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Extracurricular Fieldtrips to Theme Parks to Teach Creativity and Innovation

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Fieldtrips to Theme Parks to Teach Creativity and Innovation

Abstract

The United States National Academy of Engineering produced its seminal work, *The Engineer of 2020 – Visions of Engineering in the New Century*, to prepare industrial, governmental, and academic institutions for the future of engineering. The authors of the report state, "*Emphasis on the creative process will allow more effective leadership in the development and application of next-generation technologies to problems of the future.*" In 2011, 2012, and 2013, engineering undergraduates from Valparaiso University participated in a four-day off-site extracurricular fieldtrip focused on creativity, innovation, teamwork, and leading the creative process. The course was taught by members of the engineering faculty and included on-location sessions and tours led by employees and cast members from an external training organization. Pre- and post-course surveys identify a significant improvement in the students' understanding of the roles of leadership, communication, and teamwork in the creative process. In an attempt to determine how much the students benefitted from the fieldtrips, a full class dedicated to the creative process was taught along with the trip in 2014. Quantitatively, students who participated in only the fieldtrips showed improvements similar to those who also participated in the full class. However, additional qualitative results indicate that students who participated in the full course with a fieldtrip experience had higher levels of confidence and affinity for the program.

Introduction

In December 2001, The National Academy of Engineering established a steering committee to envision the state of engineering in 2020 and develop a framework for the future of undergraduate engineering education in the United States[1]. The 2004 final report, *The Engineer of 2020 – Visions of Engineering in the New Century* was published to present the Academy's aspirations describing the skills required for engineers completing an undergraduate degree in 2020.

As expected, strong analytical skills and the ability to work under increasing economic, legal, and political constraints were highlighted. However, the text is overwhelmingly dedicated to identifying a number of professional skills as essential attributes of the 2020 engineer: practical ingenuity, creativity, communication, business management, and leadership. However, in the report's executive summary, the authors conclude: *"If the United States is to maintain its economic leadership and be able to sustain its share of high-technology jobs, it must prepare for a new wave of change. While there is no consensus at this stage, it is agreed that innovation is the key and engineering is essential to this task….*"

Of the identified soft skills, engineering students are often most challenged to develop and hone their skills in creativity and innovation. For engineers, creativity may be defined as developing novel and original ideas with emphasis on their applicability to solving problems[2, 3]. This definition of creativity is more specific for engineering students than for students in other majors (i.e. art, music, creative writing, theater, etc.). For engineers to exercise creativity within their discipline, they must emphasize utility within the constraints of the physical world[4]. Aesthetics are secondary to solving problems or forestalling future problems[3].

Resources exist to teach creativity within an engineering context[5]. However, teaching engineering students a disciplined approach to the creative process has eluded most academia[6]. While students and professors alike have increased interest in creativity, engineering curricula are still overwhelmingly focused on mathematics, sciences, and engineering fundamentals[7]. Therefore, a need exists to instruct engineering students in a creative process that complements their existing engineering, math, and science classes.

Previous Work

To address the development of its undergraduate engineering students' soft skills, Valparaiso University began in 2001 to incorporate lessons encouraging their development in its senior design class[8]. Specific lessons on creativity were embedded into additional classes in the following years[9]. However, engineering students have been found to be better prepared for solving engineering problems by introducing concepts like creativity outside of traditional classrooms[10]. Therefore, teaching engineering students the creative process should be performed in an immersive environment with student-centered, experiential activities[11]. Such environments allow professors to act more as facilitators, allow students to take greater responsibility for their own education, and increase the levels of interactive education and peer-to-peer learning[11].

After reviewing the National Academy of Engineering's *The Engineer of 2020*, Valparaiso University began to offer a short course on creativity and innovation.[12-16] The course would introduce engineering students to the creative process and the differences between creativity (doing/making something new) and innovation (doing/making something better). These simple definitions for creativity and innovation were easy for students to grasp from the first day of class and were readily applicable as students were challenged to define and explore creative and innovative steps in the engineering design process. The class would complement rather than repeat other curricular efforts fostering creativity and innovation[9]. While the class has undergone evolutionary changes over the past five years, the course is presently known as ECE490 / Creativity and Innovation in the Engineering Design Process.

The first key decision was to partner with an external training organization to develop the course. This was done for two reasons. First, working with an external training organization would help reduce the faculty load required for the course. The course would only be offered as a four-day "fieldtrip," so minimal faculty resources would be required to support the class. Second, working with a well-known organization would bring a certain amount of prestige to the course (as we saw with our Effective Communication and Human Relations - Skills for Success course developed with Dale Carnegie[9]). After researching a number of options, we decided to work with an external training organization (ETO), a corporation known world-wide as a leader in creativity and innovation.

A significant amount of discussion was undertaken to decide if the fieldtrip should be offered for credit or non-credit. Upon a recommendation by the Dean of the College of Engineering, the course was offered for one credit. There were two reasons for this decision. First, students were required to participate in approximately twenty hours of lecture and laboratory activities over the four-day trip. Second, offering the course for credit allowed the students' participation to appear on their transcripts. This allowed students to demonstrate their participation to future employers, and the College of Engineering had some leverage to dictate appropriate behavior in the class.

The three key objectives for ECE490 are shown in Table 1[14]. It is worth mentioning that the second and third objectives do not lend themselves well to assessment. However, they served admirably in the past for student self-assessment. In the Discussion portion of this paper, their suitability will be addressed.

Table 1: Objectives for Creativity and Innovation in the Engineering Design Process Class. Students Will Be Able to:

1.	Use tools and processes that help them to be more creative and innovative.
2.	Explain how individuals can be more creative and innovative.
3.	Explain the role of a leader in the design process.

A total of 63 undergraduate engineering students participated in the 2011, 2012, and 2013 fieldtrip courses (21, 26, and 16 students, respectively). The 63 students were asked if they were creative and to assess their abilities to meet the three objectives in Table 1 using a Likert scale (1 being "No, Not At All" and 5 being "Yes, Definitely"). Because the students in the class self-selected to enroll, a control group of 24 undergraduate engineering students was given the same survey to see if the class participants showed any inclination prior to the trip that may have differed from their peers. The outcomes of the survey are shown in Figure 1[12]. From the responses, it appears the average of the self-selected course participants is comparable to the control group.

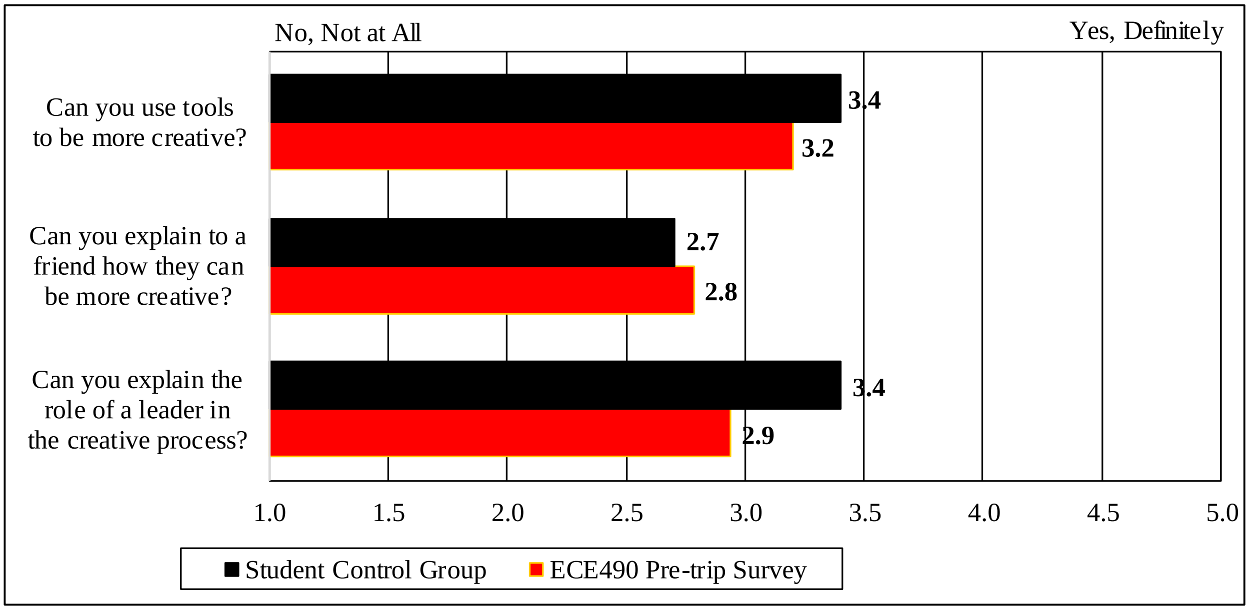

Figure 1. Averages of student self-assessments performed before the 2011, 2012, and 2013 ECE490 Creativity and Innovation in the Engineering Design Process course using a Likert scale (1 being "No, Not At All" and 5 being "Yes, Definitely"). Data is also provided for a control group of students that did not participate in fieldtrip course.

Traditionally, ECE490 was held over a four-day fall break and began with students transporting themselves to the local airport. At the airport, students received the fieldtrip textbook[17], a reading assignment for the flight, and additional details about the course's activities. Upon their arrival in Florida, students receive additional orientation and a quick introduction of creativity and innovation by participating in a variety of theme park attractions. The majority of the fieldtrip course content was delivered on Thursday, Friday, and Saturday, with a brief session on Sunday morning followed by the return home. An outline for the 2013 fieldtrip course is shown in Figure 2.

The average student price for the fieldtrip course has been $980. This price included flights, hotel, theme park tickets, food, and all workshops, tours, and discussion sessions. Partial scholarships donated by an alumnus were available.

<table>
<tr><th></th><th>Wednesday</th><th>Thursday</th><th>Friday</th><th>Saturday</th><th>Sunday</th></tr>
<tr><td>7:00 AM</td><td></td><td>Bus to Theme Park</td><td>Bus to Theme Park</td><td>Bus to Theme Park</td><td>Bus to Theme Park</td></tr>
<tr><td>8:00 AM</td><td></td><td rowspan="3">Theme Park Tour

Origins of Theme Parks

Creativity vs. Innovation</td><td rowspan="4">Workshop

Leading the Creative and Innovation Process

Leadership Styles and Techniques</td><td rowspan="4">Workshop

Techniques of Teamwork Through Improvisation</td><td rowspan="3">Faculty Led Discussion

Exploring the Engineering Vocation</td></tr>
<tr><td>9:00 AM</td><td></td></tr>
<tr><td>10:00 AM</td><td rowspan="2">Drive to Airport</td></tr>
<tr><td>11:00 AM</td><td>Monorail to Theme Park</td><td rowspan="3">Bus to Airport</td></tr>
<tr><td>12:00 PM</td><td rowspan="2">Get Boarding Pass
Go Through Security
Lunch on Your Own</td><td>Lunch / Play</td><td>Lunch / Play</td><td>Lunch / Play</td></tr>
<tr><td>1:00 PM</td><td rowspan="2">Workshop

The Design Process</td><td rowspan="3">Discussion

The Role of the Engineer in Theme Park Design</td><td rowspan="3">Faculty Led Discussion

Old vs. New

Old Isn't Bad
New May Not Be Better</td></tr>
<tr><td>2:00 PM</td><td rowspan="3">Flight</td><td rowspan="5">Flight</td></tr>
<tr><td>3:00 PM</td><td rowspan="3">Faculty Led Workshop

Creativity and Innovation

How the Two Fuel the Design Process</td></tr>
<tr><td>4:00 PM</td><td rowspan="2">Faculty Led Discussion

Thrill Rides
Virtual Reality
Animatronics 101</td><td rowspan="5">Free Time</td></tr>
<tr><td>5:00 PM</td><td rowspan="2">Bus to Hotel</td></tr>
<tr><td>6:00 PM</td><td rowspan="2">Free Time</td><td>Free Time</td></tr>
<tr><td>7:00 PM</td><td rowspan="4">Faculty Led Workshop

at Theme Park

"The World Is Flat"

Diversity and the Creative Process</td><td>Private Dinner Party</td><td rowspan="2">Drive Home</td></tr>
<tr><td>8:00 PM</td><td>Private Dessert Party</td><td>Rollercoaster Engineering</td></tr>
<tr><td>9:00 PM</td><td>Solving the Unsolveable</td><td>Bus to Hotel</td><td>Finding the Right Solution</td><td rowspan="5">Sleep</td></tr>
<tr><td>10:00 PM</td><td>Bus to Hotel</td><td rowspan="4">Sleep</td><td rowspan="3">Free Time</td></tr>
<tr><td>11:00 PM</td><td>Bus to Hotel</td><td rowspan="3">Sleep</td></tr>
<tr><td>12:00 AM</td><td rowspan="2">Sleep</td></tr>
<tr><td>1:00 AM</td><td>Bus to Hotel</td></tr>
</table>

Figure 2. Agenda for 2013 Fieldtrip Course on Creativity and Innovation in the Engineering Design Process. Sessions in green were developed and led by the faculty at Valparaiso University. Sessions in yellow were developed and led by the external training organization.

There are many ways to evaluate creativity including interviews, observations, and self-assessments. However, there is evidence that self-efficacy is a reliable predictor for topics like creativity where confidence levels impact a student's performance[18].

Therefore, after the fieldtrip course, the 63 undergraduate engineering students again were asked to self-assess if they were creative and their ability to meet the three objectives in Table 1, using the same Likert scale. The results are shown in Figure 3[12].

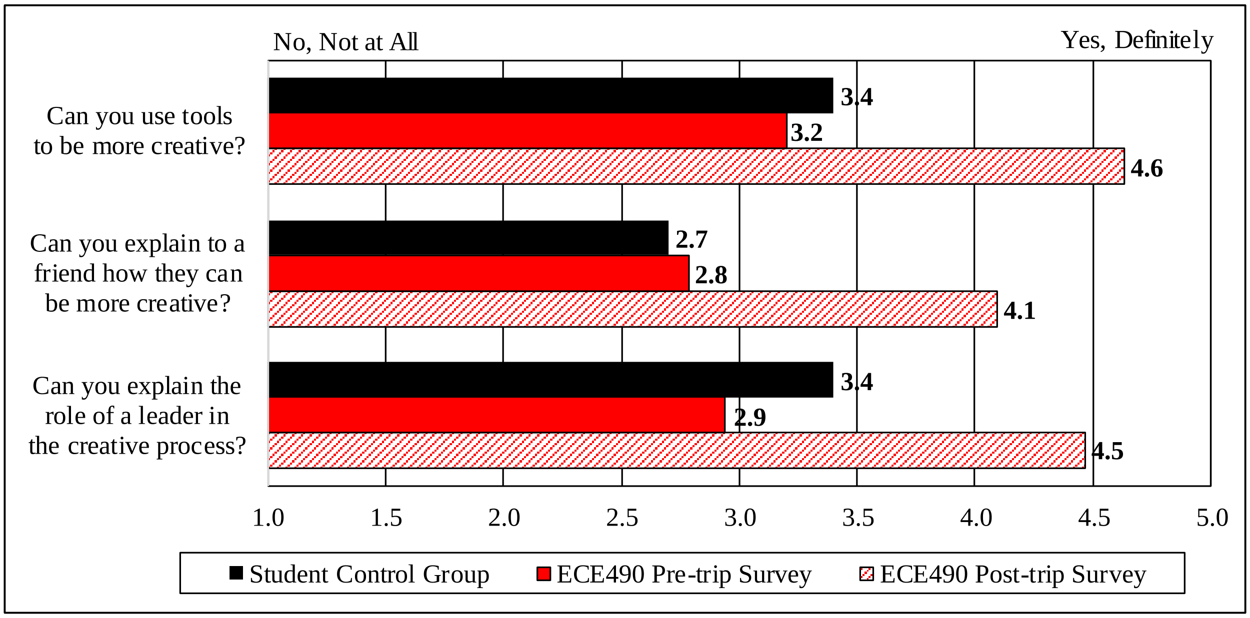

Figure 3. Averages of student self-assessments performed before and after the 2011, 2012, and 2013 ECE490 Creativity and Innovation in the Engineering Design Process fieldtrip to the external training organization using a Likert scale (1 being "No, Not At All" and 5 being "Yes, Definitely"). Data is also provided for a control group of students that did not participate in fieldtrip course.

A Semester Long Course Complementing Previous Work

As seen in Figure 3, the 2011 - 2013 class sessions were remarkably successful. However, we believed that we could reach even higher and improve the students' learning experience. As a result, we performed an overall class evaluation that included input from students, College of Engineering faculty members, and employees and cast members from the ETO[13]. The outcome of the evaluation was to create a new semester-long course featuring the same fieldtrip in the middle of the semester over fall break. The motivation for change was three-fold. First, there was a desire to teach creativity and innovation more effectively and thoroughly. Second, past participants consistently wanted to extend the duration of the class and see additional examples of applying creativity and innovation to real-world problems. Finally, by integrating the fieldtrip as a required component of a semester long class, an analysis and evaluation could be performed to determine if the course should continue (as in the past) as a stand-alone short-course/fieldtrip course by itself, or if it should evolve into a traditional fifteen-week class with a required fieldtrip component.

While the desire to teach creativity and innovation more effectively by extending the class duration were straightforward, it was not obvious how to build a college-level course around a fieldtrip. Very little research has been done in this area. A significant body of work includes the use of short (one day or less) fieldtrips as part of K-12 and university classes[19-28]. However, there is very little quantitative analysis into how a fieldtrip contributes to university student success.

The biggest advantage of the 2014 semester-long version of the class was time. This structure provided seven weeks of class preparation prior to the fieldtrip and seven weeks after the fieldtrip to review and apply the lessons learned during the trip. The expectation was that the full semester of classes would allow us to implement improvements to the existing format. During the first three years of the ECE490DI course, various participants identified the need for more in-depth discussions, especially on the subjects of teamwork, creativity, and leadership. The general feeling was that students were getting a broad overview of these topics but were not having enough time to fully delve into them and deeply comprehend them. The short workshops, already in place, provide the students with a way to improve their leadership, creativity, innovation, and teamwork skills. However, due to the time limitations of the workshops, students needed other opportunities to absorb and reuse these skills in a practical way. The real question, though, was whether the additional class time would be worth the investment above and beyond the previous stand-alone fieldtrip format.

The pre-trip and post-trip class sessions were held once per week. The duration of each meeting was 75 minutes. A brief outline of the pre-trip and post-trip classes is shown in Table 2[13]. Figure 4 shows that while there was some variation in the 2014 fieldtrip schedule, a majority of the lessons were included from previous years to provide a better apples-to-apples comparison of the fieldtrip course vs. the traditional semester class with the fieldtrip component.

Table 2: Outline of the Semester-Long ECE490 / Creativity and Innovation in the Engineering Design Process Class

Week	Meeting Topics
1.	The design process. Video on the design process. Defining creativity, identifying problems and needs. Case study.
2.	Identifying requirements and constraints. How do requirements and constraints help define and refine design problems? Case study.
3.	Brainstorming solutions. What is brainstorming? What are the rules of brainstorming? Role of a leader in brainstorming? Role of research in brainstorming? Case study.
4.	Creating a brainstorming tool portfolio. Storyboarding and other "Tried and true" brainstorming tips. Case study.
5.	Innovation and improving the creative process. How does innovation improve creativity? Using innovation to predict the future. Case study.
6.	Video on creative/innovative individuals. Case study.
7.	Theme park engineering. Case study.
8.	Class trip to external training organization
9.	Review of creativity and innovation in the engineering design process Introduction of final projects.
10.	Requirements and constraints of final project.
11.	Brainstorming for final project.
12.	Building models of final project.
13.	Refining models of final project. Presentation of draft model to peers and peer review of models.
14.	Refining models of final project. Presentation of draft model to peers and peer review of models.
15.	Submission of final project and presentation of final projects to peers.

	Wednesday	Thursday	Friday	Saturday	Sunday
6:00 AM	Drive to Airport	Bus to Theme Park		Bus to Theme Park	
7:00 AM		Workshop Leading the Creative and Innovation Process Leadership Styles and Techniques Part 1	Bus to Theme Park	Workshop Leading the Creative and Innovation Process Leadership Styles and Techniques Part 2	
8:00 AM	Clear Security and Wait for Flight		Theme Park Tour Origins of Theme Parks Creativity vs. Innovation		Bus to Theme Park
9:00 AM					Faculty Led Discussion Exploring the Engineering Vocation
10:00 AM	Flight				
11:00 AM				Bus to Theme Park	
12:00 PM		Lunch Workshop Techniques of Teamwork Through Improvisation	Lunch	Free Time	
1:00 PM			Discussion The Role of the Engineer in Theme Park Design		Bus to Hotel
2:00 PM	Bus to Hotel				Lunch Lessons Learned
3:00 PM					Bus to Airport
4:00 PM	Check into Hotel	Creativity and Innovation Case Study Alternative Fuel Vehicles			
5:00 PM	Bus to Theme Park		Free Time		Clear Security and Wait for Flight
6:00 PM	Faculty Led Discussion Old vs. New Old Isn't Bad New May Not Be Better	Free Time		Private Dinner Party Servant Leadership	
7:00 PM			Private Dinner Party Lessons Learned		Flight
8:00 PM		Private Dessert Party		Rollercoaster Engineering	
9:00 PM		Solving the Unsolveable	Bus to Hotel	Free Time	Drive Home
10:00 PM		Bus to Hotel			
11:00 PM	Bus to Hotel				

Figure 4. Agenda for 2014 fieldtrip as part of semester-long course on Creativity and Innovation in the Engineering Design Process. Sessions in green were developed and led by the faculty of Valparaiso University. Sessions in yellow were developed and led by the external training organization.

Results

22 undergraduate engineering students participating in the 2014 semester-long class participated in pre- and post-class surveys. As mentioned above, self-efficacy has been shown to be an excellent tool for measuring students for our key objectives. Figure 5 shows the results of the 2014 semester-long class in comparison to the 2011, 2012, and 2013 fieldtrip classes and the control group. Table 4 summarizes the improvements in the student survey's following the classes. Table 5 shows the standard deviation for each question and year.

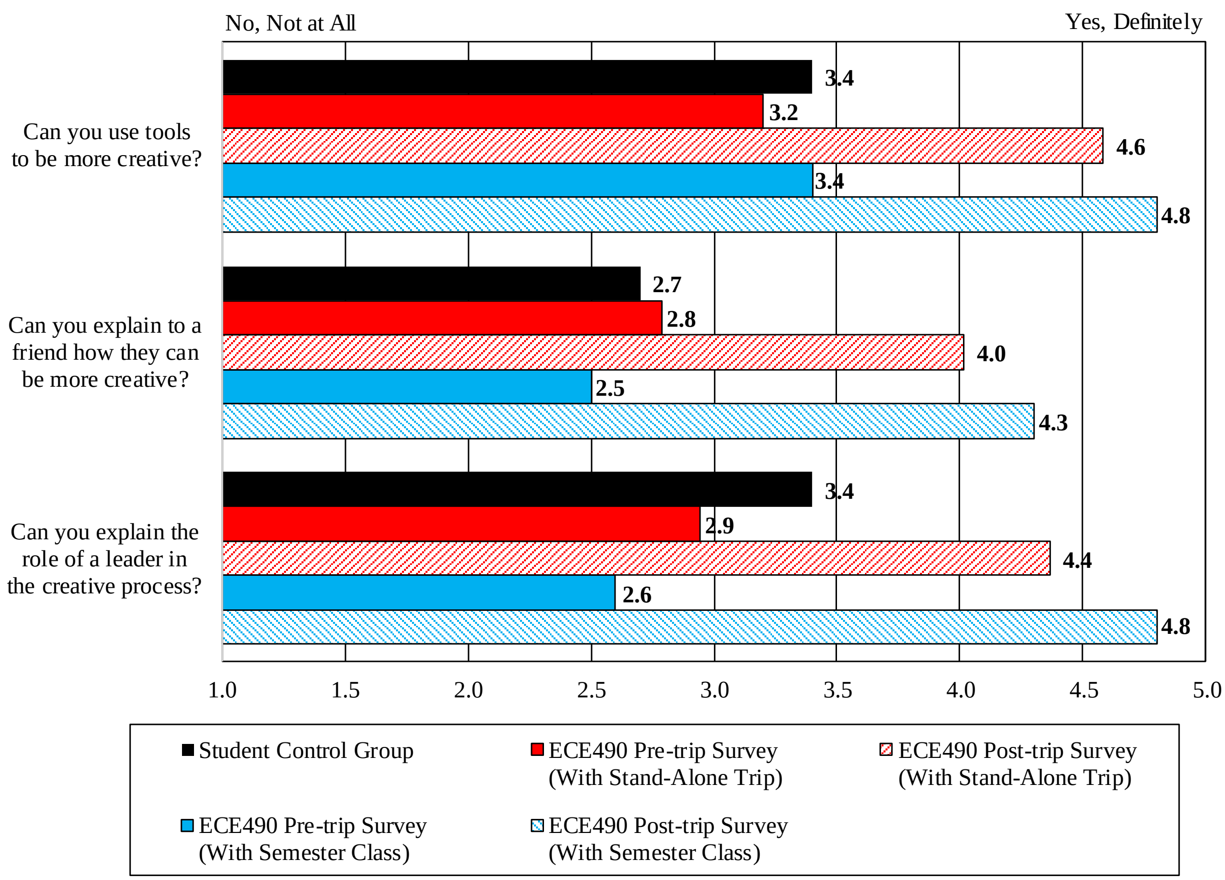

Figure 5. Averages of student self-assessments performed before and after 2014 semester-long class and the 2011, 2012, and 2013 fieldtrip courses using a Likert scale (1 being "No, Not At All" and 5 being "Yes, Definitely"). Data is also provided for a control group of students that did not participate in any of the classes.

Table 4: Averages of Student Self-Assessments Performed Before and After 2014 Semester-Long class and the 2011, 2012, and 2013 Short Fieldtrip Courses Using a Likert Scale (1 Being "No, Not At All" and 5 Being "Yes, Definitely").

Self Assessment Questions	2011 - 2013 Fieldtrip Only			2014 Semester Class and Fieldtrip		
	Pre-Course	Post-Course	Delta	Pre-Course	Post-Course	Delta
Can you use tools to be more creative?	3.2	4.6	+1.4	3.4	4.8	+1.4
Can you explain to a friend how they can be more creative?	2.8	4.0	+1.2	2.5	4.3	+1.8
Can you explain the role of a leader in the creative process?	2.9	4.4	+1.5	2.6	4.8	+2.2

Table 5: Standard Deviation of Student Self-Assessments Performed Before and After 2014 Semester-Long class and the 2011, 2012, and 2013 Short Fieldtrip Courses Using a Likert Scale (1 Being "No, Not At All" and 5 Being "Yes, Definitely").

	Pre-Trip Survey		Post-Trip Survey	
	2011 - 2013 Fieldtrip Only	2014 Class and Trip	2011 - 2013 Fieldtrip Only	2014 Class and Trip
Can you use tools to be more creative?	1.2	1.0	0.6	0.6
Can you explain to a friend how they can be more creative?	1.2	1.0	0.8	0.9
Can you explain the role of a leader in the creative process?	1.1	0.8	0.5	0.4

A quick look at the quantitative results showed that students participating in the semester-long class in 2014 benefitted significantly from the additional meeting times before and after the fieldtrip. The students were significantly more confident in their ability to explain to a friend how they can be more creative and to explain the role of a leader in the creative process. This was expected based on the significant number of case studies and the final project that allowed the students to practice these skills. The 2014 semester-long class, however, did not appear to result in significantly better results in using tools to be more creative.

A *p*-value analysis was performed to verify these impressions. Because of the relatively small sample-size for the 2014 class (22 students), t-scores were used to calculate the *p*-values. As expected, the *p*-value for the first question (use of tools) was significantly higher (0.5) than for the last two questions ($p = 5x10^{-3}$ for explaining to a friend and $p = 2x10^{-8}$ explaining the role of a leader).

Qualitatively, however, the students who participated in the 2014 semester-long class have shown significant additional benefits. First, a number of professors in the Valparaiso University College of Engineering have noticed improvements in attitude and work ethic among the students taking the class. Second, these students have bonded as friends based upon this longer shared experience. Finally, they have taken on an almost evangelical approach to campaigning for the continuation of the semester-long version of Creativity and Innovation in the Engineering Design Process. These sentiments come through in a number of the comments made by the students in the course evaluation (see Table 3).

Table 3. Student feedback on semester-long course on Creativity and Innovation in the Engineering Design Process.

1.	The trip to [the external training organization]! But not just because of how much fun it was, but because of what we learned and what privileges we were provided.
2.	The exercises we did to promote better creativity.
3.	The entire course and especially the trip was more than just seeing behind the scenes at [the external training organization].
4.	I feel so confident in my abilities to be creative and successful in my engineering career.
5.	Learning about the inner workings of [the external training organization] and how to apply it to life everywhere.
6.	I honestly didn't believe creativity could be taught or worked on…. I have been proven wrong.
7.	How everything ties together.
8.	Everything was beneficial. The creativity assignments, the group projects, and ESPECIALLY the trip itself.
9.	I cannot even begin to describe how awesome this course is
10.	I now look very differently at problems that I have in my daily life.
11.	I am so glad I could take this class!!!
12.	This course needs to continue to be taught. It has helped to tremendously improve my problem solving skills which will help me out so much in the professional world.
13.	Best. Class. Ever….
14.	This class and Professor Budnik are AWESOME. I wish everyone could take this class. I've learned so much.
15.	YAY
16.	This was one of the best classes I have taken
17.	Thank you for this opportunity!
18.	I had an amazing experience and I would do it again in a heartbeat!

Based upon the quantitative and qualitative feedback from the students enrolled in the semester-long version of the class, the Valparaiso University College of Engineering has decided to continue offering the course as a fall semester class with a required fieldtrip component. However, because the benefits for the shorter fieldtrip-only version of the class were also apparent, the College will also offer a fieldtrip-only version of the class in the spring semester for students who decline to take advantage of a more intensive look at creativity and innovation in the engineering design process.

Discussion and Future Work

Over the past four years, 85 undergraduate engineering students at Valparaiso University have participated in ECE490, a Creativity and Innovation in the Engineering Design Process class. The results in Figure 5 show that students gained considerable confidence throughout the class, both as a stand-alone fieldtrip and as a semester-long class.

Educators and administrators at other institutions are encouraged to investigate developing similar stand-alone fieldtrips or semester-long classes that incorporate fieldtrips. The qualitative feedback in Table 3 illustrates the passion students exhibited for the experience. Caution, however, is advised. While both versions of ECE490 were developed with an ETO, the class at Valparaiso University has evolved to the point that it requires a considerable amount of administration and preparation. Annually, ECE490 now requires approximately 33% of one faculty member's time.

Finally, there are many ways to evaluate creativity including interviews, observations, and self-assessments. As previously indicated, there is evidence that self-efficacy is a reliable predictor for topics like creativity where confidence levels impact a student's performance[18]. It is acknowledged that self-assessments measure perceptions of a skill and not the skill itself. Therefore, future work should be performed to determine additional methods of assessing class objectives, including such options as the Torrance Tests of Creative Thinking[29]. Additionally, it is suitable for the class objectives to be rewritten such that they are more quantitative in nature. Finally, future work should also include a longitudinal study of students who have participated in the class.

Conclusion

Over the past four years, Valparaiso University and an external training organization have developed a program to teach Creativity and Innovation in the Engineering Design Process. Significant benefits have been observed both in a five-day fieldtrip-only version of the class and in a semester-long version of the class. The 85 undergraduate engineering students who participated in the class reported significantly higher confidence in their ability to use tools to inspire creativity and innovation, teach a friend how to be more creative and innovative, and lead the creative and innovation process. For this reason, Valparaiso University's College of Engineering will provide both options for students beginning in 2015.

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