# Quality Approaches in Higher Education

## IN THIS ISSUE:

*Editor's note:* This issue of *Quality Approaches in Higher Education* is focused on STEM education and partnerships among universities, industry, and government that enhance and provide experiential learning to STEM and engineering majors. This issue celebrates the ideas and planning behind the upcoming ASQ Education Division's Advancing the STEM Agenda Conference, co-sponsored with Grand Valley State University's Seymour and Esther Padnos College of Engineering and Computing on June 3-4. Significantly, the theme of the conference is "Collaboration with Industry on STEM Education." We asked Dean Paul Plotkowski to introduce this issue with a commentary on the engineering program at Grand Valley State University and the collaboration it has with industry. We further highlight advances in STEM learning, education, leadership, and collaboration with articles from NASA's Langley Research Center, The Ohio State University, and Southern Illinois University Carbondale. Together, these articles represent different and critical perspectives on how the STEM agenda is impacting STEM programs to develop better prepared professionals.

—Cindy P. Veenstra, special issue editor

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A case study supports the use of blended learning to assure quality course outcomes.

# Case Study: Application of Blended Learning for an Engineering Simulation Course

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### Abstract

This case study documents the transition of an undergraduate software laboratory from face-to-face only instruction to a blended-learning model motivated, in part, by instructor cost savings. To assure quality in learning outcomes was preserved, we implemented the transition using a randomized experiment. Participating students were randomly assigned to blended (treatment) and traditional (control) groups. Performance was measured by pre- and post-knowledge assessment and quizzes. Attitude was measured by the results of a survey administered at the end of the course. The results show that students' performance in a purely face-to-face instructional class was not significantly different from that based on a blend of online and face-to-face instruction. In addition, the blended type had significantly more consistently favorable ratings than the purely face-to-face instruction. We conclude that blended learning and our experimental approach could be usefully replicated for other face-to-face software laboratory courses and propose four topics for future research.

### Keywords

Teaching Quality, STEM, Student Support, Survey Results

## Introduction

This paper documents a case study of the implementation of a blended-learning method to teach a discrete-event simulation course at The Ohio State University (OSU). Within the last three years at OSU, there has been more than a 50% increase in the number of students in engineering overall and a 33% increase in the number of students in the department of Integrated Systems Engineering. Previously, our simulation laboratory course size was limited by the number of computers in our largest computer classroom and instructional resources needed to teach multiple sections. The transition to blended learning was implemented in part to remove an effective constraint on the number of students that we could maintain in our program. We imagine that similar bottleneck issues may be emerging around the world as there is growing student interest in the labor-intensive instruction associated with science, technology, math, and engineering (STEM).

Overall, online or e-learning course delivery has increased gradually despite the continual preference for face-to-face instruction in colleges. Research indicates that the worldwide e-learning market has been growing at an annual rate of 35.6% (Sun, Tsai, Finger, Chen, & Yeh, 2008). In the United States alone, annual growth rate in the number of students taking at least one online course stood at 29% in 2009 (Allen & Seaman, 2010). In the fall of 2009, for example, about 5.6 million (nearly 30%) of higher education students in the United States took at least one online course compared to 1.6 million in the fall of 2002 (Allen & Seaman, 2010). Allen and Seaman (2010) also found that 63% of selected higher institutions in the Unites States surveyed said that online learning is an important part of their institutions' long-term strategy.

Early problems hindering widespread use of online learning primarily stemmed, in part, from a lack of personal computers and Internet access at home (Abdelaziz, Kamel, Karam, & Abdelrahman, 2011). Therefore, it might not be surprising that, with the easy

access to Internet and the proliferation of laptops and hand-held portable devices, interest in online learning is growing.

Several empirical studies have compared online course delivery to its traditional counterpart. Online instruction typically takes place through web-based tools such as chat rooms, threaded discussion groups, Internet activities, videos or slides of course materials, links to resources, and e-learning management systems such as Blackboard, eCollege, and ANGEL (Rovai, 2007). This type of instruction is usually asynchronous, allowing students to work on their own schedule in different locations. In face-to-face courses, synchronous communication exists, where professors and students are in the same location learning together.

A considerable portion of recent research has concluded that students in online courses perform as well as those in traditional courses when comparing student performance using pre-test and post-test scores and grades (Arbaugh, Godfrey, Johnson, Pollack, Niendorf, & Wresch, 2009; Larson & Sung, 2009; Dutton & Dutton, 2005). In Moskal and Dzibuban, (2011); Plum and Robinson, (2012); and Graham, (2005), online courses are shown to perform favorably when comparing overall course satisfaction.

Others have found mixed results when comparing face-to-face and online methods of instruction. Wueller (2013) for example, identified similarities in overall performance and satisfaction in some courses but also found significant and mixed differences in performance and satisfaction in other courses. Some researchers have identified significant benefits for face-to-face instruction over online instruction. Kelly, Ponton, and Rovai, (2007) identified that face-to-face students tend to consider the instructor more important than online students. There is also a widely-held perception that face-to-face instruction offers hard-to-measure benefits such as socialization (Waksler, 1991).

Blended-learning courses offer students the convenience of a hybrid learning environment comprised of online technology and personal contact with each other and the professor. Thus, blended learning could bring together the best of both classroom and online strategies (Graham, 2005). This combined approach aims to maximize the positive features of each delivery mode, in particular by offering the means for discussions seen as critical to the thorough understanding of course materials (Collopy, & Arnold, 2009; Hara, 2000). Blended learning is argued to be particularly suited to courses that involve significant computer laboratory classes (Djenic, Krneta & Mitic, 2011).

Therefore, a relevant consideration is the type of material presented. This article documents the application of a blended-learning approach in which some of the material (the theory portion) was presented face to face and other material (software laboratories) was presented predominantly online. Given the mixed results in the literature relating to outcomes, our transition to the blended-learning approach also included an experimental study to verify that there were not significant losses in student outcomes. The intervention did not affect the methods for student evaluation which relied previously and still on face-to-face examinations. Students continue to take both the theory exam (Quiz 1), which relates to lecture material and the laboratory exam (Quiz 2). As all the students took the same lecture and theory exam regardless of their mode of learning laboratory material, the theory exam results offer a way to evaluate student quality, largely independent of our experiment.

The remainder of this article is organized as follows. In the next section, we document the case for blended learning with regard to the specific educational objectives relating to discrete-event simulation. Next, we describe the purpose of our study relating to assuring quality through the transition to blended learning. Then, we describe the methods used in our study which relate to securing student approvals and experimental randomization. The results from our content and attitude surveys are presented and analyzed. Finally, we describe our case study conclusions and opportunities for future research.

## The Case for a Blended-Learning Course in Discrete-Event Simulation

Discrete-event simulation is widely regarded as a critical subject for integrated systems engineering practice as well as a key enabler for students to understand the role of modeling and optimization (Kelton, Sadowski & Sadowski, 2002). At OSU, discrete-event simulation is used to teach students how to model a familiar system using real data that they collect. Students then develop potentially valuable system improvement recommendations. The experience of modeling and using computers and software to potentially change lives in our broader community explains why some believe a simulation course is among the best ways to introduce systems engineering to new students.

During the existing course, students learn how to:

- identify the roles simulation plays in improving existing systems and designing and building new ones,

- identify the theoretical foundations and limitations of simulation (e.g., how historical data relates to expected values),

- implement simulations in both EXCEL and ARENA to offer solutions to customers,

- determine reasonable distributions for helping to predict future events (e.g., goodness of fit testing and empirical distributions),

- apply simulation output analysis to get insight over many system options,
- recognize the basic M/M/C queue and know the benefits of queuing theory, and
- apply input analysis, output analysis and answer a question using real input data.

Our discrete-event simulation is required for all departmental undergraduates. The course is offered twice a year. The current course structure includes face-to-face lectures and one "theory" exam (Quiz 1) and laboratories as well as one laboratory or "practice" exam (Quiz 2). The face-to-face lectures are designed for teaching the theory of discrete-event simulation, independent of software. The laboratories primarily build practical simulation software skills but also reinforce the theoretical concepts from the face-to-face lectures and interactive exercises. Before this experiment, more than half of the laboratory time in the discrete-event simulation course involved rote learning in which students repeated the instructor actions to build a simulation model using ARENA software. This type of learning in which there is straightforward copying of instructor actions, is not one of the most desirable approaches in the educational community because it limits the students' ability to retain critical concepts and reflect on their experiences (Roche et al., 2009). Anecdotally, the course instructor observed less retention of ARENA material than expected. This could be a result of two challenges: the method of instruction utilized in the laboratory component and the laboratory environment.

Part of the motivation for replacing the face-to-face laboratory instruction related to cost reduction. There would be a need for less instructor time and fewer face-to-face laboratory sections. At the same time, part of the motivation related to a desire to revise the method of instruction and (possibly) improve student retention and outcomes. As a result, the project team explored a blended-learning approach to modify the existing structure of the course, partly to enhance the learner's experience. The authors designed a blended-learning course combining classroom lecture and self-paced, interactive learning activities and exercises following some of the best practices in the literature (see for example Angelino, Williams, & Natvig, 2007; Ginns & Ellis, 2007; Sun, Tsai, Finger, Chen, & Yeh, 2008; Anderson, 2008).

## Purpose of the Study and Quality Measures

The purpose of our experimental study was to assure that the cost saving transition did not harm student learning. This was evaluated by comparing students' performances and attitudes in blended-learning (treatment) and face-to-face

(control) groups. Specifically, the present study addresses the following questions:

1. Is there a significant difference in performance as measured by the content survey in Appendix A and student performance on the in-class exams (Quiz 1 and Quiz 2)?

2. Is there a significant difference in attitudes as measured by a student survey for students in a blended-learning model and a traditional model of a discrete-event simulation laboratory?

## Methods

In this section, we describe both the methods for generating the online course materials and also the experimental design for our study. Chronologically, our team:

- studied best practices for developing online materials,
- planned the experiment and applied to the Institutional Review Board,
- developed course materials,
- pilot tested the course materials,
- revised the materials (performed two iterations),
- obtained consent from students,
- randomized the student selection,
- administered the pre-test,
- taught the course,
- administered the post-test, and
- analyzed results.

Next, we describe each of these activities in greater detail. Our first step involved securing permission from OUS's Institutional Review Board to conduct our experiment.

## Studying Best Practices and Developing Materials

As an initial step for our experimental design, the research team sought advice from several experienced e-learning developers. As noted previously, we also attempted to follow some of the best practices in the e-learning pedagogical literature (Rovai, 2007; Sun, Tsai, Finger, Chen, & Yeh, D, 2008; Anderson, 2008). Through this study we identified an iterative method involving pilot testing and also the use of Camtasia, PowerPoint, and Desire-to-Learn (Carmen) software.

In developing the online materials, we chose to mimic the face-to-face instruction. The face-to-face instruction started with a brief PowerPoint presentation, usually less than 15 minutes, to introduce the laboratory objectives and the example problems covered. Then, the instructor led the students who followed each

command to create the example simulation models similar to those in the required textbook.

Following the conceptual model for creating effective online learning materials in Rovai, (2007), the blended course involved two components:

1. Self-paced instruction supported by ARENA PowerPoint, Camtasia, and Desire-to-Learn. Camtasia video capture software, combined with PowerPoint, was used to achieve the laboratory objectives and to introduce the discrete-event simulation problems and the ARENA simulation software. The project team utilized Desire-to-Learn (Carmen), the university's learning management system, to help monitor and assess a student's progress in the course. This learning management tool allowed the students the flexibility to master the course material at their own pace and increase the level of accountability since it is not always clear that every student is achieving the laboratory objectives in the face-to-face setting.

2. Classroom lecture time. The blended course maintained the face-to-face lecture. Students had the option to ask questions and to interact with the instructor and other students.

The result from the development process was eight laboratories presented using .swf files, which were converted to .html files for presentation within the Desire-to-Learn system. After the initial materials were developed, the materials went through three iterations of pilot testing. The reviewers of these pilot tests were research collaborators, and their feedback was recorded anonymously and destroyed. Through this process the resulting teaching materials were refined.

## Obtaining Consent and Initiating the Main Phase

The students were required to take the course and nearly all were third-year industrial and systems engineering majors. We asked the students for their consent to join our study while promising that their decision to participate (or not) would have no bearing on their grades. All participants in the study were full-time students between 18 and 22 years of age. After we recruited the participants, those giving consent were randomly assigned to the blended-learning (treatment) and face-to-face (control) groups. Both groups used the same textbook and simulation modeling software package. Both groups also had the same grading rubric, covered the same material, shared the same lecture (with the same professor for instruction), and had identical syllabi and weekly schedules. The face-to-face portion for the control group laboratory section was taught by an experienced teaching assistant who had received above average ratings in a previous offering.

In all, 53 students enrolled in the discrete-event simulation course. The sample for this study, however, consisted of 33 students, 11 enrolled in the face-to-face discrete-event simulations laboratory and 22 enrolled in the blended-learning group. Fewer students were selected for the face-to-face group in part because students generally preferred being selected into the online group. In addition, the 20 students who opted out of the study automatically joined the traditional face-to-face laboratory. The room for the face-to-face laboratory seats only 35 students, therefore we could have at most 15 control group students and uneven sample sizes were unavoidable.

## Pre-Test Assessment, Course Administration, and Post Test

The pre-test, post-test, and attitudes assessment were all administered to consenting students online using Desire-to-Learn survey and quizzing procedures. The pre-test and post-test were the same and are documented in Appendix A. The tests were administered to the consenting student in week one of the class encouraged by an email notification. Both the post-test and the attitudes assessment were administered during the last week of the class.

Student learning outcomes were also measured using results from two different exams (Quiz 1 and Quiz 2). Quiz 1 related to lecture material (theory) and Quiz 2 related to laboratory material. As all students experienced the same lecture, there was no expectation that the performance between treatment and control groups on Quiz 1 would be different. Quiz 2 was of greater interest because there was a concern that students might learn less from the blended-learning approach.

## Results

In this section, we describe the analysis of the content and attitude surveys as well as the quiz results.

### Pre-test and Post-test Results

We omit the survey data for raw score data for space reasons but the mean, median, and standard deviation for the results on both pre-test and post-test are shown in Table 1. The mean pre-test score for students in the treatment and control group was 2.67 with a standard deviation of 1.50; and 3.19 with a standard deviation of 1.78 respectively. The lower mean score and a relatively higher standard deviation is an indication of how little the students knew about discrete-event simulation prior to taking the course. A parametric two-sided equal variance assumption t-test on the pre-test results had a p-value of 0.419 revealing that there was not enough evidence to suggest one group was associated with higher mean performance initially than the other.

Due to the small sample size of the data, the Mann-Whitney, Kruskal-Wallis, and Mood tests were conducted to test for a

difference in the distribution of pre-test treatment and control groups, as shown in Table 1. These test statistics do not support the hypothesis that there is a difference between the two medians.

There was also no significant difference found between the two groups in the post-test data as shown in Table 1. All the hypothesis tests, both parametric and non-parametric, had p-values greater than 0.05. Based on the post-test results, there was no significant difference in performance between face-to-face and blended-learning instructions.

As expected, judging from the differences in the pre-test and post-test data, all five hypothesis tests revealed significant differences between the results on the pre-test and the post-test exams for both the treatment and the control group. This provides evidence that the participants in both groups acquired significant mastery of the discrete-event simulation ARENA software during their instruction.

### Quiz Results

Students in both the blended-learning (treatment) and face-to-face (control) groups were allowed the same amount of time to take identical quizzes. Three closed-book quizzes were offered of which the best two counted toward the final grade. As mentioned previously, the first quiz (Quiz 1) was based on the theory from the lecture and the second quiz (Quiz 2) was based on the laboratory classes. The third quiz was a combination of both theory and laboratory questions. We analyzed data on only Quiz 1 and Quiz 2 since many of the students were satisfied with their result on the first two quizzes and did not take Quiz 3. However, some did not take Quiz 1 or Quiz 2, usually for family reasons, thus resulting in some missing data. The maximum percent grade on the quizzes was 100%.

The box-and-whisker plot shown in Figure 1 displays a graphical summary of the distribution of Quiz 1 and Quiz 2 grades for the treatment and the control groups. The median score on both Quiz 1 and Quiz 2 is higher for the control group than the treatment group. Variability is higher on Quiz 1 than on Quiz 2, although variability is almost the same when the treatment group is compared to the control group on both quizzes. Next, we describe formal hypothesis tests relating to the data from both quizzes.

**Table 1: Parametric and Non-Parametric Hypothesis Test of Treatment (Blended Learning) Versus Control (Face-to-Face) Instructions on Pre-test and Post-test**

|  | Mean | Median | Std Dev. | T-test | P-value Mann-Whitney test | P-value Kruskal Wallis test | P-value Mood test |
|---|---|---|---|---|---|---|---|
| Pre-test Treatment | 2.67 | 2 | 1.50 | 0.419 | 0.469 | 0.455 | 0.376 |
| Pre-test Control | 3.19 | 3 | 1.78 |  |  |  |  |
| Post-test Treatment | 6.10 | 6 | 1.20 | 0.556 | 0.650 | 0.637 | 0.382 |
| Post-test Control | 5.83 | 6 | 1.13 |  |  |  |  |

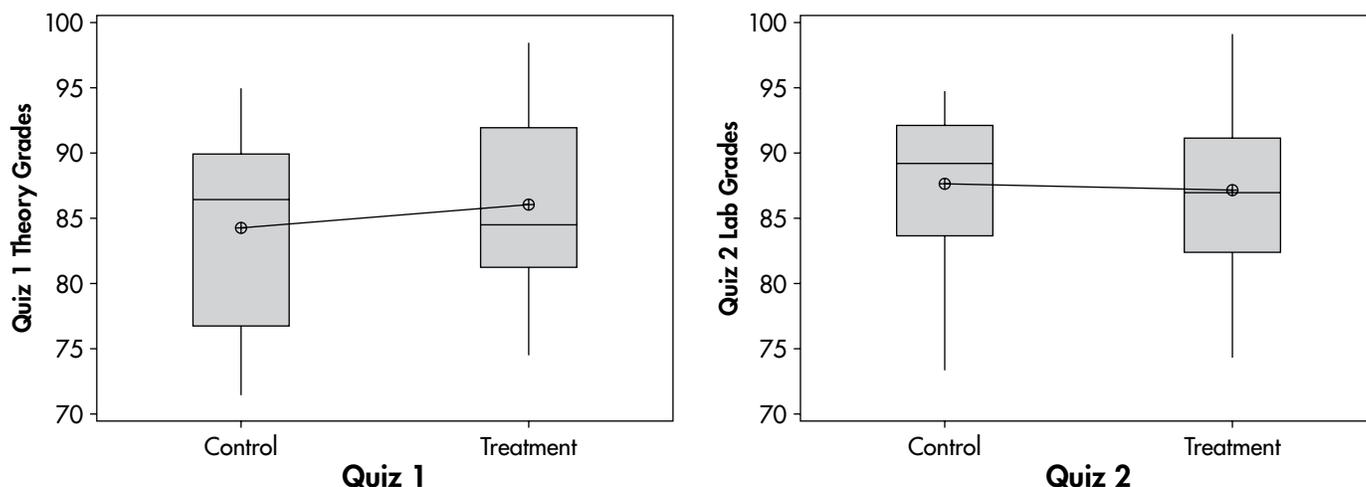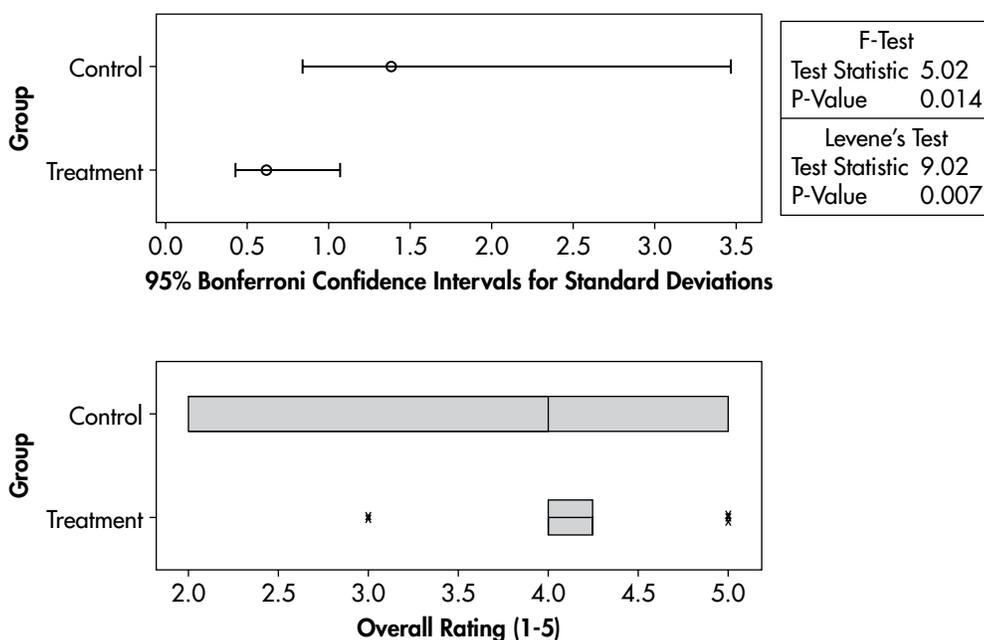**Figure 1: Comparison of Quiz 1 (Theory) and Quiz 2 (Laboratory) Grades Between Control and Treatment Groups**

| | Mean | Median | Std Dev. | T-test | P-value | | |
| | | | | | Mann-Whitney test | Kruskal Wallis test | Mood test |
|---|---|---|---|---|---|---|---|
| Quiz 1 Treatment | 85.98 | 84.30 | 6.33 | 0.367 | 0.480 | 0.468 | 0.622 |
| Quiz 1 Control | 83.35 | 85.00 | 7.40 | | | | |
| Quiz 2 Treatment | 87.50 | 87.67 | 6.43 | 0.849 | 0.642 | 0.627 | 0.372 |
| Quiz 2 Control | 88.15 | 89.75 | 6.54 | | | | |

**Figure 2: Comparison of the Student Attitude Data Relating to Responses for the Overall Appreciation Question**



| F-Test | |
|---|---|
| Test Statistic | 5.02 |
| P-Value | 0.014 |
| Levene's Test | |
| Test Statistic | 9.02 |
| P-Value | 0.007 |

95% Bonferroni Confidence Intervals for Standard Deviations

The mean, median, and standard deviations for results on both Quiz 1 and Quiz 2 are shown in Table 2. The mean Quiz 1 score for students in the treatment and control group was 85.98 with a standard deviation of 6.33 and 83.35 with a standard deviation of 7.40 respectively. A parametric, two-sided equal variance assumption t-test on Quiz 1 results had a p-value of 0.367 suggesting there was not enough evidence to reject the hypothesis that students perform better in a face-to-face instruction than in a blended-learning instruction. Similar conclusions can be drawn from the Mann-Whitney, Kruskal Wallis, and Mood non-parametric tests as shown in Table 2.

The mean Quiz 2 score for students in the treatment and control group was 87.50 with a standard deviation of 6.43 and 89.75 with a standard deviation of 6.54, respectively. A parametric, two-sided equal variance assumption t-test on Quiz 2 results had a p-value of 0.849 suggesting there was not enough evidence to support the hypothesis that students perform better in a face-to-face instruction than in a blended-learning instruction.

Results from the Mann-Whitney, Kruskal Wallis, and Mood non-parametric tests on Quiz 2 are shown in Table 2. None of the tests reveal a different outcome from that of the parametric test. Therefore we conclude that there is not enough evidence to suggest a significant difference in performance exists between face-to-face and blended-learning instructions.

### Attitude Survey

The students' overall attitude relating to the course was measured using a Likert scale from 1 (strongly disagree) to 5 (strongly agree). Only seven participants in the face-to-face group and 14 participants in the blended-learning group responded to the survey.

The survey included a question on overall satisfaction with the course: "Overall Rating of the Course: This course was a valuable learning experience." The mean for the blended-learning group (treatment) was 4.07. The mean for the face-to-face group (control) was 3.71. The mean difference is not significant at the 0.05 level with a p-value of 0.535. However, the variance in appreciation for the blended group is significantly reduced. The standard deviation of the Likert score for the blended-learning group was 0.616 and for the face-to-face group was 1.38. Using an F-test, the p-value is 0.014. Figure 2 summarizes the results graphically. Therefore, we

conclude that the appreciation for both methods of delivery was generally good but the treatment group was more consistent.

## Conclusions

We implemented blended learning in Integrated Systems Engineering in part motivated by a desire to increase our program size while reducing instructional costs. This goal was achieved. In fact, the blended-learning laboratories are now used for graduate-level instruction with similar benefits in reducing instructional effort. Naturally, we were concerned about losses in student learning resulting from our cost savings. Yet, results of the present study indicate that there were no significant differences in students' performance in the blended-learning and traditional models of the discrete-events laboratory course when pre- and post-knowledge assessment and quizzes were compared. The blended-learning treatment group performance was not significantly worse than the face-to-face control group performance. This is in agreement with the conclusions from Larson and Sung (2009) who conducted a similar study comparing student success in face-to-face, blended, and online instructional delivery modes.

Like in Larson and Sung (2009), this study found significant differences on a Likert-scale attitude survey. Although, the differences that we detected were in the Likert-scale variances not the Likert-scale means. For the attitude measures, the blended-learning model offered significantly more consistently positive student attitudes. The control group may have had more variability on the question of satisfaction with the course because some students in the control group preferred the blended-learning option. What might have occurred is that some students who were selected for the control group were disappointed that they were not allowed to enter the blended-learning group. This result conflicts somewhat with the experience of Moskal and Dzibuban (2011) who generally found no significant differences in student evaluations of online verse traditional. Further, the sample mean and written comments were also consistent with higher appreciation of the online option. We conclude that teaching discrete-event simulation software laboratories in a blended-learning format is preferable when taking costs, outcomes, and student attitudes into account for our department for the foreseeable future.

There are a number of items for future research. First, our experience in applying blended learning confirms that certain types of knowledge are well conveyed using the blended approach. Specifically, the memorization and experiential nature of our discrete-event simulation software laboratory seems to make it a fit for online learning. Further research into the possible interaction of the type of learning outcome and blended approaches could be conducted. Second, as we apply blended approaches to new courses, it is of interest to develop a standard operating procedure with associated benchmarking and systematic evaluation. Third, a control charting method for evaluating and monitoring both student individual progress, instructor progress, and program progress can be developed. Finally, while the blended-learning methods offered clear advantages in student appreciation, student feedback was not universally and continually positive. A system for periodic maintenance and improvement of the online content is likely needed. The maintenance of online educational resources is a relevant topic for research.

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## Appendix A: Content Survey Instrument

In this appendix we include the survey instrument used to evaluate student learning. We administered the same survey to participating students in the first week and the last week of the class. Correct answers are indicated by check marks.

### Question 1

Which of the following order of modules correctly describes a full arena simulation model?

- ❍ A) Create → Dispose → Process
- ✓ ◉ B) Create → Process → Dispose
- ❍ C) Process → Create → Dispose
- ❍ D) Dispose → Process → Create
- ❍ E) Process → Dispose → Create

### Question 2

Correctly identify all the data modules in the following

i    Create
ii    Assign
iii    Process
iv    Queue
v    Record

- ❍ A) i only
- ❍ B) i and ii only
- ❍ C) i and iii only
- ❍ D) i, iv and v only
- ✓ ◉ E) i, ii, iii, iv and v

### Question 3

Which of the following is correct and most complete about stations and station transfers?

i    They can be used to display movement of entities among stations during animation
ii    Both are data modules under the Advanced Transfer panel
iii    Station module is used for collecting vital statistics at a station
iv    They are used to transfer entities from one station to another station
v    The Route module is a type of station transfer

- ❍ A) i and ii
- ❍ B) i and iii only
- ✓ ◉ C) i and iv and v only
- ❍ D) i, ii, iii only
- ❍ E) i, ii, iii, iv, and v

### Question 4

Which of the following is/are true?

i    A simulation can be terminated either by specifying the replication length or by specifying a condition
ii    Often, initial conditions in steady-state simulations don't really matter
iii    If customers arrive to a system via the Poisson Process then the time between arrivals must be modeled as an exponential distribution
iv    The triangular distribution is commonly used when the exact form of the distribution is not known but estimates for the minimum, maximum and most likely values are available
v    Every ARENA simulation model must end with the Advanced Process module "REMOVE"

❍ A) i only

❍ B) i and ii only

❍ C) iii and iv only

✓ ⊙ D) i, ii, iii, and iv only

❍ E) i, ii, iii, iv and v

## Question 5

Which of the following is/are correct and most complete?

i   The schedule data module is used for modeling plan variation in the availability of resources such as shift change

ii  The failure data module is used to model random events that cause a resource to become unavailable

iii The schedule data module is best suited for modeling random downtime or maintenance time of a resource

iv  If the mean arrival rate of an arrival process is a function of time, then the type of arrival should be modeled as a stationary Poisson process

v   Time units at all stages of a simulation model need not be consistent as long as the specified time unit of the model's "Base Time" matches that of the first module

❍ A) i only

❍ B) ii only

✓ ⊙ C) i and ii only

❍ D) iii, iv and v only

❍ E) i, ii, iii, iv and v

## Question 6

We can change the entity picture at different places in a simulation by using?

✓ ⊙ A) an ASSIGN module with an option "Entity Picture"

❍ B) an ALLOCATE module and choose "Entity Picture" under Attribute

❍ C) a REQUEST module and choose "Entity Picture" under Attribute

❍ D) a STORE module and choose "Entity Picture" as an attribute

❍ E) a REQUEST and ALLOCATE modules together

## Question 7

Which of the following is/are correct and most complete?

i   Warm-up period is used when we suspect there is initialization bias

ii  A terminating simulation must have a warm-up period

iii Batch in a single run are preferred to truncated-replication methods when one long replication is carried out due to long warm-up period

iv  Truncated-replication strategy is best used when one can identify an appropriate run-length and warm-up period

✓ ⊙ A) i only

❍ B) i and ii only

❍ C) ii and iii only

❍ D) i, iii, and iv only

❍ E) i, ii, iii, iv and v

## Question 8

Movable resources that are moved to the location where the requesting entity resides in ARENA are called

❍ A) Conveyors

❍ B) Trackers

✓ ⊙ C) Transporters

❍ D) Overhead trolleys

❍ E) Carts

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# Education Division's *Advancing the STEM Agenda Book*

## A collection of conference papers from the 2011 Advancing the STEM Agenda Conference. Available through ASQ Quality Press.
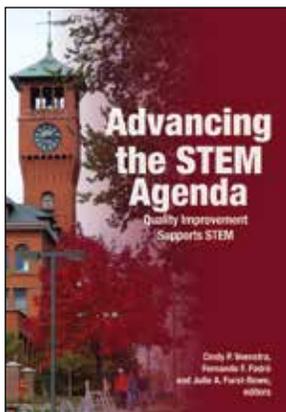
This publication is full of collaborative models, best practices, and advice for teachers, higher education faculty, and human resources personnel on improving the student retention (and thereby increasing the supply of STEM workers). Ideas that will work for both STEM and non-STEM fields are presented. The introduction maps out the current landscape of STEM education and compares the United States to other countries. The last chapter is the conference chairs' summary of what was learned from the conference and working with 36 authors to develop this book. This effort is part of a grassroots effort among educators to help more students be successful in STEM majors and careers.

"Veenstra, Padró, and Furst-Bowe provide a huge contribution to the field of STEM education. We all know the statistics and of the huge need in the area of STEM students and education, but what has been missing are application and success stories backed by research and modeling. The editors have successfully contributed to our need by focusing on collaborative models, building the K-12 pipeline, showing what works at the collegiate level, connecting across gender issues, and illustrating workforce and innovative ideas."

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