122nd ASEE Annual Conference & Exposition
June 14 - 17, 2015
Seattle, WA
Paper ID #13814

Implementation and Assessment of Required Engineering Exploration Assignments in a First-Year Engineering Course

Dr. Victoria E Goodrich, University of Notre Dame

Dr. Victoria Goodrich is the Director of the First-Year Engineering Program at the University of Notre Dame. She holds a BS in Chemical Engineering from the University of Oklahoma and a MS and PhD in Chemical Engineering from Notre Dame. Her research focuses primarily on Engineering Education issues, especially focused within the first-year engineering experience.

Dr. Leo H McWilliams, University of Notre Dame
Ms. Catherine F Pieronek, University of Notre Dame

Catherine F. Pieronek is associate dean for academic affairs in the College of Engineering at the University of Notre Dame. She holds a B.S. in aerospace engineering and a J.D. from the University of Notre Dame, and an M.S. in aerospace engineering from the University of California, Los Angeles. A member of the College of Fellows of the Society of Women Engineers, she focuses her academic research on the factors that affect the persistence of women in engineering.

Implementation and Assessment of Required Engineering Exploration Assignments in a First-Year Engineering Course

Starting in fall 2012, the first-year engineering course at the University of Notre Dame has required students to complete four "Engineering Explorations" over the course of each semester of their first year. These are loosely defined as "any event related to your growth as an engineering student" and typically consist of professional development events, student group meetings, and departmental lectures. The Engineering Exploration assignment series was instituted so that students can affirm or clarify their future discipline before officially entering their major of choice and beginning to integrate academically and socially into the College of Engineering. While the basic assignment has remained the same each year, the application has changed in some way each year. In 2012, four regularly scheduled class sessions were cancelled to provide additional time for students to attend or reflect on their events. Students were provided a list of possible events to attend and regular announcements were made of appropriate events that were being hosted around the university. Based on student feedback from the first year's offering, along with the recognition that the cancelled classes provided additional opportunities to bring in exploration content (and that some students, due to other constraints, could attend only activities during normal class times), the second year offering was modified. The first-year instructional staff scheduled some optional Engineering Exploration events to occur during the normally scheduled class time and in the regular class location. One exploration, for example, featured the Dean of the College of Engineering speaking National Academy of Engineering's Grand Challenges. In both years, students documented their participation by listing the events in which they participated and writing a short summary and reflection as evidence of completion.

Because students were free to choose events of interest to them, the continued implementation and evolution required understanding what types of events students attended. There is an additional interest in whether attendance at a certain type of event (or a series of events), characterized on a continuum of convenience to the student, is indicative of student interest in engineering or their propensity to continue in engineering for another semester.

This paper details the additional findings that delve deeper into the student attendance rates for various events. For both 2012 and 2013, a chi-square analysis confirmed that those who left engineering after just one semester attended high-convenience events at a higher frequency than those who stayed in engineering. In 2013, 32% of leavers, but only 16% of those who stayed for at least one more semester, attended only in-class events (chi-square p-value of 0.012), These findings could lead to a meaningful approach to identifying students with low interest in continuing in engineering and creating meaningful content for them early in their career.

INTRODUCTION

A student's sense of belonging plays an important role in the student's educational experience and retention. For decades, the educational community has understood how critical link between student involvement with other university members and retention is to receiving a degree.[1,2]

Astin describes involvement in terms of energy expended to a specific context with factors such as: energy devoted to academic study, participation in student organizations, time spent on campus, and interaction with other students and faculty. Since Astin's early work on student involvement, the engineering education community has further extended this concept to engineering-specific retention[3-5] with similar findings. These studies and others indicate that helping students to develop an engineering identity and community can be a strong encouragement to persist in engineering to graduation. In many ways, engineering colleges are well situated to encourage academic involvement and faculty-student interactions for their students, but they are less likely to address peer interactions and student involvement in social or academic extracurricular activities.

It stands to reason that finding effective methods to increase student involvement may benefit overall retention. While students leave engineering throughout their academic careers, attrition is generally most prevalent in early semesters.[6] Therefore, first-year programs are ideally situated to aid students in building these interactive support networks. With these findings in mind, Notre Dame sought to create an educational experience within the first-year course that would encourage students to explore the extracurricular activities available to them within the university. By making students academically responsible for attendance at extracurricular events, the course staff sought to increase the chance that students would find encouragement and community early in their academic careers while learning more about the engineering major choice. More explicitly, the goals of these Engineering Exploration assignments were to help students:

1) Clarify their future major path,
2) Affirm their intended discipline choice,
3) Learn about careers related to their future discipline,
4) Explore and/or join engineering clubs and societies, or
5) Network with students, faculty, and mentors within engineering

In this paper, we investigate the various ways a newly created "Engineering Exploration" assignment was completed by students in the Fall 2012 and Fall 2013 semesters of the first-year engineering course. Because of the rather large number of events occurring at the university, the first focus of this paper is to describe the types of events students attended and with what frequency. Secondly, the paper will detail some initial difference between students who chose to leave engineering before their sophomore year and those who persisted into at least the first semester of their sophomore year (at the University of Notre Dame, sophomore-to-senior retention is ~90% and therefore less of a concern). Finally, suggestions will be made for how to effectively incorporate feedback from these assignments in intervention strategies to increase retention.

COURSE AND ASSIGNMENT BACKGROUND

Course Background

An introductory engineering two semester course sequence is taught to all engineering intents during their first-year at the University of Notre Dame. For both the Fall 2012 and Fall 2013 semesters 475 – 525 students completed the fall semester of the course sequence, with

approximately 85% of those students persisting through the second semester course. For both academic years, the course consisted of large lecture sections (~250 students) that introduce basic concepts and background for projects followed by smaller group sessions (30-35 students). Overall, the course focused on understanding general engineering principles by completing multi-week projects as a means of understanding the Engineering Design Process. Virtually no class time is used to discuss various engineering disciplines or possible careers for students. However, through a series of reflective assignments, including attending four Engineering Exploration events, students are tasked with considering their major choice and aligning it with their career interest.

Exploration Assignment Mechanics

This section details the mechanics of a typical Engineering Exploration assignment. An appropriate Engineering Exploration includes, but is not limited to: discernment, professional development, department lectures, and events hosted by student chapters of professional society. Students can choose from a pre-approved list of activities, or they may attend appropriate activities not from the list but as defined above. Because these events typically occur outside of the normal lecture time, four lectures were cancelled so that students had ample time to complete the activities. In the Fall 2013 semester, the Engineering Exploration assignment was changed slightly to ease scheduling conflicts by adding content into the normal lecture time. Student groups and departmental faculty were encouraged to provide this content; therefore, each event was not necessarily created to be of interest to all of our students.

A student documents participation at an event by writing a short (~200 words) reflection. A reflection requires a student to: summarize the event, personalize why they attended, and explain how it helped them to grow as a student/engineer. At our university, these reflections were gathered in electronic portfolios and graded by the course instructors. While this provides a wealth of quantitative and qualitative data about student experiences, this paper will focus solely on what event was intended; all reflections will be ignored.

METHODS

All Engineering Exploration data were collected throughout the academic year through assignments in electronic portfolios. After the completion of the academic year, students were sorted into three groups depending on the number of semesters enrolled in College of Engineering courses:

(1) First-semester leavers – Students who completed the first-semester of the course sequence but who decided not to continue in engineering and did not enroll in the second semester.
(2) Second-semester leavers – Students who completed both semesters of the course sequence but did not select an engineering discipline and left the College of Engineering.
(3) Sophomore stayers – Students who enrolled in one of the engineering disciplines during the fall semester of their sophomore year.

As detailed previously, sophomore-to-senior retention is ~90%; therefore, first-year retention is the most significant retention concern. Table 1 reports the potential number of students as well

as the number of participants in each group for this study. As shown, data for all of the first-semester leavers and second-semester leavers were collected, as they represent a relatively small percentage of the overall population. However, only a randomly drawn subset of the sophomore stayers was studied at this time.

Table 1: Potential and Actual Study Participants for 2012 and 2013 years.

	Fall 2012		Fall 2013	
	Potential	Number Selected	Potential	Number Selected
First-Semester Leavers	48	48 (100%)	65	65 (100%)
Second Semester Leavers	19	19 (100%)	26	26 (100%)
Sophomore Stayers	399	95 (23.8%)	425	96 (22.6%)

From the Engineering Exploration assignments, event titles and dates were recorded for each student and coded for each of the four events attended. Once student information was linked to the attendance record, all entries were anonymized. At this time, reflections were ignored as a source of information.

Events were first categorized based on how convenient they were for the students to attend (Table 2). For instance, an event that did not require advanced planning on the part of the student and could be completed at any time (i.e. – reading and reviewing a technical paper) was coded as "highly convenient" while a career fair that has a set date but drop-in hours was coded as "medium convenience". Table 2 shows the number of reported events that fell into each category. The vast majority of events in both years were low convenience events, indicating that the event took place on a set time and date.

Table 2: Coded Convenience Level of Events Reported by Sample Group

Code	**Level Description**	**2012**	**2013**
High	Date and Time Open or Completed In-Class	5 (6.9%)	10 (12.5%)
Medium	Scheduled date but more open time	11 (15.3%)	14 (17.5%)
Low	One scheduled date and time	54 (75%)	55 (68.74%)
None	Didn't attend anything/Not an appropriate event	2	1

Next, events were coded based on the type of event or the hosting group (Table 3). For example, any event that was career focused and hosted by the University Career Center was labeled in one group (Group3 – Career Center/Professional Development). In total, 9 categories were used to describe the events. In both years, student groups (for example: Society of Women Engineers, Engineers Without Borders, American Institute of Chemical Engineers) accounted for the largest percentage of events reported, followed by academically focused events.

Table 3: Categorical Descriptors of Reported Events Attended by Sample Group

Code	Description	2012 Events (% of total)	2013 Events (% of total)
1	In-class explorations	0 (0%)	4 (5%)
2	One-on-one Meetings	6 (8.33%)	5 (6.25%)
3	Career Center /Professional Development	10 (13.89%)	9 (11.25%)
4	Discernment - Major Choice	3 (4.17%)	7 (8.75%)
5	Company Sponsored Event	8 (11.11%)	9 (11.25%)
6	Student Group (AIChE, SWE, etc)	25 (34.72%)	31 (38.75%)
7	Academic - Lecture Series, poster session, etc.	17 (23.61%)	13 (16.25%)
8	Reading a Technical Paper	1 (1.39%)	0 (0%)
99	Didn't attend or not appropriate	2 (2.78%)	2 (2.5%)
Total Events Attended by Sample Group		**72**	**80**

In both years, the overall number of events in the sample groups was fairly consistent, as were the types of events that students attended. In many cases, events are held annually and appear to be consistently attended by the students.

RESULTS

Although Table 2 indicates the number of events that were reported in each convenience level, the various events were not all attended in equal number. Figure 1, below, indicates the actual attendance count for each event convenience type. Additionally, the data are broken down by student retention groups. Although there is a large difference between the two semesters, the large increase in high convenience events in 2013 is accounted for by increased attendance at the in-class events, which were extremely popular.

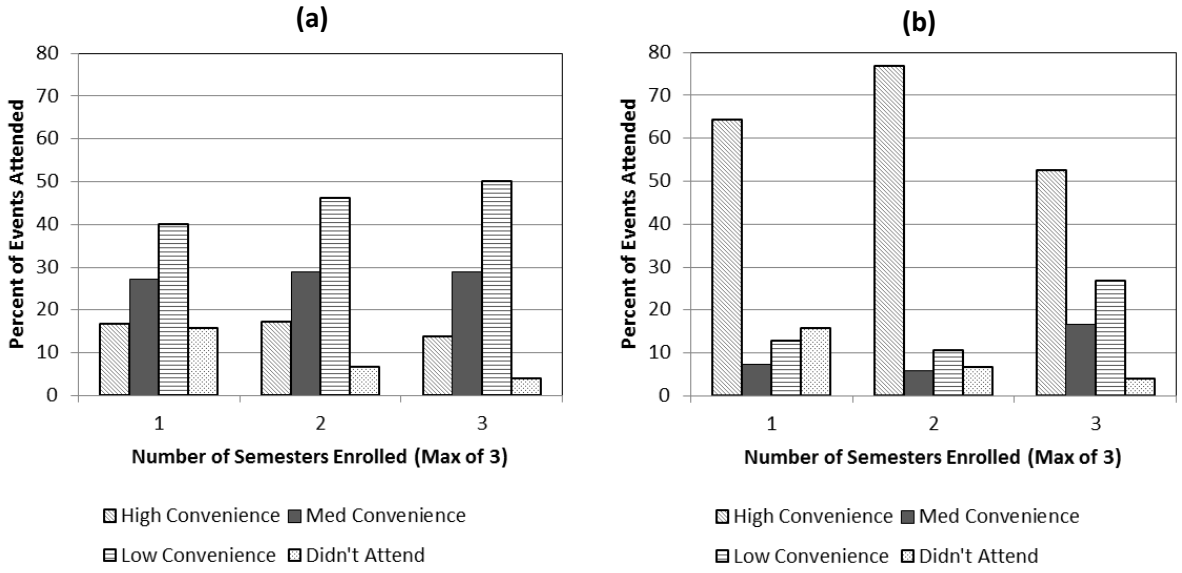

Figure 1. Total percentage of reported attendance at events based on the convenience level for (a) 2012 and (b) 2013.

In total, 1,396 Engineering Explorations were assigned to the sample group (4 events per person in the sample group). Therefore, it's important to see what categories were most popular among students. In 2012, Category 4 (Career Center Events) had the highest percentage of total attendance across all 3 study groups. This categorical dependence is shown for the 2012 cohort in Figure 2 below. This is likely in part to the early fall career fairs that were marketed heavily to the students and had a large time frame for students to attend.

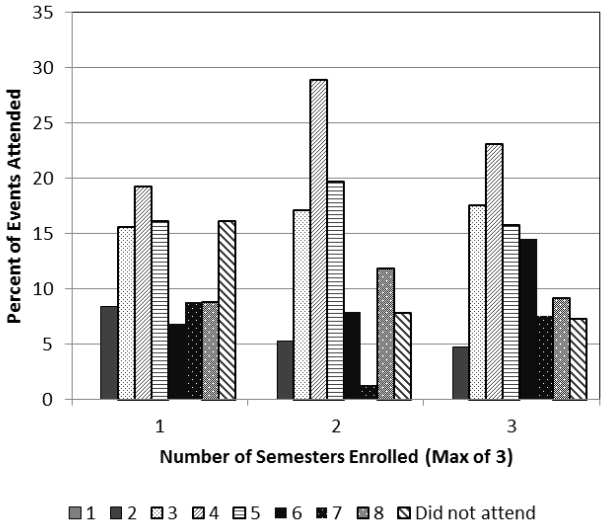

Figure 2: Categorical event attendance in the fall 2012 semester.

With the introduction of new highly convenient opportunities in 2013, in-class events (category 1) become the overwhelmingly attended events, as shown in Figure 3a. After eliminating in-class events (Figure 3b), there is not a consistent event category across all student groups.

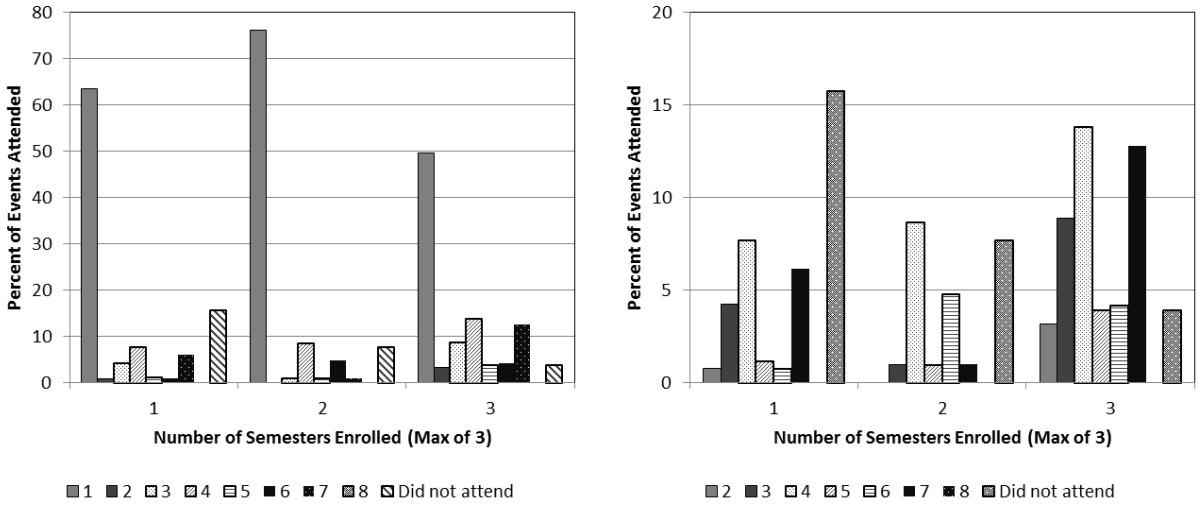

Figure 3: Categorical Event attendance in the fall 2013 semester with (a) all data and (b) without in-class events shown.

Based on data in Figures 1 and 3, attendance at high convenience events or missing events appeared to be more prevalent for the students who left engineering within the first year. To test independence of attendance patterns of these groups, a chi-square test was performed on various events that we deemed easiest to complete by the students. Specifically, this was in-class events or missing events in 2013, and in 2012 this was reading a technical paper or missing events. Because the intention is to give students early exposure to engineering before they decide it's not appropriate for them, the more in-depth statistical data will compare the students who left engineering after only one semester to those students who continued at least into the second semester of the course sequence.

Table 4: Results of chi-square tests for various event attendance patterns for 2012

	Had a 0 for at least 1 event	**Had a 0 for at least 2 event**	**Read 2 papers or more**	**2 or more papers or missed events**
Stayer	15 (13.2%)	11 (9.6%)	6 (5.3%)	17 (14.9%)
First-Semester Leaver	12 (25.0%)	11 (22.9%)	4 (8.3%)	15 (31.3%)
P value from chi-square analysis	p = 0.065	p = 0.024	p = 0.46	p = 0.017

As shown in the table above, using these most highly convenient events (or missing events) for at least half of the Engineering Exploration assignments strongly correlated to sophomore

engineering status. Unsurprisingly, students who left engineering were also most likely miss multiple events – perhaps a demonstration of their disengagement with the class or disinterest in engineering. In 2013, no students read technical papers as their highly convenient events. Instead, attendance at in-class events became prevalent for all students.

Table 5: Results of chi-square tests for various event attendance patterns for 2013

	Had a 0 for at least 1 event	**Attended 4 in-class events**	**Attended 3 in-class events**	**More than 2 in-class events**
Sophomore Stayer	20 (16.4%)	20 (16.4%)	24 (19.7%)	44 (36.1%)
First-Semester Leaver	14 (21.5%)	21 (32.3%)	17 (26.2%)	38 (58.5%)
P value from chi-square analysis	p = 0.39	p = 0.012	p = 0.31	p = 0.003

As shown above, attending more than two in-class events correlated strongly with leaving the College of Engineering after the first semester. In part, this is likely due to the events that were held during the semester; two of the events were on general engineering topics while the other two events were specific to particular departments. Many students were likely attracted to the convenience of these in-class events rather than attending due to the specific content. Some number of students that had to attend in-class events due to athletic schedules, off-campus jobs, or other commitments, making attendance at these events a somewhat more difficult predictor to use. Likely, the exact events that were offered heavily contributed to the resulting correlation of how many in-class activities proved to be a statistically significant indicator of retention.

Of particular interest is how the gender of the student played an important role in how the Engineering Exploration attendance should be considered. In Table 6, selected results are presented for female and male students. It should be noted that only a small selection of data could be analyzed using the chi-square analysis shown. In many cases, the number of students in categorical definitions was below 5 and would not be appropriate for the statistical test.

Table 6: Student participation in high convenience events and sorted by student gender.

	2012	**2013**
	2 or more papers or missed events	**Attended 3 or 4 in-class events**
Female Stayer	6 (18.2%)	16 (35.6%)
Female Leaver	11 (55.0%)	11 (45.8%)
P value from chi-square analysis	p = 0.005	p = 0.41
Male Stayer	11 (13.6%)	28 (16.4%)
Male Leaver	5 (17.9%)	21 (32.3%)
P value from chi-square analysis	p = 0.58	p = 0.012

In the data shown, 2012 found that women who left engineering were more likely to have completed readings or missed events than the female students who stayed. However, there was no similar correlation for male students. In 2013, however, the correlation switched and student status correlated only to in-class events for only male students. It should be noted that these trends held true for the other attendance measures shown in Tables 4 and 5 but are not appropriate for statistical testing due to small sample numbers. This initial finding indicates a future study into the importance of gender is necessary to more fully capture the dynamics at play.

While this paper did not focus on qualitatively reading the reflections provided, they offer another wealth of information into the students' perceptions and engagement with the events. However, the large scale of the course and assignment makes reading and identifying the most at-risk students in the 500+ person course somewhat unfeasible in the time frame that would be needed to deploy appropriate intervention strategies. At this time, small scale studies have looked into text mining the student reflections[7] using traditional text mining techniques. From this study, word count, keyword search, word clouds, and even sentiment analysis did not reveal any meaningful trends that could be exploited for at-risk identification.

Finally, the events have not yet been coded for student satisfaction, which could play a key role in identifying appropriate events to provide to our students. While course staff could not identify any events that were poorly received overall, there are regularly events that are well attended and engaging to students. Anecdotally, we believe that major discernment events that are led by junior and senior engineering students (especially during the fall semester) are most meaningful to the first-year students. Other events that regularly receive positive reflections focus on various ways to own their education (through minors, concentrations, research, etc.) and events where practicing engineers describe their career path and the engineering profession. Deeper study into identifying these events and describing if attendance plays a role in an engagement is an important future direction for this work.

CONCLUSIONS/FUTURE WORK

We have found that simply monitoring the selection of explorations outside of the classroom provides a strong indicator of retention. While our information was captured using reflections, the data summarized here could be obtained with only a sign-in sheet and a course roster; therefore, making this a cost and time efficient method of capturing meaningful data. Of particular interest would be to use this methodology at mid-semester to determine at-risk students and provide appropriate Engineering Exploration content to aid in engaging those students with engineering. Other major findings include:

(1) A large diversity of events was attended with over 70 unique events recorded for both 2012 and 2013 sample groups.

(2) The most popular categories of events included major discernment, professional development, company sponsored events, and student engineering club meetings.

(3) In both years, highly convenient events were the most popular events attended. Therefore, if these are offered they should be chosen wisely to present the most effective information about engineering to the widest audience.

(4) In both years, the majority of events were put on by student organizations. However, attendance did not match these trends. If the goal of the Explorations assignment is to help students build their engineering peer connections, making highly convenient opportunities in this category would be a definite improvement to the offerings.

(5) In-class events proved to be extremely popular, but may have been used as a way to stay disengaged with the assignment. Again, these types of events should be selected carefully to more fully adhere to the spirit of the assignment as some students will only attend these no matter their topical focus.

In all, the events were successful in achieving their purpose to help students learn more about the College of Engineering and their major choice. Many anecdotal stories have been shared with the course staff of students finding value in the tasks. For instance, students reported learning about and joining student organizations because they were academically responsible for attending these events. In addition, the university Career Center reported higher than expected attendance from first-year students at many of their events. In all, we believe these events to be a positive addition to our course and will continue to use them in future years.

Future studies are planned for the data presented here and the data currently being collected. One limitation of the current sample is that due to the small number of randomly selected underrepresented minority students, ethnicity could not be used as a comparison marker. In addition, gender markers showed inconsistent results between years that should be studied further.

Because all students were required to complete reflections on events, there is a wealth of qualitative data that is yet to be fully mined for more in depth information about our study group. Through the reflections, we hope to gain more full insight into what event types are most meaningful for various student groups. We expect to find that major discernment events are especially meaningful in the early fall semester, but may give way to other content focus as the academic year progresses. A carefully constructed study is needed to fully describe student perceptions of events. Finally, we would like to expand the event count to the spring semester Engineering Explorations that were also completed to gain more insight into the students that leave after two semesters in the course.

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