AC 2010-535: IMPROVING INDUSTRIAL ENGINEERING CAREER EFFICACY THROUGH INTRODUCTORY COURSE DESIGN

Lesley Strawderman, Mississippi State University

Laura Ruff, Mississippi State University

Improving Industrial Engineering Career Efficacy through Introductory Course Design

Abstract

This study seeks to further examine self-efficacy beliefs of engineering students beyond their first-year experience. Specifically, this study focuses on career efficacy, or student perceptions of their ability to succeed in a particular career field. A 41-question survey was distributed to undergraduate Industrial Engineering students in the United States. The survey was divided into four parts: student information, career efficacy, course information, and course evaluations. Recruitment for the survey was sent via email, and 231 students submitted complete and usable responses. Results demonstrated that discipline-specific introductory courses led to significantly higher levels of career efficacy when compared to general introductory courses. Additionally, junior and senior level students reported significantly higher levels of career efficacy than lower level students, as did those who were highly satisfied with their introductory course experience. Implications and guidelines based on these results for the design of introductory courses in Industrial Engineering are discussed.

Introduction

Undergraduate students, upon selecting a major, often take an introductory course that allows them to determine the suitability of their chosen field. Within Industrial Engineering, introductory courses are commonly taught within the Industrial Engineering department, focusing on discipline-specific topics and information. Other programs offer introductory courses on a college-wide level, introducing students to the various fields of engineering. Course content and delivery method also varies between programs.

Student self efficacy is a demonstrated and valid predictor of student success. Students who possess higher levels of self efficacy are more successful, while the inverse is also true. While the direction of the relationship is up for debate (e.g. does efficacy cause success or does success cause efficacy), as educators we strive to help students achieve both self efficacy and success. The purpose of many introductory courses is to help students succeed in their chosen academic program, as well as prepare them for a career in their chosen field. Therefore, the examination of students' career efficacy is critical when evaluating introductory courses. Career efficacy measures a student's beliefs regarding their aptitude for success in their chosen career field. A beneficial and well designed introductory course should provide students with increased career efficacy.

Literature Review

As retention rates of students in engineering majors continue to decline, introductory courses have become a common component of many undergraduate engineering programs. Several studies have examined the effectiveness of various types of introductory courses. Hoit et al. showed that the conversion of a lecture-based multidisciplinary introductory course to a laboratory-based course that engaged students in "hand-on" activities for each undergraduate engineering discipline resulted in significant improvements to retention in engineering[1]. A similar attempt to implement active learning through a freshman year course that focused on an interdisciplinary design project was attempted by Courter et al. with no evidence of significant improvements in retention[2]. An alternate approach was used by Hatton et al. in which an altered "Introduction to Engineering" course focused more on student development and success skills than the traditional course's overview of engineering disciplines. Students had more positive attitudes about their university than those who took the traditional introductory course, but significant improvements in retention to engineering were not observed[3]. An intensive multidisciplinary introductory course, which covered two semesters and included multiple design projects and a wide range of conceptual topics, has been experimented with by Morris[4].

Although the success of introductory courses is typically measured in academic outcomes such as university and major retention rates, degree attainment, and grade point averages, additional literature suggests that students' efficacy beliefs may be an important measure of course effectiveness[5]. Self-efficacy, as first described by Bandura[6], can positively or negatively influence behavior based on a person's perception of his abilities to successfully complete a task. Self-efficacy beliefs of undergraduate students in STEM (i.e. Science, Technology, Engineering and Mathematics) majors have been linked to success and persistence within these fields[7]. Additionally, self-efficacy beliefs have been shown to affect interest, expectations, and choices of engineering students[8-9].

Previous work examined self-efficacy beliefs of students in relation to their expectations and perceptions of in a first-year engineering course. The difference between expectations and perceptions was found to be significantly related to academic, team, and career efficacy. Additionally, self-efficacy beliefs were found to be significantly related to student satisfaction[10]. This study seeks to further examine self-efficacy beliefs of engineering students beyond their first-year experience. Specifically, this study focuses on career efficacy, or student perceptions of their ability to succeed in a particular career field. By targeting students' career efficacy beliefs, introductory courses should become more adept at preparing students for a successful future in an engineering field. Specific hypotheses include:

- H1. Discipline-specific introductory courses are positively correlated with career efficacy.
- H2. Laboratory-based introductory courses are positively correlated with career efficacy.
- H3. Increased career efficacy from introductory courses is confounded by demographic factors.
- H4. Upperclassmen have higher levels of career efficacy than underclassmen.
- H5. Satisfaction with introductory courses is positively correlated with career efficacy.

Methodology

A 48- item online survey was developed for data collection through a survey hosting website. The survey contained four sections: demographics (20 questions), course information (15 questions), career efficacy (4 questions), and course evaluation (9 questions). The course information section addressed the content and structure of the introductory course taken (delivery method, credit hours, class size, instructor, grade assignment, topics covered) as well as when students took the course and what grade they received. The course evaluation section addressed students' likes, dislikes, and overall satisfaction with the introductory course that they took. The career efficacy section addressed students' perceptions of their ability to succeed in industrial engineering. Career efficacy questions are shown in Table 1 and course satisfaction questions are shown in Table 2. Each question was formatted using a 5-point Likert scale, with 5 representing "Strongly Agree" and 1 representing "Strongly Disagree."

Table 1. Career Efficacy Survey Questions

1. I'm certain that I can be successful in my industrial engineering program.
2. I'm confident that I can master the skills needed for the field of industrial engineering.
3. I'm confident that I can overcome challenges in my industrial engineering career.
4. I'm certain that industrial engineering is the right career choice for me.

Table 2. Satisfaction Survey Questions

1. The course increased my desire to become an industrial engineer.
2. I learned new information about industrial engineering in the course.
3. The course taught me information that will be useful in my career.
4. The course was critical to my industrial engineering education.
5. I enjoyed taking this course.
6. The course is worthwhile for industrial engineering students.

A recruitment email containing the survey link was issued to all undergraduate Industrial Engineering programs in the country. During the two weeks of data collection, 273 students took the online survey. A total of 231 responses were complete and usable for data analysis. Participants were given the option of entering a drawing to receive compensation for completing the survey. Five participants were chosen at random and a $50 gift card was mailed to the winners.

Among respondents, approximately 57% were male and 43% were female. Regarding classification, approximately 65% of respondents were seniors, 19% were juniors, 13% were sophomores, and 3% were freshmen. Approximately 68% of respondents had a GPA above 3.00, and approximately 68% had prior work experience. Among those with work experience, 62% had co-oped or interned in industrial engineering. Transfer students accounted for 28% of respondents. Approximately 84% of respondents had completed an introductory course in industrial engineering, while most others (15%) had completed a general engineering introductory course. Remaining respondents reported having completed an introductory course for engineering and science majors or some other type of introductory course. Approximately 49% of respondents reported having taken an introductory course with both lecture and laboratory components, while 48% of respondents reported that their introductory course was lecture only. Remaining respondents (2%) reported having taken a laboratory only course.

Raw data was downloaded from the survey host and Likert-scale responses were coded for analysis. Following descriptive analysis of the data, hypotheses were tested using ANOVA and Pearson correlation tools in MINITAB.

Results

An overall career efficacy score was calculated by averaging responses for each of the four efficacy questions. The mean overall career efficacy for all respondents was 4.27 with a standard deviation of 0.74. The following sections investigate differences in career efficacy based on course structure, demographics, and student satisfaction.

Course Structure

The design and delivery of an introductory course is the first aspect of the results that were investigated. As shown in Table 3, the type of course, structure of the course, and number of credit hours offered by the course were evaluated to examine the impact of each on average career efficacy.

A significant difference was found in average career efficacy when examining the type of introductory course taken ($F = 3.34$, $p = 0.037$). Students who took a discipline-specific (industrial engineering) course had higher career efficacy when compared to those who took a general engineering introductory course. This supports the first hypothesis that discipline-specific introductory courses lead to higher career efficacy scores.

There was no statistical support for the second hypothesis that course structure (lab versus lecture) impacted career efficacy. No significant difference was found between students' scores based on the course structure ($F = 0.16$, $p = 0.851$). Additionally, no significant relationship was found between the number of credit hours offered in the course and career efficacy ($F = 0.15$, $p = 0.964$).

Table 3. Impact of Course Structure on Average Career Efficacy

Variable	Sample Size	Mean	Standard Deviation
Type of Introductory Course Taken			
Industrial Engineering	194	4.32	0.68
General Engineering	35	3.98	1.01
Engineering & Sciences	2	4.00	0.00
Introductory Course Structure			
Lecture-based	112	4.24	0.82
Lecture/Lab Combination	114	4.29	0.68
Laboratory-based	5	4.20	0.54
Number of Credit Hours in Introductory Course			
Zero	4	4.38	0.43
One	66	4.26	0.79
Two	45	4.22	0.87
Three	99	4.30	0.70
Four	17	4.19	0.54

Demographic Factors

The efficacy results were also analyzed based on various demographic factors, as shown in Table 4. Specifically, gender, classification, co-op experience, transfer student status, and GPA were all examined.

Student classification proved to significantly impact average career efficacy ($F = 2.98$, $p = 0.032$), as predicted in the third and fourth hypothesis. Higher classification levels (juniors and seniors) had significantly higher efficacy scores than lower classification levels. However, no other demographic factors had an individual significant impact on average career efficacy scores. This included gender ($F = 0.68$, $p = 0.410$), co-op experience ($F = 1.29$, $p = 0.257$), transfer student status ($F = 0.02$, $p = 0.886$), and GPA ($F = 1.39$, $p = 0.227$). Analyzing the demographic factors in a combined manner, rather than individually, may lead to significant results in future studies. For example, the effect of co-op experience may be more pronounced when it is considered along with GPA.

Table 4. Impact of Demographics on Average Career Efficacy

Variable	Sample Size	Mean	Standard Deviation
Gender			
Male	131	4.30	0.67
Female	100	4.22	0.83
Classification			
Freshman	7	3.68	1.22
Sophomore	43	4.08	0.97
Junior	151	4.34	0.66
Senior	30	4.28	0.53
Co-op/Intern Experience in Industrial Engineering			
Yes	101	4.33	0.76
No	130	4.22	0.73
Transfer Student Status			
Transfer student	51	4.28	0.83
Non-transfer student	180	4.27	0.72
GPA			
4.00	8	4.38	0.46
3.50 – 3.99	70	4.35	0.62
3.00 – 3.49	88	4.25	0.87
2.50 – 2.99	56	4.25	0.68
2.00 – 2.49	8	3.75	0.81
Below 2.00	1	3.25	---

Student Satisfaction

The impact of student perceptions/satisfaction with the introductory course was also examined to see if a significant impact on career efficacy existed. Specifically, students' average satisfaction scores and the grade received in the introductory course were analyzed.

Both variables were found to significantly impact career efficacy, as predicted in the fifth hypothesis. Students who had higher satisfaction scores with the course had significantly higher efficacy scores ($F = 8.66$, $p < 0.001$). Additionally, satisfaction and career efficacy scores were significantly correlated ($r = 0.335$, $p < 0.001$). The grade a student received in the introductory course also had a significant impact on career efficacy (F = 2.74, p = 0.030). Students who received an "A" in the course had significantly higher efficacy scores than those who received a "B."

Table 5. Impact of Student Satisfaction on Average Career Efficacy

Variable	Sample Size	Mean	Standard Deviation
Average Satisfaction with Introductory Course			
>4.00	125	4.41	0.60
3.00 – 3.99	74	4.16	0.81
2.00 – 2.99	28	4.14	0.57
<2.00	4	2.75	2.06
Grade Received in Introductory Course			
A	168	4.32	0.69
B	43	3.95	0.96
C	5	4.50	0.50
No Grade Assigned	12	4.54	0.33
Pass	3	4.25	0.66

Qualitative Results

Qualitative results from the course evaluation section of the survey provide additional insight into factors of introductory course design that promote success within undergraduate industrial engineers. The open-ended questions which asked students what they liked, disliked and would change about the course revealed some clear preferences in course components that were not apparent in the quantitative analysis. Foremost, students perceived team work as a valuable component of introductory courses both for its hand-on approach to learning as well as its ability to foster relationships among team members. From one student's perspective, the course "helped establish friends and colleagues in the department. Since then, I have had a friend in almost every class that I've taken, which has helped me perform better in classes." Another student referred to team experience as "invaluable, even if we lack technical proficiency in industrial engineering techniques for problem solving." In addition, students frequently commented positively about guest speakers from industry who spoke during the course, and many of the aspects mentioned for change within the course dealt with bringing in more guest speakers or visiting more workplaces in order to enlighten students from an industry perspective.

Discussion & Conclusions

The results presented above demonstrate a number of key findings that can be used to improve student career efficacy by examining the design of introductory courses. The average career efficacy of all respondents was very high, 4.27. This speaks very highly of the current state of industrial engineering education in preparing students to be confident engineers in the field. The finding that more senior level students had higher efficacy was not surprising. It can actually be expected as students are more exposed to topics and courses related to the field, which should help them to validate their choice of profession.

With respect to course design, discipline-specific introductory courses within industrial engineering led to significantly higher career efficacy scores when compared to general introductory courses. To best prepare our students for careers in their chosen field, it is essential that they be exposed to topics in the field early in their academic career. The significant relationship between satisfaction with the introductory course and career efficacy is also intuitive. Those that enjoyed an introductory industrial engineering course will likely have higher confidence that industrial engineering is the right career field for them.

In conclusion, the design of introductory courses in industrial engineering was shown to have a significant impact on students' career efficacy. Therefore, it is important to design the courses with student outcomes in mind, particularly their preparation for careers as industrial engineers. The project work presented in this paper is ongoing. Future work includes expanded analyses that will focus on assessing the impact of various factors on individual efficacy and satisfaction questions, rather than average scores. The data will also be used to develop a predictive model of career efficacy. Finally, the project will be expanded beyond industrial engineering, to determine if similar conclusions can be drawn in other disciplines.

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