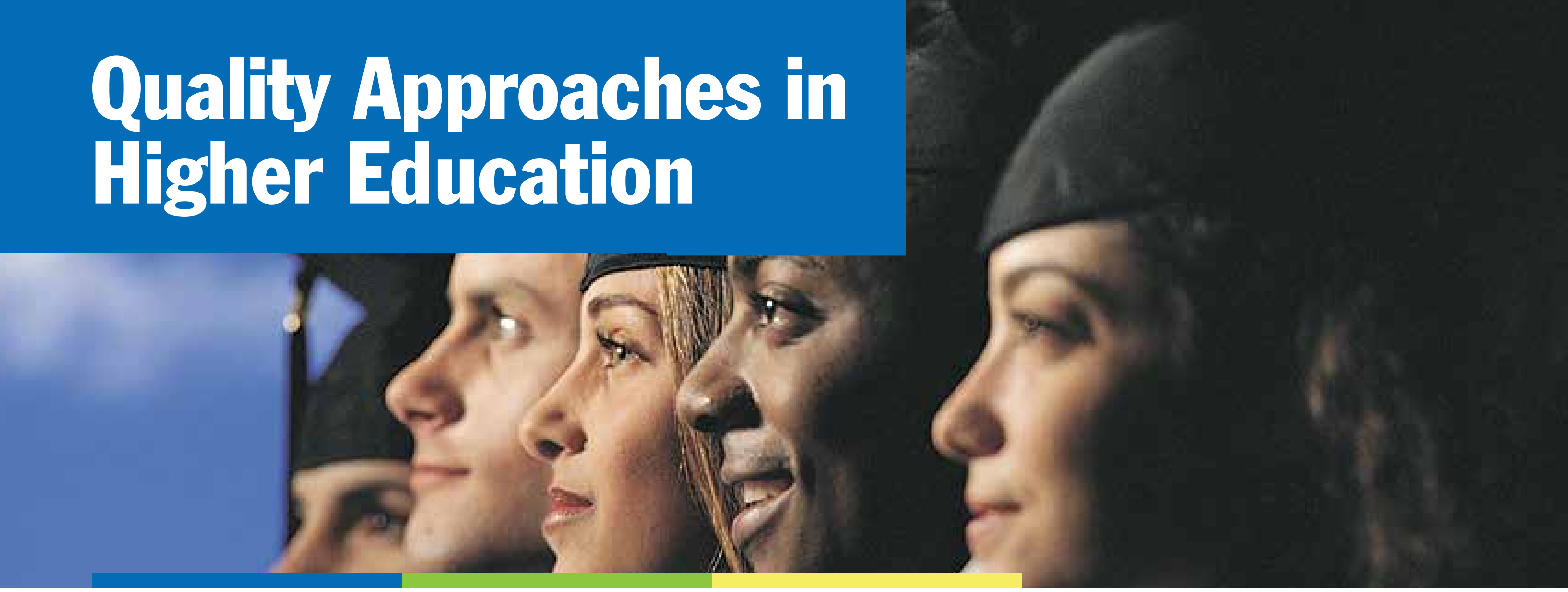
Quality Approaches in Higher Education



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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

The Journal That Connects Quality and Higher Education

Quality Approaches in Higher Education (ISSN 2161-265X) is a peer-reviewed publication that is published by ASQ's Education Division, the Global Voice of Quality, and networks on quality in education. The purpose of the journal is to engage the higher education community in a discussion of topics related to improving quality and identifying best practices in higher education, and to expand the literature specific to quality in higher education topics.

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GUEST COMMENTARY

Real-World Engineering Education: The Role of Continuous Improvement

Paul D. Plotkowski

Recently, the National Academy of Engineering (NAE) recognized 29 undergraduate engineering programs in the United States as "Exemplars of Real-World Engineering Education." This recognition was the result of a project addressing classic concerns about engineering education. Mark Papermaster, senior vice president and chief technology officer, AMD and one of the leaders of this project, explained the need for "real-world experience" in the engineering workplace as part of an engineer's education:

> "Historically, engineers have received excellent technical education, but have generally lacked formal training in the additional skills required to succeed in today's globally connected, rapidly evolving workplace. Young engineers need to be taught how to think independently, communicate clearly and adapt to change to become leaders in the global marketplace." (NRC, 2012, p. 3)

In recognizing the engineering education exemplars, the NAE report, *Infusing Real-World Experiences into Engineering Education,* explains the aim of the report and exemplar recognition:

> "The aim of this report is to encourage enhanced richness and relevance of the undergraduate engineering education experience, and thus produce better-prepared and more globally competitive graduates, by providing practical guidance for incorporating real world experience in US engineering programs." (NRC, 2012, p. 2)

This is further summarized by Charles Vest, president, National Academy of Engineering, as:

> "The basic idea is to create an engineer who has deep, strong, up-to-date technical education and the experiences that wrap around that to enable him or her to work in industry, to work across geographical boundaries, to work with people from totally different professional fields." (NRC, 2012, p. 4)

I am proud to report that the engineering program at Grand Valley State University (GVSU) was named as one of the NAE Exemplars in recognition of our approach to undergraduate engineering education. This approach includes an interdisciplinary foundation, highly integrated cooperative education, extensive use of design and build-oriented courses with extensive laboratory components, and a highly successful industry-based, interdisciplinary capstone project experience. Of equal significance is the fact that the engineering program at GVSU was first established and continues to be guided by the principles of continuous improvement.

GVSU is located in the greater Grand Rapids area of West Michigan. This is a community with an extensive and very diverse industrial base. The top 20 employers in this region are in 19 different industry sectors.

In the early 1980s, GVSU was approached by a substantial group of industry leaders with the request to introduce an engineering program. They recognized that the area was underserved in the number of engineering graduates, and that the graduates available did not have many of the essential skills and abilities expected of entry-level engineers in our contemporary regional industries.

The leadership of GVSU agreed to take on this task via an approach that was typical of industry, but very rare in education. The university established a project team of faculty and practicing engineers to define the requirements of local industry and to draft a proposal for an academic program that would address those requirements and ensure that the program maintain currency and relevancy.

The results of that effort provided the foundation for the engineering programs that GVSU offers today. The fundamental principles upon which these programs are based include:

- Engineering graduates cannot be prepared in only the theoretical elements of engineering.
- Contemporary engineers require a strong interdisciplinary background as an "engineering generalist" as well as depth in their engineering specialty area.
- A contemporary engineering education must integrate strong design and technical content with an equally strong liberal arts and sciences foundation.
- Prior to graduation, engineering students must have substantial "hands-on" experience in designing and fabricating their designs.
- Prior to graduation, engineering students need to develop the skills to be effective in an organization, in communication, and in dealing in team environments.

It was quickly realized that:

- It is not possible for any academic institution to provide this type of education in isolation.
- Program evolution and then maintaining currency (continuous improvement) would require frequent and regular communication and feedback between the university, employers, and alumni.
- This approach could only be accomplished through a true and sustainable collaboration between the university, our industrial partners, and our alumni.

The program that was developed, and is still the foundation of our current programs, included several key elements:

- Highly integrated cooperative education for all engineering students that provides a full year of industry experience prior to graduation.
- A highly common first two years that integrate engineering design and science topics throughout and provide a broad foundation across engineering disciplines and preparation for the co-op program.
- Extensive use of laboratory experiences, with more than two thirds of the engineering courses having formal labs.
- A common, interdisciplinary capstone senior project.

GVSU's continuous improvement efforts are well supported by a unique approach to cooperative education that includes:

- A preparation course that involves not only instructors from the engineering faculty and our career services office, but also makes extensive use of industry representatives and alumni (drawn from the advisory board that has evolved from our original planning working committee).
- During the co-op semesters of full-time work experience, students have academic as well as work assignments and a faculty supervisor as well as the industrial work supervisor. The faculty supervisor meets with the industry supervisor and the student each semester.
- Assessments are completed by the industry supervisor, the student, and the faculty supervisor each semester. These assessments speak directly to the student's preparation and performance as well as the quality and contribution of the work experience.

This approach has established one of the foundational pillars of our continuous improvement process (nearly two decades before either ABET or the regional accreditation associations implemented similar expectations). The "in-process" feedback that is received each semester provides a rich data set for formal assessment of the elements of our curriculum content, lab experiences, design experiences, facilities, etc. and how these match with current industry expectations.

Perhaps more importantly, however, is the relationship element that this approach has produced. The frequent and regular interactions between the faculty, the students during their work semesters, and the industry supervisors has created a unique dynamic. It has become a highly productive ongoing dialog that has generated true ownership of the programs and the continuous improvement process by the faculty, students, employers, and alumni.

A few of the improvements that have resulted from this very interactive relationship include:

- Frequent curriculum review and revision to remain responsive to the needs of industry and the students.
- A vastly expanded use of project-based learning in a wide variety of engineering courses (frequently projects from industry).
- Regular review and updating of the hardware and software tools utilized at the university to reflect (to the extent possible with such a broad industry base) industry practices.
- The addition of online instruction modules during co-op semesters that address topics such as project planning, engineering economics, and professional ethics.
- Use of industry-based and funded senior capstone projects.
- The creation of the Sebastian Endowed Chair in Engineering Cooperative Education. The duties of this position include leading our assessment efforts.

- The introduction of additional engineering programs that are in high demand by local employers, including emerging areas such as biomedical engineering, alternative and renewable energy, nanotechnology, product design and manufacturing engineering, and computer engineering that complements traditional strengths in electrical engineering and mechanical engineering.

The industry-based senior project program is a major hallmark of the GVSU engineering education program. These are highly interdisciplinary in content and team make up and provide an additional eight months of industry-based experience for the students. Each of these projects has an industry sponsor who is asked to treat the team as they would a custom engineering design house. As such, the process includes industry standard design proposals, design reviews, sign-off procedures, etc. Again, just as in the co-op program, there is systematic assessment by the faculty supervisors, the industry sponsors, and the students themselves. This provides significant and invaluable "end-of-process" feedback to our continuous improvement process. The technical content of these projects includes designing, building, testing, and delivery of working products, automation systems, testing systems, etc.

Employers need professionals with strong technical, critical thinking, interpersonal, and communications skills. Feedback from employers and alumni alike lead us to believe that the university-industry partnership approach, embedded in a strong liberal education foundation that is utilized by GVSU, is very successful in producing such engineering graduates. This is consistent with the stated GVSU mission of *"Educating students to shape their lives, their professions, and their societies."*

Reference:

National Research Council (NRC). (2012). *Infusing real world experiences into engineering education.* Washington, DC: The National Academies Press.

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NASA's LARSS program shows the benefits and lessons learned from its collaborative internships.

Using Assessments to Determine the Quality and Effectiveness of a Collaborative Internship Program in Research

Thomas E. Pinelli, Cathy W. Hall and Kimberly M. Brush

Abstract

The Langley Aerospace Research Student Scholars (LARSS) program is a nationally ranked, highly competitive, and collaborative internship program that uses NASA research opportunities to inspire and motivate students to complete a degree in science, technology, engineering, or mathematics (STEM). The program's ultimate goal is to prepare students to be work-ready for employment and research. Formative and summative assessment is used to help determine the quality and effectiveness of the LARSS program. We present data from one portion of our annual (formative) program assessment—mentors' and student interns' overall perception of the internship and their assessment of interns' acquisition of 21st century workplace skills. We provide a detailed description of a (summative) longitudinal study presently underway that will provide a long-term view of the program's quality and effectiveness.

Keywords

STEM, Career Development, 21st Century Skills

Introduction

The success of the Langley Research Center, NASA, as well as the United States in the 21st century depends on the education, innovation, and skills of its people. The ongoing value of these assets will be determined in no small measure by the quality and effectiveness of science, technology, engineering, and mathematics (STEM) education in the United States. STEM education must produce the engineers, mathematicians, scientists, and technologists who will:

- make the fundamental discoveries that will advance our understanding;
- create new ideas, new products, and innovation-based growth, as well as produce new industries and occupations; and
- help retain America's position as a world leader in science and technology.

Collaboration and Experiential Learning

In the 21st century, innovation and engineering may hold the key to the economic growth and prosperity, security, and competitiveness of the United States. Consequently, the engineering community continues to devote considerable effort to keeping engineering education relevant, flexible, and adaptable, and to predicting the elements and practices essential to preparing a 21st century engineering workforce. A number of factors, individually and in combination, influence the discussion:

- a doubling of engineering and scientific knowledge about every 10 years (Wright, 1999);
- dynamic advances in instrumentation, communications, and computational capabilities;
- multiple issues associated with workforce recruitment, education, training, and retention;
- lack of public understanding and concern about STEM;

- the rate of technological change and the introduction of disruptive technology;
- the increasingly interdisciplinary nature of science and technology, dramatic advances in such fields as biotechnology and nanotechnology, and the creation of new disciplines; and
- cuts in funding for higher education and a meteoric rise in the cost of a college education.

Added to the discussion are two important facts: Engineering requires a four-year degree for entry-level employment and the "disconnect between the system of engineering education and the practice of engineers appears to be accelerating" (National Academy of Engineering (NAE), 2005, p.13). The challenge for academia is "how to produce engineering graduates that are immediately work-ready and who understand that they have a commitment to life-long learning" (NAE, 2005). To help meet that challenge, the academic engineering community is increasing its use of collaboration and experiential learning.

A variety of programs have been developed to make engineering graduates more work-ready. Two that have the greatest support are collaboration and experiential learning. Organizationally, collaborations occur at the institutional level; between institutions; and among academia, government, industry, and professional organizations. These collaborations include engineering faculty spending summers and sabbaticals in government and industry research facilities, and engineers from government and industry joining advisory boards of engineering schools and teaching courses on campus and online.

Experiential learning has a long history in engineering education in the form of cooperative education programs. Co-op students devote a fixed amount of time to working in industry as part of their academic studies. Cooperative education remains a time-tested method of merging education and practice to make engineers work-ready. The term "internship" is also applied to engineering work-experience programs. Curricula that combine education and practice provide universities opportunities to collect data that can be used to determine the quality and effectiveness of their programs. For example, data in the form of feedback from mentors of student interns can be used to determine the acquisition of essential workplace skills such as:

- adaptability—the ability and willingness to cope with uncertain, new, and challenging assignments;
- communications—the ability to effectively process and interpret both verbal and non-verbal information and instructions;
- non-routine problem solving—the ability to examine and interpret a broad spectrum of verbal and non-verbal information and develop solutions;
- self-management—the ability to work autonomously and in groups, to be a leader and to be led, to be self-motivating; and
- systems thinking—the ability to understand how an entire system works; how an action, change, or malfunction in one part of a system affects the rest of the system.

These same data can be used by universities as assessment tools to demonstrate to accreditation groups like the Accreditation Board for Engineering and Technology (ABET) that an engineering curriculum is relevant, thorough, and does, in fact, prepare individuals to transition from students to professionals.

Benefits of Collaborative Internship Programs

The benefits of participating in an internship program have been cited in various research studies (Linn, Ferguson, & Egart, 2004; Maletta, Anderson, & Angelini, 1999; Pelton, Johnson, & Flournoy, 2004; Westerberg & Wickersham, 2011). An internship provides benefits not only to the student but also to the academic institution and business/industry (Cooperative Education and Internship Program (CEIP), 2009; Scholz, Steiner, & Hansmann, 2004). Student benefits include:

- gaining experience in the chosen career field,
- applying skills and knowledge from the classroom,
- engaging in collaboration with colleagues and teams,
- developing technical skills,
- enhancing the potential for job opportunities after graduation,
- gaining insight into ethical guidelines in the workplace, and
- understanding real-life expectations (CEIP, 2009; Couch, n.d.; Scholz et al., 2004).

Research by Schouurman, Pangborn, and McClintic (2008) shows that undergraduate work experience usually results in the greater likelihood of receiving a job offer prior to graduation and a higher starting salary. Benefits to academia include increased visibility for programs, enhanced experiences for students, feedback from potential employers, and partnership development with business/industry (CEIP, 2009; Schouurman et al., 2008).

The benefits for business/industry include the ability to see and evaluate potential employees in a workplace setting, interns bringing current and relevant skill sets to the workplace, and a possible pipeline for future hires (Pilon, 2012; CEIP, 2009). The National Association of Colleges and Employers (NACE, 2010) notes that roughly 75% of potential employers prefer to hire recent graduates who have had prior work experience. Converting an intern to an entry level, full-time employee can save the employer from $6,200 to $15,000 per person when recruiting and training costs are factored in (Gault, Leach, & Duey, 2010).

The LARSS Program

The NASA Langley Research Center (LaRC) is an ecosystem for innovation, problem solving, and creativity. Since 1917, LaRC engineers and scientists have performed breakthrough research and development to pioneer:

- the future of flight (including entry, descent, and landing) in all atmospheres;
- the characterization of all atmospheres;
- space exploration systems and technology; and
- materials concepts, analysis, and integration.

LaRC researchers are also engaged in innovative challenges including atomistic materials; Earth systems science; affordable, safe, and sustainable space exploration; and "green aviation."

LARSS is a paid (stipend), highly competitive, and collaborative research internship program for undergraduate and graduate students pursuing degrees in the STEM fields. A year-round program, LARSS has 3 sessions—fall and spring (15 weeks) as well as summer (10 weeks). Eligibility requires U.S. citizenship; full-time student status at an accredited U.S. community college, college, or university; and a cumulative GPA of 3.0 on a 4.0 scale. Although small numbers of talented high school students are accepted, the primary focus is on higher education. Of approximately 1,500 students who apply annually, about 250 are selected. Multiple collaborations with universities, professional/technical societies, and organizations are used to ensure geographic diversity and the participation of female students and underrepresented minorities, first-generation college students, students from economically-disadvantaged backgrounds, and military veterans (students).

For 26 years, the LARSS program has provided exceptional students the opportunity to work with Langley researchers on some of the nation's most important, difficult, and challenging problems that require multi-disciplinary, novel, and collaborative solutions. Vault Career Intelligence recognizes the LARSS program as one of the top ten college internship programs in the United States (Vault Editors, 2012).

Anticipated outcomes for LARSS interns include the following:

- learning to apply basic engineering and science concepts and principles to developing research-based solutions using research methods, experimental designs and techniques, data analysis, and interpretation;
- gaining proficiency in presenting scientific and technical concepts—including study design, analysis, research findings, and interpretations—to peers and colleagues;
- learning to use the physical and intellectual (analytical and computational) tools necessary for experimental design and research;
- developing the skills needed to succeed as professional engineers and scientists, fulfill professional responsibilities, and make sound, ethical decisions;
- learning to work and successfully function as a member of a team composed of individuals with divergent backgrounds and life views; and
- developing an appreciation for and the skills necessary to engage in life-long learning and to understand the need to exploit those skills in refining and updating one's knowledge base.

A variety of assessment tools are used to measure the program outcomes. Many of the skills listed above are based on the 21st century skills; a skill set developed by the Partnership for 21st Century Skills that outlines the knowledge and skills that are needed to prepare future professionals (Partnership for 21st Century Skills, 2004). These skills include basic and applied skills, with a focus on applied skills such as communication, teamwork, and critical thinking (Cavanagh, Kay, Klein, & Meisinger, 2006). A complete list of the 21st century skills included in this assessment appears in Table 2.

Formative Assessment

Each program year, student interns and their mentors are interviewed and surveyed after completing the summer session of the LARSS program. We use third-party evaluations to collect basic demographics, perceptions of the internship experience, and information about the development of 21st century workplace skills. The data that follow were obtained from students and mentors who participated in the summer 2012 program.

Student interns. The study included 199 students participating in the 10-week LARSS summer internship program. Participants included eight high school seniors, 19 college freshmen, 22 college sophomores, 46 college juniors, 47 college seniors, 36 master's students, and 21 doctoral students. One hundred students (50.3%) were first-time interns and 138 (69.3%) were first-time LARSS participants. Seventy-one (35.7%) of the participants were women and 128 were men. Even though the internship is open to students from around the country, the majority of the LARSS participants came from Virginia (44.7%); the next highest number of participants came from North Carolina (9.0%); and the rest of the students came from 41 other states, the District of Columbia, and the

U.S. territory of Puerto Rico. The majority of student interns, 149 (76.4%), indicated their race/ethnicity as Caucasian; 15 (7.7%) as African American; 15 (7.7%) as Asian American; eight (4.1%) as Hispanic; six (3.1%) as Native American/Alaska Native; and four did not answer this question.

Mentors. Two hundred twenty-three (223) professionals served as mentors for the 2012 LARSS program. Seventy-one (31.8%) had completed an internship as part of their undergraduate education. Thirty-six (16.1%) were first-time mentors. Fifty-nine (26.5%) were females. One hundred ninety-two (87.7%) were classified by NASA as engineers, scientists, mathematicians, or technologists. Ninety (40.5%) of the mentors held a doctorate. The mentors' total years of professional work experience ranged from one year to 40 years with the mean and median number of years being 23.5 and 25.0, respectively. The race/ethnicity of the mentors was Caucasian, 171 (78.4%); African American 12 (5.5%); Asian American 28 (12.8%); Hispanic six (2.8%); Native American/Alaska Native zero (0.0%); and five did not respond to this question. Eighty-two (37.8%) of the mentors had more than one intern.

Results

Our survey, given to interns and mentors, included their overall perception of the internship and their assessment of interns' acquisition of 21st century workplace skills. A 1-4 point scale (disagree, somewhat disagree, somewhat agree, agree) was used to measure agreement. There were 59 questions. Results are presented for two aspects of the 10-week (summer) internship experience: mentors' and interns' overall perceptions of the internship (Table 1) and ratings of 21st century workplace skills (Table 2).

Statistical significance was found for all variables in Table 1 based on t-tests for equality of means for comparing the interns' and mentors' perception scores. Although mentors and interns indicated growth in interns' self-confidence over the course of the internship, mentors indicated stronger growth in this area than interns did. Both indicated an increase in the interns' learning new skills and procedures and gaining new knowledge. Both mentors and interns agreed that the interns had a better understanding of NASA, its role, and missions by the end of the 10-week internship. Both mentors and interns agreed that the interns had a better understanding of what a full-time job in research was like.

A 1-4 point scale (disagree, somewhat disagree, somewhat agree, agree) was used to measure agreement ratings of interns' 21st century workplace development skills (Table 2). Overall, both mentors and interns agreed that interns' workplace skills were appropriate for their educational levels. T-tests of equality of means were performed to determine statistical significance for the difference between the interns' and mentors' rating scores.

Table 1: Mentors' and Interns' Overall Perceptions of the Internship

Type	Description	$\bar{\chi}$	N
Intern	I acquired new skills, learned new procedures, and gained new knowledge	3.86*	196
Mentor	My intern acquired new skills, learned new procedures, and gained new knowledge	3.95	222
Intern	I learned what a full-time job in research is like	3.67*	191
Mentor	My intern learned what a full-time job in research is like	3.84	205
Intern	The internship improved my confidence in my abilities	3.84*	198
Mentor	My intern gained confidence in her/his abilities	3.94	221
Intern	The goals established for my internship were met	3.67*	196
Mentor	My intern accomplished the goals established for her/his internship	3.89	221
Intern	I now have a much better understanding of NASA, its role, and mission	3.70*	198
Mentor	My intern now has a better understanding of NASA, its role, and mission	3.80	222

*Indicates significance at or below the .05 level for comparison of the mean scores between mentors and interns.

Statistical significance was found for eight of the 16 21st century workplace skills. For each of the eight significant skills, mentors rated the interns higher than the interns rated themselves. Mentors rated their interns' skills highest in the following categories: professional behavior ($\bar{\chi}$ = 3.94), collaboration ($\bar{\chi}$ = 3.93), and working as part of a team ($\bar{\chi}$ = 3.93). Interns rated their flexibility/adaptability ($\bar{\chi}$ = 3.87), professional behavior ($\bar{\chi}$ = 3.86), and thinking critically ($\bar{\chi}$ = 3.85), solving problems ($\bar{\chi}$ = 3.85), and working independently ($\bar{\chi}$ = 3.85) highest. Mentors rated their interns' workplace skills lowest in the following categories: creating and innovating ($\bar{\chi}$ = 3.72), communicating in writing ($\bar{\chi}$ = 3.73), and critical thinking ($\bar{\chi}$ = 3.80). Interns rated their workplace skills lowest in the following categories: time management ($\bar{\chi}$ = 3.56), communicating in writing ($\bar{\chi}$ = 3.57), and creativity/innovation ($\bar{\chi}$ = 3.65).

Discussion

Interns' and mentors' overall perceptions of the internship and their assessment of interns' acquisition of 21st century workplace skills were analyzed using a t-test for equality of means. Significance was set at 0.05. Results suggest that for all of the overall perceptions (Table 1) and eight of the 21st century workplace skills (Table 2) mentors rated interns higher than interns rated themselves. For the remaining eight skills there was no statistical difference between mentor and intern ratings.

The majority of items addressed in the survey reflected positively on student interns, mentors, and the internship experience. Mentors indicated they had seen growth in their interns' self-confidence after the interns' participation in the LARSS program ($\bar{\chi}$ = 3.94). The interns also noted improvement in their own self-confidence, but the ratings of their self-confidence (($\bar{\chi}$ = 3.84) was significantly less than the ratings by their mentors ($p \leq 0.05$). According to both groups, the interns were successful in building new skills, gaining more understanding about the role of NASA, learning what a full-time job in research is like, and meeting the goals set by the mentors.

The survey results from mentors reflect some of the same concerns expressed by human resource personnel and senior executives in a study conducted by the Society for Human Resource Management (Casner-Lotto, Barrington & Wright, 2006). This 2006 study noted two primary areas of concern to business and industry in regard to recent college hires: deficiencies in written and oral communication. In our study, written communication was one of the lowest-rated skill sets by both mentors and interns (see Table 2). However, LARSS interns noted improved skills in oral communication over the course of the internship, suggesting that the internship experience positively influenced the development of skills in this area. Business and industry consider oral and written communication among the key general skill sets, regardless of college major (Bok, 2003, 2006). Certainly the internship experience provided opportunities for student interns to improve skills in these areas as well as to gain an understanding of the importance of these skills in a work setting.

Mentors rated their interns highest in terms of professional behavior, collaboration/working

Table 2: Interns and Mentors' Ratings of 21st Century Workplace Skills

Type	Description After this internship, I think ... After this internship, I think ...	$\bar{\chi}$	N
Intern Mentor	I am good at thinking analytically My intern is good at thinking analytically	3.80 3.82	197 216
Intern Mentor	My computational skills are good My intern's computational skills are good	3.69* 3.83	189 200
Intern Mentor	I am good at solving problems My intern is good at solving problems	3.85 3.88	196 216
Intern Mentor	My technical skills are good My intern's technical skills are good	3.72 3.81	189 207
Intern Mentor	My computer skills are good My intern's computer skills are good	3.68* 3.87	192 214
Intern Mentor	I am good at working independently My intern is good at working independently	3.85 3.87	198 219
Intern Mentor	I am good at collaborating/working with others My intern is good at collaborating/working with others	3.75* 3.93	194 216
Intern Mentor	I am good at working as part of a team My intern is good at working as part of a team	3.67* 3.93	184 204
Intern Mentor	I am good at communicating orally/verbally My intern is good at communicating orally/verbally	3.66* 3.83	197 221
Intern Mentor	I am good at communicating in writing My intern is good at communicating in writing	3.57* 3.73	197 214
Intern Mentor	I am good at being flexible and adaptive My intern is good at being flexible and adaptive	3.87 3.88	198 219
Intern Mentor	I am good at thinking critically My intern is good at thinking critically	3.85 3.80	197 218
Intern Mentor	I am good at time management skills My intern is good at time management skills	3.56* 3.83	197 216
Intern Mentor	I am good at creating and innovating My intern is good at creating and innovating	3.65 3.72	196 217
Intern Mentor	I am good at demonstrating professional behavior My intern is good at demonstrating professional behavior	3.86* 3.94	196 221
Intern Mentor	I am good at exercising judgment and making sound decisions My intern is good at exercising judgment and making sound decisions	3.81 3.85	198 219

*Indicates significance at or below the .05 level for comparison of the mean scores between mentors and interns.

with others, and working as part of a team. Computer skills and flexibility and adaptability were also highly rated. These capabilities represent key areas needed by business/industry, as reported in studies by the Society for Human Resource Management (Casner-Lotto et al., 2006; NACE, 2010). Of some concern, however, were the lower ratings from mentors on interns' creativity/innovation, technical skills, critical thinking, and analytical thinking. Although mentors agreed that their interns demonstrated appropriate skill sets in these areas, the ratings for these areas were lower than for other skill sets. These general skill sets are qualities that go beyond basic knowledge in one's area of expertise and reflect important skills if we expect students to be able to identify and define problems clearly, understand arguments/reasoning on all sides of an issue, identify as many plausible solutions as possible, and exercise good judgment in choosing the best of the alternatives (Bok, 2006). These general skill sets could be addressed more systematically at the college level to help ensure students are given opportunities to develop these skills (Crouch & Mazur, 2001; Treisman, 1992).

A lack of appropriate responsibility/self-regulation has been cited as a major concern by business and industry regarding new college hires (Casner-Lotto et al., 2006). However, 97% of the mentors agreed that their interns exhibited the ability to self-regulate at the end of their internship. Work-related experiences can be highly beneficial in helping students learn these skills, but much can also be done at the college/university level to reinforce self-regulation (Bok, 2006).

When asked to rate the internship experience overall, both student interns and mentors responded positively. However, one item from the student interns stood out as discouraging. Forty-two percent of the interns reported either a weak or no connection between the knowledge they had gained in the classroom and the knowledge they had applied during the internship. This disconnect is not atypical (Garvin, 2003; Mazur, 1996).

Limitations

Certain limitations of this study should be noted. The study focuses on a particular cohort of student interns in a specialized setting. Therefore, generalizations should be made with caution. The survey statements in Table 1 are stated differently for the mentors and interns, limiting comparisons beyond descriptive information. The mentors' ratings represent a direct assessment of students' knowledge, skills, and abilities. However, the students' responses reflect their perceptions. This indirect assessment limits the ability to compare and contrast outcomes. (Since completion of this study, the survey has been modified for mentors and students to allow for a direct comparison.) The information in the current study does not address potential differences with respect to gender and minority status.

Additional Research

Additional research is needed into the benefits of internships for student retention in the STEM fields. More than one half of the students entering higher education with engineering as a declared major persist in engineering in the first eight semesters (Ohland et al., 2008). Are students who participate in an internship during their undergraduate experience more likely to be retained in comparison to students who do not? This question is especially important for women and minorities. Research outside of STEM fields supports the use of co-op and internship experiences in terms of gender and race (Weisenfield & Robinson-Backmon, 2001). Further research is also needed in linking classroom learning to the work experience for STEM majors in general and engineering majors in particular.

A study by the American Association of University Women (Corbett & Hill, 2012) reported that 39% of women who graduate as engineers enter the engineering workforce—compared to 57% of male engineering grads. In a longitudinal study of more than 3,700 women graduating with an engineering degree from more than 30 colleges/universities, Fouad and Singh (2011) found that 15% of these women chose not to enter the workforce. Four out of five, however, were working in fields outside of engineering. Of those who initially entered the workforce in engineering, one out of five left the field after a short time. Overall, roughly 40% of women with degrees in engineering had left the field within the first five years. The majority of these women are still pursuing careers but not in their original field of study. For women, leaving the organization where they are employed as engineers is often tied to leaving the profession. Would participation in an internship or internships during the academic career be helpful in stemming this exodus from the field?

Plouff &Barott (2012) found that a three-semester, mandatory co-op experience was beneficial in helping students transition from academia to the workforce. One of the benefits of the experience was helping students understand what to expect in certain work environments and to develop strategies and tactics as warranted with support from fellow students and the university. Whereas a co-op typically spans an extended period of time, would a well-constructed internship serve a similar purpose? More research is needed into the potential benefits of an internship experience for women and minorities in relation to academic and career retention.

Summative Assessment

A longitudinal study of the LARSS program is underway to help assess the quality and effectiveness of the program over time. This study focuses on the experiences before, during, and after the internship that have influenced interns in their pursuit of a STEM degree and, ideally, a STEM career. The study addresses key issues relating to the potential influence of the LARSS summer internship program on academic retention and career persistence of STEM majors, focusing on student interns who participated in the summer session programs from 1986-2011. Evaluative elements of the study include:

- determining the impact of the LARSS internship on workforce development;
- looking at the educational progression and career trajectories of interns following their LARSS experience;
- gauging the influence of the LARSS internship on career choices, and persistence in STEM fields; and
- tracking the influence of various people and experiences that led LARSS interns to develop an interest in a STEM field.

Beyond the assessment goals for the LARSS program are a set of goals that apply more broadly to NASA's efforts, namely, to ensure that LARSS is meeting the objectives of the NASA 2011 Workforce Plan. Has the LARSS internship program been effective in training and developing talent, recruiting and employing a diverse workforce, sustaining a high-performing workforce, and enabling efficient human resource services through the adequate provision of support and information? The population for the longitudinal study of the LARSS program included 1,757 LARSS interns who were STEM majors during the years 1986-2011. Non-STEM majors were excluded as were students who had completed more than one rotation in the LARSS internship program. Findings will be used to assess the long-term effects of the LARSS program in support of the STEM workforce pipeline as well as persistence in the field.

Concluding Remarks

The internship experience provides many benefits to students, colleges/universities, and business/industry. In our view the internship experience plays a key role in knowledge acquisition for students and a chance for participants to "try out" their chosen fields. It provides a means to offer feedback to institutions of higher learning on the skill sets their students bring to the workplace; and it gives business/industry an opportunity to engage with future employees. Internships also make a difference in starting salaries and offers of full-time employment prior to graduation (Schuurman et al, 2008). NACE (2010) notes that roughly 75% of potential employers prefer to hire recent graduates who also have prior work experience; 53% of these potential employers indicate a preference for internship/co-op experiences. Potential employers note that they perceive internships/co-ops as more reflective of relevant job experiences than other types of work experience. Collaborative work experiences among universities, students, and business/industry create a win-win for everyone involved.

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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

Theodore T. Allen, Sharnnia Artis, Anthony Afful-Dadzie, and Yosef Allam

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

				P-value			
	Mean	Median	Std Dev.	T-test	Mann-Whitney test	Kruskal Wallis test	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

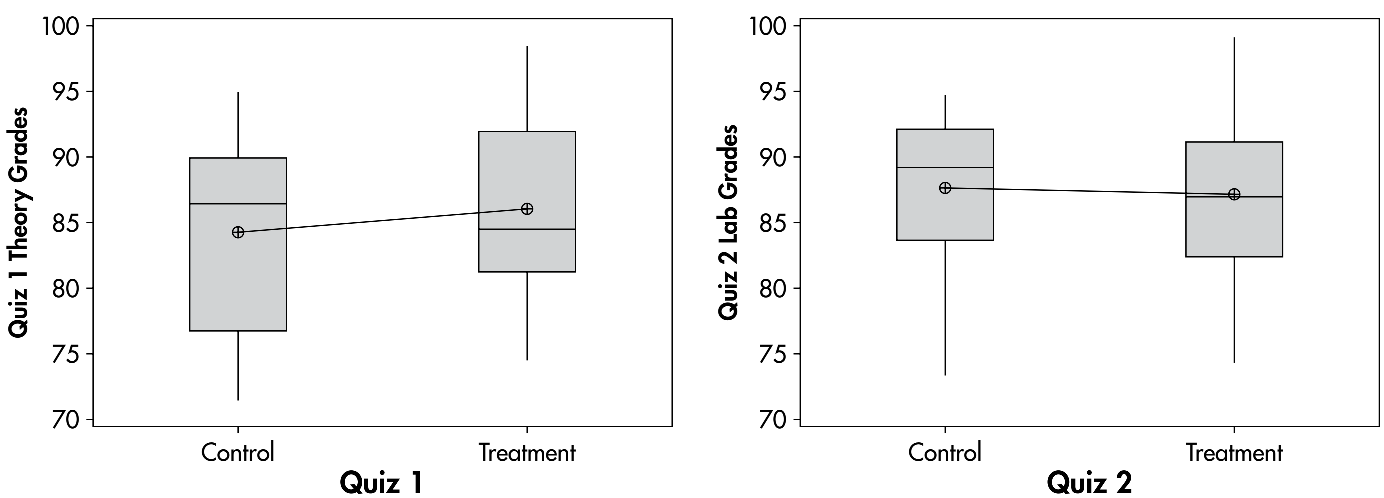
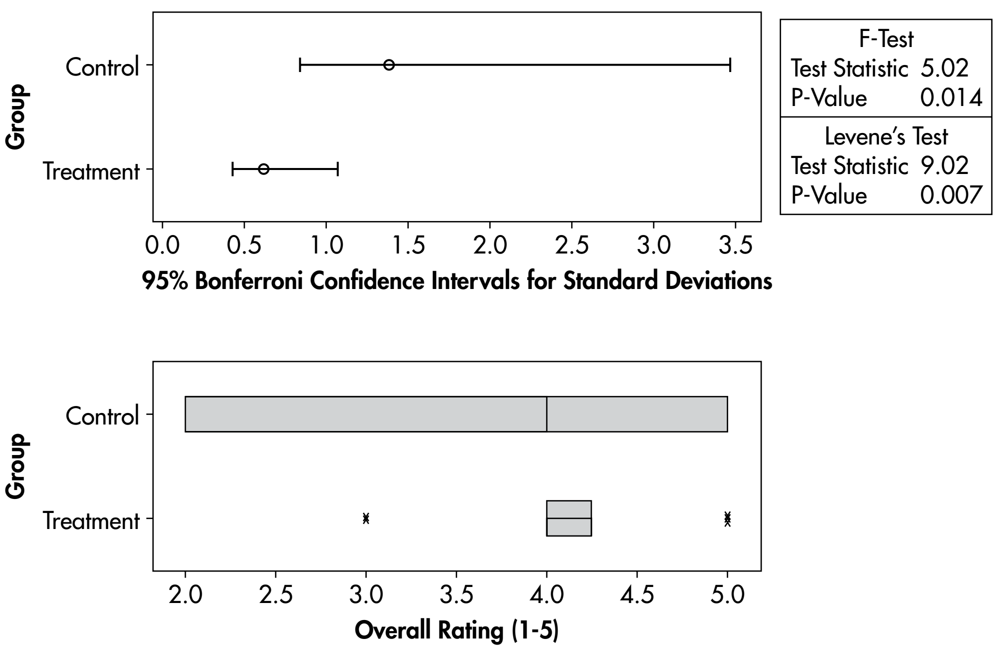


Table 2: Parametric and Non-parametric Hypothesis Test of Treatment (Blended Learning) Versus Control (Face-to-Face) Instructions on Quiz 1 and Quiz 2

					P-value		
	Mean	**Median**	**Std Dev.**	**T-test**	**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



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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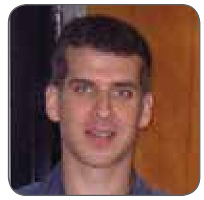

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An innovative partnership program that develops community college graduates into engineering leaders

Investing in Engineering Student Leaders Through Industrial and STEM Partnerships

Rhonda K. Kowalchuk, Bruce D. DeRuntz, and John W. Nicklow

Abstract

Students, universities, and industry are all struggling during these economically-challenging times. Students face rising tuition costs, universities face a reduction of state funding, and industry has a looming shortage of future technical leaders. Creating industrial and government partnerships to support the development of America's future technical leaders has become imperative. The Southern Illinois University Carbondale's (SIUC) Leadership Development Program (LDP) meets many of these pressing problems. The LDP has received more than $1 million from corporate sponsors and the National Science Foundation's (NSF) Science, Technology, Engineering, and Mathematics (STEM) program to attract and develop engineering technical leaders. The university strives to graduate community-college-degreed transfer students within two and one half-years in an engineering leadership program.

Keywords

STEM, Leadership, Training

Introduction

In its broadest perspective, the STEM initiative is about jobs for the American people that help grow the economy, maintain national security, and sustain the standard of living in the United States. Of course, achieving these objectives is all predicated upon the United States having a highly technically-educated workforce, capable of developing innovative products and processes. The America Competes Act, which was signed into law on August 9, 2007, seeks to double spending on NSF STEM education programs in response to a shortfall of college graduates in the technical fields (Kuenzi, 2008).

Historically, there has been little change in the total number of undergraduate and graduate students enrolled in engineering majors from 1989 to 2006 (National Science Board, 2012, Appendix Table 2-22). While this relatively flat statistic may suggest that students graduating with STEM majors are holding their own; the U.S. Bureau of Labor statistics is projecting an 11% increase in the demand for engineering professionals between 2008-18 (Bureau of Labor Statistics, 2010). With the launch of NSF's successful STEM initiative in 2007, there has been a significant increase in engineering majors (National Science Board, 2012, Appendix Table 2-22).

The National Association of Colleges and Employers salary survey (NACE, 2009) gives further evidence of the ongoing need for engineers. Their report presents data indicating that graduates with a bachelor's degree in engineering received the highest starting salary offers. This statistic, coupled with basic supply and demand market principles, confirms the ongoing shortage of new engineers entering the marketplace.

While it is a widely recognized that the United States is in need of an increasing number of STEM graduates, a greater crisis looms over a shortage of technical leaders. In his book *Where Have All the Leaders Gone?* Lee Iacocca (2007) focuses on the issue of a leadership shortage in the United States. He considers this core issue to be the greatest challenge facing the country and goes on to say:

> Name me an industry leader who is thinking creatively about how we can restore our competitive edge in manufacturing. Who would have believed that there could ever be a time when 'The Big Three' referred to Japanese car companies? How did this happen, and more important, what are we going to do about it? (p.13)

A great opportunity to fulfill the STEM mission has presented itself if key stakeholders from industry and academia can work collectively to attract community college graduates to baccalaureate-level degrees (President's Council of Advisors on Science and Technology, 2012). The public/private partnerships can create successful technical leadership development programs that can bring about a paradigm shift in the way technical leaders are created (Astin & Astin, 2000). This paper describes SIUC's success with such a program which helps to remove economic barriers that may otherwise prohibit college graduates from achieving an engineering degree and entering a technologically-challenging workforce.

Background

The SIUC's College of Engineering's LDP has achieved excellent growth and success in just its first five years. In 2006, Advanced Technology Services (ATS) CEO, Dick Blaudow, donated $250,000 to SIUC's College of Engineering (COE) to establish a leadership development program that would benefit all parties involved. This program was created with the intent and direction of supporting his alma mater, providing financial and career opportunities for students, and developing future leaders for ATS and the United States. The scholarship offers participating college students $18,000 toward the cost of two years of tuition, a summer internship with ATS, an opportunity for a fast-track career, and early leadership training and development. The early success of this program has inspired key stakeholders to expand the LDP model to more students, majors, and sponsors. In addition, NSF has recognized the potential of this program and has funded $600,000 toward its outreach to more students. NSF's investment is funding 30 scholarships over the next five years (2010-2015). Additionally, Blaudow continues to donate to the program and has invited the College of Business to participate with its students.

The LDP is a human resource development program that requires much more leadership than coordinating the allocation of scholarships. The LDP should be more closely identified with an ROTC program or top university scholarships because of the challenging program requirements and the commitment by recipients. The LDP enables recipients to make measurable progress toward developing their leadership skills by taking leadership classes with the engineering curriculum, assuming leadership roles in Registered Student Organizations (RSO), leading service projects throughout the year, developing and attending leadership workshops, and completing a summer internship.

A university's primary mission is to provide education for students and outreach services for the community. To support that mission, SIUC realized it could capitalize on its talent resources and invest in programs that attract business partners. Today, it is commonplace for the best universities to invest in research parks and centers of excellence as well as to provide matching funds for grants. Universities make these investments because the comprehensive financial returns they receive make it an attractive business proposition as well as a valuable service to the community.

The LDP is similar to other successful programs across the United States. Other prominent universities have realized the value of technical leadership programs and have made commitments to support their programs (Gordon, 2012). A few examples include: Bernard M. Gordon-MIT Engineering Leadership Program (pp. 85-91), Gordon Engineering Leadership Program (pp. 93-107), Bernard and Sophia Gordon Engineering Leadership Center University of California San Diego (pp. 133-140), the Iacocca Institute at Lehigh University, Tufts Engineering Leadership Program, University of Colorado Engineering Leadership Program, UC Berkely Engineering Leadership Professional Program, and the Miami University Lockheed Martin Leadership Institute. The LDP has realized many positive outcomes for its students and stakeholders in a short time. A few of those outcomes for students include: generous financial assistance; advanced career placement; industry internships leadership training and experience; as well as increased performance, including increased graduation rates, higher GPAs, and leadership recognition. The college receives multiple prestigious scholarships to offer, trained student leadership in most of the COE's 14 RSOs, the prestige of having one of the few technical leadership programs in the country, significant funding for their RSOs, an ability to attract high caliber students, national recognition at student competitions, greater student body participation in RSOs, tutoring support of the student body, larger and more successful service projects, stronger relationships with community college partners, and long-term industry relationships. The university receives strengthened relationships with industry and a proven student leadership model that can be expanded across the campus. Finally, industry receives future technical leaders that will allow them to meet their strategic objectives.

Project Goals

The goals associated with the LDP have evolved beyond meeting the needs of the financial sponsor. The corporate sponsor sought to attract graduates into their company, realize a financial return from intern Six Sigma projects, and recognize a high degree of leadership potential in the program graduates. The early success realized by the corporate sponsor led the way to winning an NSF STEM grant in 2010 to expand the program. NSF requires ongoing evaluation of the project to assess the progress toward achieving its primary objective.

The STEM grant aims to achieve a two and one half-year graduation rate (e.g., four and one half years after beginning at the community-college level) of at least 90%. Support activities for scholarship recipients build upon existing student support programs (e.g., peer mentoring, minority support programs, and tutoring). The intellectual merit of this funded project is the determination as to whether retention, graduation, and job placement rates of students attracted to engineering and technology can be increased by providing financial support and by implementing student support and leadership programs. The broader impact of the project is an increase in the breadth of social and economic backgrounds of students graduating in engineering and, thus, of prepared individuals entering the job market.

Methodology

Evaluation Design

The evaluation design for the NSF-funded project includes quantitative methods to assess the success of the LDP. Funding for the NSF project began in 2010 and, thus to date, only data for the first cohort is complete; however, preliminary data is presented for the 2011 cohort. Ongoing evaluation of the program for each cohort includes the following assessment tools: Student Leadership Practices Inventory (SLPI) (Kouzes & Posner, 2006); Grit Scale (Duckworth, Peterson, Matthews, & Kelly, 2007; Duckworth & Quinn, 2009; Jaeger, Freeman, Whalen, Payne, 2010); and student performance data (e.g., retention status and GPA). The LDP cohort group completes the SLPI and the Grit Scale at the start of their first year, at the start of their second year, and at the end of their second year of studies. A paired comparison with a peer group is identified from the current cohort of transfer students.

Instruments

The SLPI consists of 30 items with "six statements to measure each of The Five Practices of Exemplary Student Leadership" (Kouzes & Posner, 2006, p. 6). The five practices include Model the Way (finding your voice, setting the example); Inspire a Shared Vision (envisioning the future, enlisting others); Challenge the Process (searching for opportunities, experimenting and taking risks); Enable Others to Act (fostering collaboration, strengthening others); and Encourage the Heart (recognizing contributions, celebrate the values and victories) (pp. 11-16). The scores for each of the five practices range between six and 30. The internal consistency of the five practices varies from .68 (Model the Way) to .80 (Encourage the Heart) (p. 83).

The Grit Scale (Duckworth et al., 2007; Duckworth & Quinn, 2009; Jaeger et al., 2010) consists of 17 items measuring four subscales, and grit is defined as "perseverance and passion for long term goals" (Duckworth et al., 2007, p. 1,087). The four subscales include: Ambition, Perseverance of Effort, Consistency of Interest, and Brief Grit. For example, ambition is characterized by achieving something of lasting importance, high perseverance of effort relates to overcoming setbacks and challenges, and low consistency of interest relates to being distracted by new ideas and projects. In addition, there is a total grit score that has shown an internal consistency of .77 to .85 across studies (Duckworth et al., 2007). The brief grit is a subset of eight items from the Total Grit Scale. The scores for each subscale are averaged across their respective items and can range between 1 and 5.

Participants

Selection of first-year scholarship recipients was based upon financial need, community-college cumulative grade point average (GPA), an essay that outlines their career goals, and a personal interview. Peer comparison students were selected based on being admitted to the COE as a transfer student in the respective fall semester with a junior classification and a transfer GPA of 3.00 or greater. The GPA criterion was lowered to 2.75 or greater to increase the sample size for the peer comparison group in 2011 from 10 to 15 students.

In the 2010 cohort eight (80%) students were male and two (20%) were female, whereas in the 2011 cohort, all students were male. In the 2010 peer group, 16 (80%) students were male and four (20%) were female and in the 2011 peer group, 12 (80%) students were male and three (20%) were female. Student ethnicity distribution was: 2010 cohort, two (20%) Black and eight (80%) White; 2011 cohort, eight (100%) White; 2010 peer group, three (15%) Asian/Pacific Islander, one (5%) Hispanic/Latino, and 16 (80%) White; and 2011 peer group, 13 (87%) White and two (13%) unknown. The LDP cohorts are comprised of students primarily from Illinois' southernmost eight community colleges.

Findings

Retention and GPA

In the 2010 cohort (n = 10), three students left the LDP but remained enrolled in the COE, and one student left the university after his first semester. The two and one half-year graduation rate is six out of 10 (60%) for those students completing the LDP and eight out of 10 (80%) when including those students who left the LDP. In the 2010 peer comparison group (n = 20), one student switched majors in her second year, and one student left the university after his second year for academic reasons. The two-year graduation rate from the COE for the 2010 peer group is 11 out of 20 (55%) with an anticipated three-year graduation rate of 18 out of 20 (90%). No statistically significant difference (p = 0.05) was found for graduation rates between the 2010 cohort and peer groups. In the 2011 cohort (n = 8), one student switched majors after his first semester. The remaining seven students have been retained in the LDP. In the 2011 peer comparison group (n = 15), one student left the university in her first semester, and one student left the university after his second semester for academic reasons. Currently, retention rates are similar between the 2011 cohort and peer comparison groups.

Table 1 contains descriptive statistics for cumulative GPA for the LDP cohort and peer comparison groups at the end of year one and year two (e.g., their junior and senior years, respectively). It is noteworthy that all groups maintained an average cumulative GPA above 3.00, which is a requirement for the LDP. Furthermore, the LDP cohorts compared to their peer counterparts maintained a higher minimum GPA with less variability (e.g., smaller standard deviation). The 2010 cohort had higher average cumulative GPAs compared to their peer group, although not statistically significant (p=0.05).

SLPI and Grit Scale

Figure 1 contains the average scores for each of the five practices of the SLPI for the 2010 LDP cohort (n = 7) at the beginning of year one (Yr1), at the start of year two (Mid), and at the end of year two (Yr2); and the 2010 peer (n = 12) comparison group during their first year (Yr1) and at the end of year two (Yr2).

Examining the SLPI scores in terms of percentiles has shown that a "high" score is one at or above the 17th percentile, a "low" score is one at or below the 13th percentile, and a score that falls between those ranges is considered "moderate." (Kouzes & Posner, 2006, pp. 34-35). All scores fall in the moderate range with the following exceptions: the 2010 peer (Yr1) group score for the challenge subscale is high; the 2010 cohort (Yr1) group score for the enable subscale is high; the 2010 cohort (Yr1) group score for the challenge subscale is low; the 2010 cohort (Mid) group scores for the model, inspire, challenge, and encourage subscales are low; and the 2010 cohort (Yr2) group scores for the model, inspire, and encourage subscales are low.

An interesting finding is the drop in SLPI scores for the 2010 cohort and the consistency in pattern from the start of their second year (Mid) to the end of their second year (Yr2). Similarly, the 2010 peer comparison group also showed a drop in SLPI scores. Students complete the SLPI themselves throughout the program, during that time their education and experiences enlighten them as to what it truly takes to be a leader (per The Leadership Challenge workshop training and LDP). By the conclusion of their training and leadership experiences most of them have become "humbled" leaders who feel that there is so much more they need to do to become competent leaders who have earned the trust of their team. An improvement to this data collection methodology was made by conducting a 360-degree evaluation of the future leaders by their peers and program director (implemented in the spring 2012). One shortcoming of this approach would be the lack of data attainable at the start of the students' program because none of their peers or director would know them well enough to evaluate them and establish an absolute beginning baseline, more like a mid-training baseline.

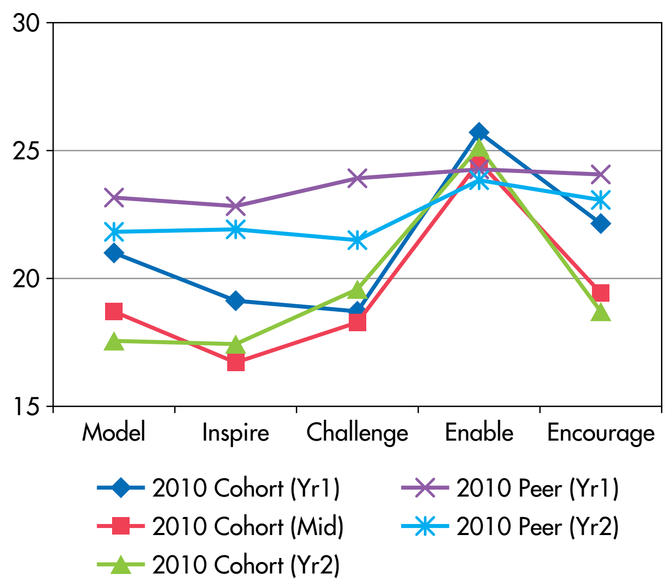
Figure 2 contains the average scores for each of the five practices of the SLPI for the 2011 LDP cohort (*n* = 7) at the beginning of year one (Yr1) and at the start of year two (Mid); and the 2011 peer (*n* = 9) comparison group during their first year (Yr1). All scores fall in the moderate range with the following exception, the 2011 peer (Yr1) group scores for the Model, Enable, and Encourage subscales are low.

Table 1: Descriptive Statistics on Cumulative GPA for LDP Cohort and Peer Comparison Groups

Group	Time	N	Min/Max	Mean	SD
2010 Cohort	Year 1	7	2.29/4.00	3.38	0.59
	Year 2	6	2.94/4.00	3.47	0.44
2010 Peer	Year 1	20	2.08/4.00	3.19	0.65
	Year 2	18	2.48/4.00	3.24	0.53
2011 Cohort	Year 1	7	2.57/4.00	3.25	0.53
2011 Peer	Year 1	14	1.54/4.00	3.34	0.62

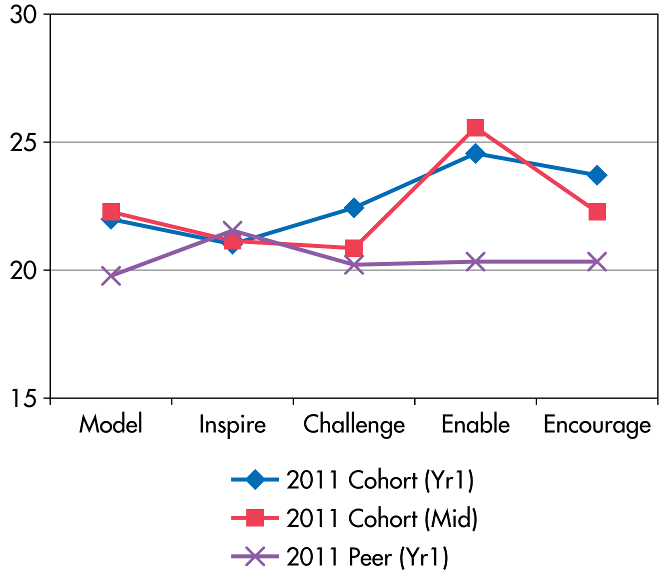
Note. Min = minimum score, Max = maximum score, *SD* = Standard Deviation. None of the mean comparisons between the respective cohort and peer groups were statistically significant at the 0.05 significance level

Figure 1: SLPI Mean Scores for 2010 LDP Cohort and Peer Comparison Groups



The 2011 cohort has a similar overall profile pattern compared to the 2010 cohort; however, the mean scores across subscales are higher for the 2011 cohort with the exception of the enable subscale.

Figure 2: SLPI Mean Scores for 2011 LDP Cohort and Peer Comparison Groups



In addition, for the 2011 cohort, the mean scores across subscales is fairly consistent from year one to the start of year two (Mid) with a slight drop in mean scores for the challenge and encourage subscales, whereas in the 2010 cohort, mean subscale scores showed a drop in scores for three out of the five subscales (e.g., model, inspire, and encourage). Also noteworthy is that the 2011 peer group has lower mean scores for four out the five subscales compared to the 2011 cohort group. This finding is opposite to the pattern observed in the 2010 cohort and peer groups on the SLPI.

Table 2 contains descriptive statistics for the Grit Total Scale score and the subscales (ambition, perseverance of effort, and consistency of interest) for the 2010 LDP cohort at the beginning of year one (Yr1), at the start of year two (Mid), and at the end of year two (Yr2); the 2011 LDP cohort at the beginning of year one (Yr1) and the start of year two (Mid); the 2010 peer comparison group during their first year (Yr1); and the 2011 peer comparison group during their first year (Yr1). For the 2010 cohort group, there was a drop in total scale scores from year one, to the end of year two, whereas for the 2011 cohort group, there was a slight increase in total scale scores from year one to the start of year two (Mid). The respective peer comparison groups have lower overall total scale scores, albeit still above the mid-point on a five-point scale.

Table 2: Descriptive Statistics on Grit Scale for LDP Cohort and Peer Comparison Groups: Mean (Standard Deviation)

Group	Time	*n*	Total	Ambition	Perseverance of Effort	Consistency of Interest
2010 Cohort	Year 1	7	3.94 (0.20)	4.40 (0.40)	4.26 (0.27)	3.62 (0.44)
	Mid	7	3.67 (0.48)	4.00 (0.67)	4.05 (0.51)	3.29 (0.47)
	Year 2	6	3.61 (0.45)	3.93 (0.47)	4.06 (0.52)	3.17 (0.43)
2010 Peer	Year 1	13	3.85 (0.42)	4.25 (0.50)	4.17 (0.65)	3.53 (0.39)
2011 Cohort	Year 1	8	3.73 (0.62)	4.25 (0.92)	4.02 (0.88)	3.44 (0.56)
	Mid	7	3.83 (0.23)	4.26 (0.30)	4.14 (0.35)	3.52 (0.26)
2011 Peer	Year 1	11	3.52 (0.47)	3.87 (0.92)	3.79 (0.85)	3.24 (0.46)

Note. None of the mean comparisons between the respective cohort and peer groups were statistically significant at the 0.05 significance level.

Although the SLPI and Grit Scale are measuring different constructs, the drop in Grit scores for the 2010 cohort mirrors the drop in scores for the five practices of the SLPI, whereas for the 2011 cohort, the Grit scores are fairly consistent across measurement occasions, similar to the pattern of scores for the SLPI. Furthermore, the 2011 peer group shows lower Grit scores compared to the 2010 peer group, which is consistent with the scores on the SLPI. The lowest subscale scores for the Grit Scale occur for the consistency of interest subscale, yet remain above the mid-point of a 5-point scale. These results are consistent with those found by Jaeger et al. (2010) for engineering majors. To assist in interpreting the Grit Scale, one can compare the results for the total scale score to previously published studies (see Table 2 from Duckworth et al., 2007 and Table 1 from Jaeger et al., 2010). These results show that our engineering transfer students are grittier than engineering freshmen and Ivy League undergraduates and are more similar to West Point Cadets in terms of overall grit. Not surprisingly, it takes perseverance and passion (grit) to become an engineer.

Summary

It is important to note that the LDP began with a private donation in 2007. Since that time, there have been four cohorts of students graduate from the program. The first cohort of NSF-funded students began the two-year training program in 2010 and completed it in 2012. Only the NSF-funded cohorts have peer comparison data due to the program evaluation aspects of the grant. The tangible and intangible rewards associated with a successful leadership program are numerous and many will not be recognized for years to come. It has been our experience that the more successful the program becomes the more opportunities that are presented. The achievements of the program since 2007 have been divided into the groups that represent the major stakeholders: students, university, industry, and NSF.

Student leadership achievements: Above 3.0 cumulative GPA at graduation, four recipients of the Illinois Technology Foundation's "50 for the Future" Award, three recipients of the Outstanding Senior Awards in the COE, presidents in nine student organizations, more than $40,000 raised for other student organizations, two national robotic championships, three new student organizations established, a sixth place showing in NASA's Great Moon Buggy design competition, first place finishes in two campus-wide blood drives, and leadership of more than 30 university and community service projects.

University achievements: Named best ATMAE student chapter in the nation, earned the best student organization award for the university, achieved 80% graduation in two and one half-years for the 2010 cohort, raised more than $325,000 in donations from sponsor for scholarships, and awarded $600,000 NSF STEM grant for the expansion of the program.

Industry achievements: Delivered more than $2 million in six sigma cost savings during the internships and signed 13 out of 17 students interns to work for ATS; both early positive indicators of LDP's success.

NSF achievements: Eighty percent graduation rate and all students who completed the LDP are employed in a STEM field for the 2010 cohort.

Suggestions for Best Practices

Every program of this nature will experience successes and disappointments. It is important to realize the lessons that can be learned from a disappointment. Suggestions can be divided into three groups: program development, student leadership development, and industry partnership.

To improve the development of the program: First, it is suggested to lengthen the student's participation to three years. It has been observed that the mastery of leadership skills increases greatly in the second and third years for students. Second, program directors should consider developing a team-building week that will unite all of the incoming and present students the week before the school year starts. Third, while NSF or corporate financial funding can often be generous, it is equally important to secure university support so the program is truly valued by all stakeholders.

For improving student leadership development: First, the majority of the best learning occurs through experiences. The LDP students realized most of their best learning by serving as a student organization president or leading an applied project. Second, having upperclassmen mentor younger students accomplishes two goals. One, it develops the younger students faster by giving them a steady stream of experienced feedback and two, it teaches the older students how to give constructive feedback for developing the maximum potential in someone else. Third, it was determined that using service projects to learn how to lead a team, coupled with a structured evaluation system was a very effective method for accelerating a young leader's development.

For improving industry sponsorship: The easiest way for a corporate sponsor to contribute to the program is to donate money. While this is an important element to making the program operate, providing meaningful internships, offering career planning within the sponsoring company, and conducting professional development seminars for the students have shown to produce the greatest benefit for the sponsor to achieve its objectives.

Conclusions

The SIUC LDP will graduate its fifth cohort of future technical leaders in May 2013. From all indications, the program is gaining acceptance, momentum, and success. A couple of prime indicators are the award of an NSF STEM grant, additional financial support from the sponsoring company, addition of a second corporate sponsor, and the many positive endorsements by the key stakeholders, including the following:

> "The technical leadership program in manufacturing is integral to ATS' future growth and development of our leaders. The program has met and exceeded our expectations and initial goals. We are fortunate to have such a unique program to feed our future pipeline and are able to hire based on results versus just their interview. "
>
> —Jeff Owens, president, Advanced Technology Services

> "The LDP has been the most beneficial student development and corporate sponsorship I have ever been associated with as a college dean. The program continues to exceed the goals and expectations I have set for it."
>
> —John Warwick, dean, College of Engineering

> "Program has greatly impacted not only my career but also my outlook on life. Through this experience, I have learned about the impact I can make in business and my community. "
>
> —Nick Turnage, LDP graduate

From the NSF's perspective, the primary objective of the project is to achieve a two and one half-year graduation rate of at least 90%.

For the 2010 cohort, six out of 10 students remained in the LDP and three students remained enrolled in the COE. A two and one half-year graduation rate of 80% has been achieved if we broaden the definition to include students retained in the COE. For the 2011 cohort, seven out of eight students (88%) remain in the LDP and are on track to graduate within that time frame. A goal of the project is to determine the impact of providing financial support and implementing a leadership program on retention, graduation, and job placement rates. Ongoing evaluation of the project will assess these rates and the broader impact of the program.

Future Work/Research

The success of the program has generated a lot of interest with the primary stakeholders. The authors believe that they have developed a successful model that can be expanded across campus to benefit STEM majors first, followed by other interested colleges. Research could be conducted to study the LDP model's success as it is applied to these different fields.

Perhaps the greatest opportunity for future research is already underway with the LDP's corporate sponsor, ATS. From the very beginning of the program, ATS insisted that a longitudinal study be conducted with the new hires who graduated from the LDP. While a program evaluation is scheduled for year five of the program, the researchers do not anticipate being able to determine any significant findings in the graduates' careers until year 10. Additionally, conversations have begun with the SIUC College of Business as it now expressed the need for business-minded graduates with leadership skills.

The last promising opportunity for future research requires a macro research project that would bring together a consortium of the technical leadership programs at universities. Consortium members could use their collective experience from their training programs and sponsor outcomes to develop a best practices guide that would become the curriculum for STEM-funded leadership programs.

Editor's Note: This article is updated from the conference paper, "Industrial and STEM Partnership Creates Engineering Student Leaders," presented at the 2012 ASQ Advancing the STEM Agenda Conference at the University of Wisconsin-Stout, Menomonie, WI.

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Quality Approaches in Higher Education

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- Case studies research studies, or conceptual articles on how student service units and intervention programs impact the quality of student experience and student learning.
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Quality Approaches in Higher Education

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- Studies or conceptual articles on how higher education practices impact the quality of student life for different student populations.
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