# Engineering Major Discernment: A Model for Informing Students and Offering Choice

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***Abstract:***

This complete evidence-based practice paper explores the longitudinal impact of a first-year engineering course designed to help students discern their future engineering major. The purpose of this study was to assess an engineering educational program's effectiveness in helping students to make an informed selection of an engineering major. Effectiveness is relative and based on measures of student persistence and major changes after five semesters. The institution studied is a medium-sized Midwestern, urban public institution in which four cohort years were tracked. Two cohorts (2012 and 2013) took a one-credit hour large lecture (200+ students) course to learn about the engineering majors offered and is contrasted with two cohorts (2014 and 2015) who took a small section (20-25 students) course to initially learn about each engineering discipline and were then given the opportunity to select / tailor the other class sessions towards the discipline of greatest interest. Initial results show that the second approach (with active learning, small sections, and student choice) increased the rate at which students selected a major (i.e. moving from first-year engineering into a major). In measures of retention rates, the new model did not show improvement (the differences were not statistically significant); however, the benefits for the student for a more engaged, hands-on experience and informed decision making are justifications for continued additional administrative efforts.


***Literature Search:***

Born out of the shortage of qualified engineers in the U.S. (and around the world), research on engineering education has increased over the past decade and were highlighted in key National Reports[1-2]. And while prior studies have focused on why students go into engineering initially[3], there has been recognition that selecting an engineering major has not always been based on significant understanding of the profession[4]. It was recognized that an engineering educational approach based on a capstone design project offered tangible understanding of the field to students but not until it was too late to reasonably change their intended plan of study, a study by Marin and Associates assessed the most important elements including student preparation, project selection, and project mentorship[5]. This is a rational for cornerstone design projects offered in the first year, often as part of a First-Year Engineering Program, to offer earlier design experiences[6].

The content and structure of these programs varies widely by institution and have been described by a taxonomy introduced by Ried and associates[7]. A primary objective of First-Year Engineering Programs surrounds informed decision making in selecting engineering and engineering discipline[8-10]. Studies have reported that First-Year Engineering Programs can be "polarizing" for students, either affirming the pathway they thought they were interested in or dissuading them in favor of another pathway[8]. While other studies have shown an increased engineering student retention benefit from First-Year Engineering Programs[11-12]. Students enrolled in common First-Year Engineering course were more likely to persist to the third semester than students directly admitted to an engineering department or undesignated students[11-12] and were less likely to leave their institution by their 8th semester. Students in First-Year Engineering were more likely to choose Mechanical or Civil Engineering as their intended engineering discipline and less likely to choose Electrical Engineering (EE was not impacted). It was reported that students who take a semester or more to select their engineering major (even without a First-Year Engineering course / program) were more likely to remain in their first major choice (41.9% vs. 37.9%), but a required FYE course / program helps even more (48.8% vs. 39.5%) based on the large scale data collected through MIDFIELD[12]. The learning structure of the engineering course as lecture (passive) vs. hands-on (active) was also shown to increase the number of major changes during the first-year which is a desirable time to make a major change as it likely does not delay the time to graduation[9].

The introduction of a course model designed to increase informed selection of an engineering major was developed through a National Academy of Engineering Symposium[13]. The model was based on introducing all incoming First-Year Engineering students to the different engineering disciplines available to study at that institution, followed by "choice" sessions to hear from upper division students and alumni about their educational and professional pathways[9]. This approach has been implemented at two institutions, a medium sized, Midwestern Public institution since 2012[10] and also at a selective Midwestern Private institution since 2016 which is currently being assessed. The Midwestern Public reported: (1) an increased major changes during the first-year, (2) decreased major changes after the first-year, and (3) increased retention in STEM and the engineering college as a whole five semesters following the program[10]. The current study is a follow on to the original study in that, there are now four cohorts for consideration, two that did not participate in the new model and two cohorts that did participate tracked for five semesters beyond.

Foundationally, this engineering major discernment study is theoretically founded in Social Cognitive Career Theory (SCCT) to consider students decisions[14-15]. SCCT is used to evaluate the goals, outcomes expectations, and self-efficacy beliefs[14]. An engineering education based study on engineering major discernment used SCCT by VanDeGrift and Lao reported that course projects, faculty advisory interactions, and other laboratory experiences were influential in engineering major selection. The current study expects to reveal that other targeted course experiences would likewise influence students[16].

*Research Questions:*

1. How effective is the engineering informed decision making module at meeting its intended goals?
   a) What amount of change (increase/decrease) after the first year is there in student's selecting a major (i.e. leaving first-year engineering) after the introduction of this module as compared to before indicating more informed decision making?
   b) What amount of change (increase/decrease) after two years is there in student's selection of a major (i.e. leaving first-year engineering) after the introduction of this module as compared to before indicating more informed decision making?
2. To what extent does retention increase/decrease within the STEM College and in engineering after introducing the informed decision making module?

3. To what extent have disciplines students are selecting after the informed decision making module was introduced changed?

***Introduction***

A required one-credit course for all incoming first-year engineering students was redesigned and assessment measures are compared before and after. The course is intended to allow all students considering engineering as an option to get an understanding of engineering and help make an informed selection of a major. The medium-sized university was where the study was conducted in which there are between 300 and 350 first-year engineering students and approximately 1, 000 engineering students across each of the five disciplines.

The goal of the redesigned course is to expose students to the five different engineering disciplines (Civil, Chemical, Electrical, Industrial, and Mechanical) offered at the institution to support the student having an informed selection of their major. The newly designed course included five instructors teaching one of each of the discipline for a total of 10 sections of 20-25 students (two sections per instructor). Figure 1 compares the old course to the new redesign, as first depicted in Meyers & Brozina[10].

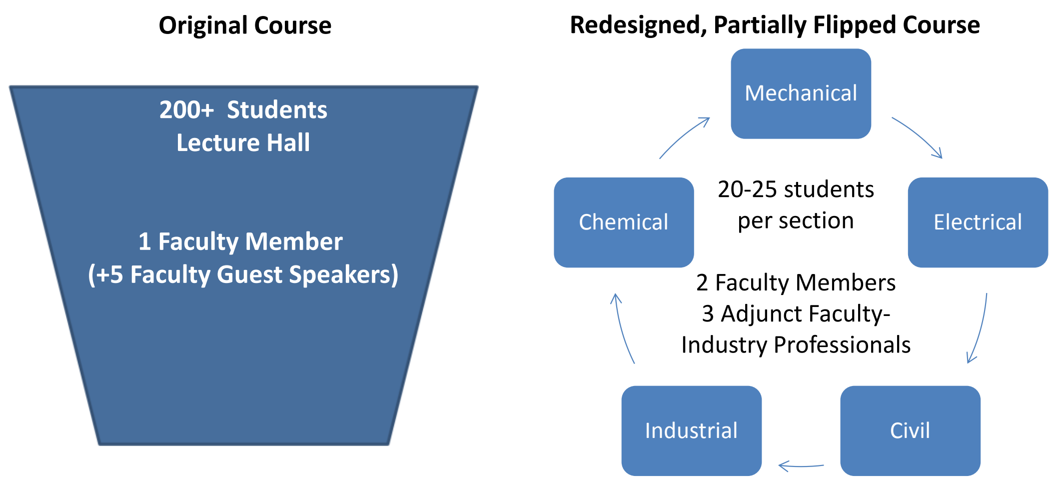


**Figure 1. Comparison of Course Structures[10]**

The redesigned course has students rotate to a new engineering discipline each week where they watch a short online video prior to coming to class about that week's engineering discipline. During the class session they learn about the discipline, what engineers do and where they can work, and participate in a short hands-on activity. During the second half of the course students dive deeper into one of the five disciplines which they wish to explore further, which is typically their intended major. Each week is something different for the students to engage with, such as upper-division students coming in to discuss their transition, faculty members discussing their research and courses they teach, going on lab tours one week, and going on a facility tour another week. Table 1 shows a week by week comparison of the old and new versions of the course[10].

**Table 1. Week by Week Comparison between the Original and Newly Designed Courses[10]**

| Week # | Original Course (2013) | Redesigned Course (2014) |
|---|---|---|
| 1 | Introductory Class Session | |
| 2 | Lecture on different engineering disciplines: Each of 5 disciplines (Civil, Chemical, Electrical, Industrial, and Mechanical) have 2 - 50 minute class periods | Hands-on Class Sessions on each of the 5 engineering disciplines (Civil, Chemical, Electrical, Industiral, and Mechanical) 1 - 50 minute class period |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | Resume Workshop and Co-op / Internship Discussion |
| 8 | | Choose Which Discipline: Faculty representatives (academic requirements of a discipline) |
| 9 | | Choose Which Discipline: Upper Division Students |
| 10 | | Choose Which Local Engineering Company to Tour |
| 11 | | Choose Which Discipline: Engineering Campus Lab Tours |
| 12 | Lecture on Co-Op / Internship Opportunities | Choose Which Discipline: Professional Society Panel of Student Members |
| 13 | Panel of Engineering Professionals from different disciplines | Choose an engineering professional to conduct an informational interview |
| 14 | N/A | Final Exam: Meet with an Engineering Course Instructor to Discuss Engineering Discipline Selection |

### *Methods:* Data analysis of ENGR 1500 participants from Group 1 (Fall 2012 + Fall 2013) and Group 2 (Fall 2014 + Fall 2015)

We conducted data analysis on both groups using Excel. The large lecture cohorts from Fall 2012 and Fall 2013 are combined to form Group 1 while the small group sections from Fall 2014 and Fall 2015 are combined to form Group 2. Analyses to answer each research question compare Group 1 and Group 2. Table 2 below shows the total number of students in each cohort where Group 1 has a total population size of 415 and Group 2 has 401 students. Each group contains students who participated in the ENGR 1500 course and identified as a First-Year Engineering student in the university database. This is important to note as there were students in the course who were not first-year engineering students but were in a different major and perhaps were taking the course to explore the opportunities within engineering.

**Table 2. Summary of Cohorts Studied**

| Fall Cohort Year | Class Format | Number of Students |
|---|---|---|
| 2012—Group 1 | Large Lecture – Passive | 189 |
| 2013—Group 1 | Large Lecture – Passive | 226 |
| 2014—Group 2 | Informed Decision Making – Small Group, Hands-on | 205 |
| 2015—Group 2 | Informed Decision Making – Small Group, Hands-on | 196 |

*Research Question 1:* How effective is the engineering informed decision making module at meeting its intended goals? ***Statistically significant for parts (a) and (b).***

Research question one comprises two parts (a) What amount of change (increase/decrease) after the first year is there in students selecting a major (i.e. leaving first-year engineering) after the introduction of this module (Group 2) as compared to before (Group 1) indicating more informed decision making and (b) what amount of change (increase/decrease) after two years is there in students selecting a major (i.e. leaving first-year engineering) after the introduction of this module (Group 2) as compared to before (Group 1) indicating more informed decision making?

To answer part (a), we compared the percentage of students still categorized as first-year engineering students at the beginning of the third semester between Group 1 and Group 2. Table 3 shows that for Group 1 21.2% of students (n=88) still have not declared a major while Group 2 only 12.9% of students (n=52) have not declared a major at the third semester mark.

**Table 3. Summary of Majors Selection after 1-year (Group 1 and Group 2)**

| Group 1-Total | Sem1 | Sem2 | Sem3 | Sem3 % |
|---|---|---|---|---|
| 1st-Year ENGR | 402 | 361 | 88 | 21.2% |
| ENGR Dept | 13 | 15 | 219 | 52.8% |
| STM | 0 | 6 | 20 | 4.8% |
| Non-STEM | 0 | 5 | 17 | 4.1% |
| Not Attending | 0 | 28 | 71 | 17.1% |

| Group 2-Total | Sem1 | Sem2 | Sem3 | Sem3 % |
|---|---|---|---|---|
| 1st-Year ENGR | 399 | 358 | 52 | 12.9% |
| ENGR Dept | 2 | 6 | 234 | 58.2% |
| STM | 0 | 10 | 23 | 5.7% |
| Non-STEM | 0 | 8 | 23 | 5.7% |
| Not Attending | 0 | 19 | 69 | 17.2% |

A z-score was calculated to determine if the difference of 8.3% more students choosing a major is significant at the .05 alpha level between Group 1 (21.2%) and Group 2 (12.9%). The z-score is 3.12, which provides a *p-value* of .002, rejecting the hypothesis that there is no change between groups. Therefore, we can conclude that the new model for ENGR 1500 does help students make an informed decision to select a major (i.e. leaving first-year engineering) after the first-year.

To answer part (b), we compared the percentage of students categorized as first-year engineering students at the beginning of the fifth semester (i.e. after two-years) between Groups 1 and 2. Group 1 has 8% (n=33) and Group 2 has 3% (n=12) categorized as a first-year engineering student for a difference of 5%, as shown in Table 4.

**Table 4. Summary of Majors Selection after 2-years (Group 1 and Group 2)**

| Group 1-Total | Sem1 | Sem2 | Sem3 | Sem4 | Sem5 | Sem5 % |
|---|---|---|---|---|---|---|
| 1st-Year ENGR | 402 | 361 | 88 | 56 | 33 | 8.0% |
| ENGR Dept | 13 | 15 | 219 | 222 | 211 | 50.8% |
| STM | 0 | 6 | 20 | 34 | 40 | 9.6% |
| Non-STEM | 0 | 5 | 17 | 23 | 27 | 6.5% |
| Not Attending | 0 | 28 | 71 | 80 | 104 | 25.1% |

| Group 2-Total | Sem1 | Sem2 | Sem3 | Sem4 | Sem5 | Sem5 % |
|---|---|---|---|---|---|---|
| 1st-Year ENGR | 399 | 358 | 52 | 28 | 12 | 3.0% |
| ENGR Dept | 2 | 6 | 234 | 224 | 211 | 52.6% |
| STM | 0 | 10 | 23 | 33 | 40 | 10.0% |
| Non-STEM | 0 | 8 | 23 | 33 | 38 | 9.5% |
| Not Attending | 0 | 19 | 69 | 83 | 100 | 24.9% |

A z-score was calculated to determine if the difference of 5% more students choosing a major after two years is significant at the .05 alpha level. The z-score is 3.10, which provides a *p-value* of .002, rejecting the hypothesis that there is no change between groups. Therefore, after two years the new model of ENGR 1500 helps students select a major.

*Research Question 2:* To what extent does retention increase/decrease within the STEM College and in engineering after introducing the informed decision making module? ***No statistically significant difference.***

To answer this question we compare the retention rates of each group within engineering and the STEM College at the three semester and five semester mark to determine if there is a significant difference between the two modules, Group 1 and Group 2. Table 5 shows the total number of students for each group (G1=415, G2=401) and the retention rates after 1 and 2 years (i.e. Semester 3 and Semester 5).

**Table 5. Retention Rates for ENGR 1500 Groups**

| Group 1 | | Group 2 | |
|---|---|---|---|
| Total Students | 415 | Total Students | 401 |
| Semester 3 ENGR | 74.0% | Semester 3 ENGR | 71.3% |
| Semester 5 ENGR | 58.8% | Semester 5 ENGR | 55.6% |
| Semester 3 STEM | 78.8% | Semester 3 STEM | 77.1% |
| Semester 5 STEM | 68.4% | Semester 5 STEM | 65.6% |

As the table shows there was a decline in all the retention rates from Group 1 to Group 2. To determine if any were significant at the alpha .05 level a series of z-scores were calculated for each of the four comparisons (e.g., Group 1: Semester 3 ENGR vs Group 2: Semester 3 ENGR, etc.). For the comparison of engineering retention rates at the third semester, a z-score of 0.85 was determined which provides a *p-value* of .40 and indicates no significant difference. Comparing engineering retention rates at the fifth semester, a z-score of 0.92 was calculated which provides a *p-value* of .36 and indicates no significant difference. Moving onto STEM College retention rates at the third semester, a z-score of 0.60 with a *p-value* of .55 indicates no significant difference between Group 1 and Group 2. And lastly, STEM College retention rates at the fifth semester were compared between groups with a z-score of 0.87 with a *p-value* of .38 indicates no significant difference.

Even though Group 2's retention rates declined slightly, overall there was no significant difference between the old model and new model with regards to retention rates within engineering and the STEM College. This finding is indicative of the complexity of students in that there are a lot more factors in place with regards to retention than what one course can overcome. Further, as other studies have reported[8], the discernment process is "polarizing" in helping students to make a decision – this may mean that some students discontinue engineering but this course is not focused on retention in engineering but rather informed decision making.

*Research Question 3:* To what extent have disciplines students are selecting after the informed decision making module was introduced changed? ***No statistically significant difference.***

Lastly, we want to determine if there were any changes in which engineering disciplines students selected as a result of the new format. To investigate the engineering discipline selection process we compare Group 1 and Group 2 discipline rates for each of the five engineering disciplines at the third semester mark. Table 6 shows the five disciplines along with the percentage of each selected for all the students who selected an engineering major at the third semester mark.

**Table 6. Engineering Discipline Selection Rates**

| Group 1: Engineering Major | N= | % | Group 2: Engineering Major | N= | % |
|---|---|---|---|---|---|
| Chemical ENGR | 33 | 14.7% | Chemical ENGR | 47 | 19.3% |
| Civil ENGR | 30 | 13.3% | Civil ENGR | 30 | 12.3% |
| Electrical ENGR | 54 | 24.0% | Electrical ENGR | 42 | 17.3% |
| Industrial ENGR | 15 | 6.7% | Industrial ENGR | 21 | 8.6% |
| Mechanical ENGR | 93 | 41.3% | Mechanical ENGR | 103 | 42.4% |

Again, a series of z-scores were calculated to determine if the rate of selection of any of the five engineering disciplines changed at alpha .05 as a result of the new format (i.e. Group 1 vs Group 2). For chemical engineering the difference between groups is 4.6% resulting in a z-score of 1.34 and a *p-value* of .18 indicating no significant difference. Civil engineering had a difference of 1.0% resulting in a z-score of 0.32 and a *p-value* of .75 indicating no significant difference. Electrical engineering had a difference of 6.7% resulting in a z-score of 1.80 and a *p-value* of .07 indicating no significant difference. Industrial engineering had a difference of 1.9% resulting in a z-score of 0.80 and a *p-value* of .42 indicating no significant difference. And lastly, mechanical engineering had a difference of 1.1% resulting in a z-score of 0.23 and a *p-value* of .82 also indicating no significant difference.

The new module did not prove to show any significant differences between selections of a specific engineering discipline. Overall though there is a shift from electrical engineering into chemical engineering and industrial engineering. Prior analysis of the middle 2 cohort years found that the percentage of students that changed majors from what they originally indicated to the end of the year increased by 11% and there was a statistically significant increase in how "certain" students felt in their selection of an engineering major[17].

## Discussion and Conclusion

Overall, the results show a positive effect of the implementation of the new, small group format for helping students select a major. This informed decision is important early on in a student's studies so that they have a clear pathway to graduation. Even though retention rates did not increase from the old method to the new method, helping students determine if engineering is appropriate for them is equally as important as retaining them within engineering or STEM. These results can be used to enhance the importance of having a first-year engineering orientation course that allows students to understand what each engineering discipline has to offer. And while administratively more costly and burdensome, students were much more positive about the second model and indicated personal benefits came from a formalized discernment process. A prior study of major discernment at this institution that included only 2 cohort years reported that student satisfaction increased under the new model on measures of: interest, engagement, and effectiveness (all statistically significant positive increases under the new model)[9].

Future work should look at: (1) student satisfaction with their engineering major, (2) professional persistence, and (3) developing a more comprehensive model using logistic regression with such independent variables as starting math level, first semester math course grade, gender, and GPA to name a few variables. A regression model will help determine the amount of variation in moving from a categorization of first-year engineering to another major of the new model versus the old model.

**References:**


1. Duderstadt, J. Engineering for a Changing World: A Roadmap to the Future of Engineering Practice. Research, and Education, 2008.
2. National Academy of Engineering (NAE). Educating the Engineer of 2020: Adapting Engineering Education to the New Century. (2005). Nataional Academy Press.
3. Matusovich, H. M., Streveler, R. A., & Miller, R. L. (2010). Why do students choose engineering? A qualitative, longitudinal investigation of students' motivational values. *Journal of Engineering Education, 99*(4), 289-303. 4.
4. Seymour, E., & Hewitt, N. M. (1997). Talking about leaving: Why undergraduates leave the sciences (Vol. 12). Boulder, CO: Westview Press.
5. Marin, J., Armstrong, J., and Kays, J (2013). Elements of an Optimal Capstone Design Experience. Journal of Engineering Education, Volume 88 Issue 1.
6. Dym, C. (1999) Learning Engineering: Design, Languages, and Experiences. Journal of Engineering Education, Volume 88, Issue 2, pg. 145-148.
7. Reid, K., Reeping, D., & Spingola, E. (2018). A Taxonomy for Introduction to Engineering Courses. *International Journal of Engineering Education*.
8. Meyers, K., Bucks, G., Harper, K., & Goodrich, V. (2015, June), *Multi-Institutional Evaluation of Engineering Discipline Selection.* Paper presented at the ASEE Annual Conference and Exposition, Seattle, Washington. 10.18260/p.24512
9. Meyers, K. (2016) A Course to Promote Informed Selection of an Engineering Major using a Partially Flipped Classroom Model. Journal of STEM Education, Vol. 17. Issue 3.
10. Meyers, K., & Brozina, C. (2017). *Supporting an Informed Selection of an Engineering Major*. Paper presented at the American Society for Engineering Education Annual Conference, Columbus, OH.
11. Brawner, C., Camacho, M., Long, R., Lord, S., Ohland, M., and Wasburn, M. (2009) Work in Progress – The Effect of Engineering Matriculation Status on Major Selection. ASEE / IEEE Frontiers in Education Conference, San Antonio, TX.
12. Ohland, M., Brawner, C., Chen, X., and Orr, M. (2014) A Comparative Study of Engineering Matriculation Practices. American Society for Engineering Education National Conference, Indianapolis, IN.
13. National Academy of Engineering – Frontiers in Engineering Symposium 2013. https://www.naefrontiers.org/
14. Brown, S. D., & Lent, R. W. (1996). A social cognitive framework for career choice counseling. *The Career Development Quarterly, 44*(4), 354.
15. Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive career theory of career and academic interest, choice, and performance. *Journal of vocational behavior, 45*(1), 79-122.
16. VanDeGrift, T., & Liao, S. (2017). *Helping First-Year Engineering Students Select a Major.* Paper presented at the American Society for Engineering Education National Conference, Columbus, OH.