
Age	0.455	0.377	0.306	0.523
Gender	0.252	0.815	0.120	0.269
Marital Status	0.962	0.399	0.347	0.825
Children	0.680	0.934	0.656	0.835
Race	0.573	0.725	0.768	0.554
Class Level	0.287	0.069	**0.011**	0.062
Work Experience	0.207	0.428	0.441	0.523
Parental Educational Level	0.145	0.500	0.458	0.479
Parental Citizenship	0.818	0.213	0.531	0.719
Economic Status	0.164	0.125	**0.024**	0.197
Work (while in school)	0.442	0.666	0.775	0.976
Study (hours/week)	0.612	0.567	0.462	0.426
Review (hours before test)	0.523	0.779	0.946	0.568
Days (missed/year)	0.498	0.317	0.270	**0.040**
Professor Consultation	0.740	0.995	0.947	0.989
Confer with Student Group	0.742	0.939	0.501	0.167

Table 5. Statistical Results of Participant Surveys

and a final exam) were much lower for undergraduate students vs. graduate students (Figure 1).

Every undergraduate student worked with a graduate student on the course project for a total of eight groups between the two courses. Both graduate and undergraduate students worked together and earned the same grades except one group consisting of only undergraduate students. There was only one group that did not include graduate students (Group 7). This group acted as a control group to test the effect of not working with graduate students. While the seven other groups earned >90% on their projects, the group with undergraduate students only earned significantly less (70%). This suggests that undergraduate students benefit when mixing groups with graduate students. However, it does not test the fact that graduate students may have done the work for undergraduate students (Figure 2).

Undergraduate vs. Graduate Test 1	
Factor	*p-value*
Gender	0.514
Class Level	**0.027**
Year Course Taken	0.114

Undergraduate vs. Graduate Test 2	
Factor	*p-value*
Gender	0.266
Class Level	**0.003**
Year Course Taken	0.243

Undergraduate vs. Graduate Project	
Factor	*p-value*
Gender	0.869
Class Level	0.112
Year Course Taken	0.727

Undergraduate vs. Graduate Test 3	
Factor	*p-value*
Gender	0.953
Class Level	**0.001**
Year Course Taken	0.665

Table 6. Statistical Analysis of Study Grade Data from Fall & Spring

Discussion

Overall performance on four key measures (Tests 1-2, project and a final exam) was compared between graduate and undergraduate students taking two upper-level cross-listed courses. Undergraduate students performed much lower overall than their graduate counterparts. However, the results suggested that undergraduate students' scores improved significantly after working with graduate students on the group project.

According to the statistical results from the questionnaire, it could be assumed that class level (graduate vs. undergraduate) and economic status may be significant factors in student performance.

Note that both graduate and undergraduate student did worse than after the group project. This may be due to the fact that the first test may have been more difficult, or students may not have known what to expect from the professor on the first test. Therefore, after learning the professor's testing style, all students generally improved on the second test. However, at the end of the semester, students may have been more fatigued; therefore, they may not have put forth their best effort. Also, Test 3 (final exam) may have been more difficult than the previous two tests.

Limitations

While this study was carefully designed and carried out and took a significant amount of time in data collection, there were a few limitations that can be tested in future studies. These limitations include the fact that individual effort of graduate students vs. undergraduate students on the project was not tested.

Also, the small size of the participants in the survey leaves little variation within the group. To improve the robustness of the results, more data are needed to confirm the abovementioned findings.

In addition, many of the students did not answer the questions concerning their previous standardized tests, such as GRE, GMAT,

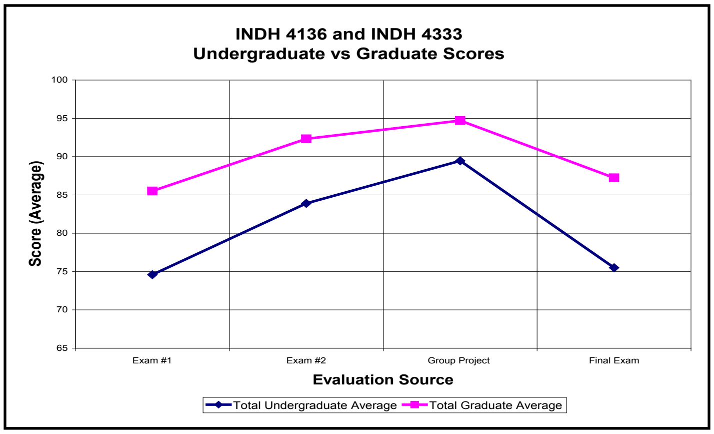

Figure 1. Grade Comparison of Undergraduate vs. Graduate Students

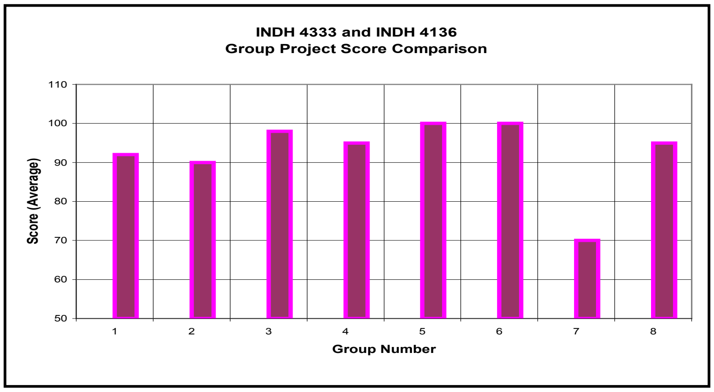

Figure 2. Group Project Scores

ACT, SAT and TOEFL. Furthermore, many students did not reveal their GPA. Therefore, there was no history of the past academic performance used in the statistical evaluation.

Another limitation of this research is that the duration of a semester is too short to determine the influence of the students on each other. This research model may need to have a time period of at least a year and a half to determine the effects.

Also, both classes were upper-level Industrial Hygiene/Safety courses, which limit the type of students who would take the class. In addition, UHCL is an upper-level institution (junior, senior and graduate students only). Most are working or nontraditional students. These students are usually older than the traditional age students (18-24), and the sample group was not representative of the younger, straight-out-of-high-school students.

Conclusions

The amount of data collected and studied in this research was very beneficial in shedding light and confirming expectations regarding certain variables and factors that may affect academic performance of academic students. While a few of these factors may be within the control of the instructor, many factors are not. However, testing the fact that students influence each other has been proven effective.

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