How Well Do They Match? Does High Confidence in Selection of Major Translate to High Graduation Rates in a Major?

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Background

Universities across the United States use a variety of methods to admit students into an engineering program. Some universities require students to complete one to two years of a general education curriculum before admitting students to an engineering major, while others require all incoming students to declare a specific engineering major at the onset. Many universities also require all engineering students, regardless of major, to take common fundamental first-year engineering courses that often include an exploration of the different engineering disciplines so their students can both gain an appreciation of engineering as a profession and make an informed selection of engineering major. In addition to these courses that devote significant effort to elucidating engineering majors, there is a plethora of websites that claim to help students decide on an engineering major by providing information on the various engineering disciplines or quizzes that pinpoint which engineering major may be best for a given individual. Additionally, most university websites provide information on each major offered at the university. With all this information easily accessible by students before and as they enter a university, is the time and effort expounded by first-year engineering courses in this regard worthwhile?

Most studies related to graduating in engineering focus on identifying factors that influence success in an engineering curriculum. A longitudinal and cross-institutional study by Zhange, Anderson, Ohland, and Thorndyke (2004) found students' high school grade point averages and SAT scores were predictive of graduation in an engineering curriculum. Budny, LeBold, and Bjedov (1998) found that factors such as structuring a first-year course series in a way to provide optimal mathematics placement and support for students, increased their graduation rate in engineering. A study of graduation rates at nine southeastern universities by Borrego, Padilla, Zhang, Ohland, and Anderson (2005), found that one's gender is also predictive of successful completion of an engineering degree, where females left engineering at higher rates than males.

More recently, Zahorian, Elmore, and Temkin (2013) examined factors that influenced students' selection of engineering major. They found class lectures, labs and projects in required Exploring Engineering and Engineering Design courses intended to expose the students to all options of engineering major were less significant factors in major selection than factors such as potential for societal contribution, personal academic interests, perceived job prospects, and their decision before they entered the engineering program. However, Myers (2016) found that students felt a first-year engineering course which included lectures and/or activities designed to expose students to engineering majors *did* influence their plans for a future engineering discipline. A study by Chamberlain, Benson, and Crockett (2008) found that core passions, the appeal of non-engineering courses and professions, a General Engineering course exposing students to engineering majors, and career interest surveys were significant factors in first-year students leaving engineering.

Description of the Study

Michigan Technological University uses a hybrid system for admitting engineering students, where entering students can declare a specific engineering major or enroll with an Engineering Undecided major and then transfer to the discipline of their choice at any time thereafter. In the fall of 2000, Michigan Tech adopted a common first-year engineering program where all the freshmen engineering students take the same classes regardless of engineering major. One of the reasons for adopting a common first-year program was that many of the engineering disciplines required similar first-year courses, and the creation of a common first-year curriculum would reduce the duplication of effort across many disciplines. Additionally, the adoption of a first-year program would allow entering students more flexibility in choosing an engineering major. After their first year, all students would be at the same place in their curriculum, and then could easily move into any engineering discipline their second year without having to "make up" any first-year course previously required in a discipline-specific engineering curriculum. This provided all engineering students their first year to either decide upon or change engineering majors without setting them behind in their coursework. Furthermore, the common curriculum provided an opportunity to expose all engineering freshmen to the variety of engineering disciplines to broaden their view of engineering, help them select an engineering major, and give them experience in working with others outside of their specific discipline.

As part of the first-year engineering program at Michigan Tech, all freshmen students are required to take two or three introductory engineering courses based on their level of mathematics preparation. In the first of these courses, particular effort is placed on introducing students to the various engineering disciplines offered at the university in order to help them either confirm or decide upon a specific engineering major. This is accomplished in part by requiring each engineering department to conduct evening sessions to describe their discipline and potential career paths to the freshmen engineering students. The engineering students are required to attend at least two of these sessions as part of the first introductory engineering course. Surveys completed by the students at the end of the course indicate these sessions are minimally helpful in selecting an engineering major.

In the falls of 2007 and 2008, all students in the introductory engineering courses were administered a survey related to their confidence in their selection of an engineering major as well as in their abilities and preparation in several academic areas. The survey was adapted from one created by Chris Brus, (2004). Possible responses to each question were configured on a five-level Likert scale. The questions and possible responses are included in the appendix.

Responses to the survey were analyzed to elucidate whether student confidence in their initial selection of major affected the major they earned their degree in, as well as how other factors may have influenced their completion of their initial declared major.

Study Participants

All students enrolled in the first-semester introductory engineering courses in the fall of 2007 and 2008 were administered the survey the first day of class. Students who declared majors in any of the engineering fields including those with a declared major of Engineering Undecided

were required to take the courses. 1559 students completed the survey. Students were told to select their chosen major on the survey based on what they felt best represented their selection of major at that time in case they declared a major during initial enrollment, but changed (or made-up) their mind over the summer.

Discussion of Results

Of the 1559 students who participated in the survey, 27.8% did not complete a bachelor's degree at the university. Of the 72.2% of students who did earn a bachelor's degree, 82.5% earned degrees in engineering, 6.8% in engineering technology, and 5.9% in either mathematics or a science field such as forestry, psychology, physics, chemistry, or biology. Most of the remaining 4.8% of degrees earned were in scientific and technical communication, business, finance, accounting, or another type of business-related field.

Of the 1559 students, all of whom matriculated with an engineering major, 59.6% went on to earn an engineering degree. 43.4% of the 1559 students earned an engineering degree in their initially declared field, or, in other words, 72.9 % of the engineering graduates received a degree in the major they declared upon matriculation. Because the computer engineering and electrical engineering curricula at Michigan Tech are similar, if a student selected electrical engineering as their declared major on the freshman survey but graduated with a computer engineering degree (and vice versa), that student was considered to have graduated in the same curriculum as their initial major. 9.7% of the students declared Engineering Undecided as their matriculation major and went on to earn engineering degrees. 6.5% earned an engineering degree in a different engineering field than their initially declared major with six of these students earning a General Engineering degree, which at that time was considered a "consolation" degree. These students could not successfully complete their desired program of study, but managed to pass a less rigorous General Engineering curriculum. A small percentage of students (~1%) completed two engineering degrees or earned a second bachelor's degree outside of engineering.

Several students earned degrees that were similar to their originally declared major. Table 1 lists originally declared majors along with degrees earned that were thought to be similar to these majors.

Table 1: List of earned degrees considered as similar to matriculation major

Original declared major	Degree earned in similar major
Biomedical engineering	Bioinformatics, Pharmaceutical Chemistry, Clinical Lab Science, Biochemistry and Molecular Biology, Biology, Exercise Science, Mechanical Engineering Technology, Mechanical Engineering
Chemical engineering	Chemistry, Biochemistry and Molecular Biology
Civil engineering	Surveying, Construction Management, Environmental Engineering, Geological Engineering
Computer engineering	Computer Science, Computer Network and System Administration
Electrical engineering	Electrical Engineering Technology, Audio Technology
Mechanical engineering	Mechanical Engineering Technology, Industrial Technology, Biomedical Engineering
Environmental engineering	Civil Engineering, Geological Engineering

To examine if high student confidence in a declared major correlated with graduation within the same major, student survey responses were examined. The students were divided into five groups: a "*No-change*" group (graduated with the same engineering major they matriculated with), "*Slight-change*" group (graduated with an engineering, technology, or science degree similar to the matriculation major), "*Engineering-change*" group (graduated with an engineering major that was not similar to what they matriculated with), "*Non-similar Degree*" group (graduated with a general engineering degree or a non-engineering major that was not similar to matriculation major), and "*No-degree*" group (did not earn a degree at the University).

17.2% of the study participants matriculated with an Engineering Undecided major. Of the Engineering Undecided students, 56% went on to earn engineering degrees (9.7% of the entire group), 19% of the Engineering Undecided students earned degrees that were outside of engineering (3.2% of the entire group), and the remaining Engineering Undecideds did not obtain a degree from the University (4.3% of the entire group). Responses from students who matriculated with an engineering undecided major and graduated in engineering were not included in the following analysis. However, it should be noted that Engineering Undecided students were included in the *Non-similar* and *No-degree* groups. Engineering Undecided students comprised about 38% of the *Non-similar* group and about 15% of the *No-degree* group.

Table 2 compares the confidence students felt in both choosing engineering as a career and their confidence in their chosen major. In the table (and in subsequent tables), a score of five corresponds to a response of "Completely confident", while a score of one corresponds to a response of "Not at all confident", thus the higher the score, the greater the confidence level. A two-tailed t-test was used to determine if the average response for each group was statistically different from the average response of the students who graduated in the same major they matriculated with (the *No-change* group). The analysis indicates students who earned *Non-similar* degrees outside of engineering had the lowest level of confidence that engineering was the right career for them. The confidence of both the *Non-similar* and *No-degree* groups that engineering was the right career for them was statistically different, and lower, than the *No-*

change group. The *No-change* and *Slight-change* groups had the highest confidence in their selection of engineering major. The *Engineering-change* and *Non-similar Degree* groups had the lowest confidence in their selection of engineering major, and the differences were statistically significant. The *No-degree* group also had statistically significant lower confidence in their selected major than the *No-change* group.

Table 2: Comparison in confidence in engineering as a career and selection of engineering major

	***No-change* group (n = 677)**	***Slight-change* group (n = 95)**	***Engineering-change* group (n = 71)**	***Non-similar Degree* group (n = 132)**	***No-degree* group (n = 434)**
Engineering as a career	3.91	3.86	3.80	3.60***	3.77***
Chosen engineering major	3.68	3.62	3.38**	3.41**	3.58*

* $p < 0.05$ ** $p < 0.005$ *** $p < 0.0005$: Statistical significance of difference from the *No-change* group

To understand if personal connections to engineers contributed to students successfully completing a degree without changing majors, students were asked whether they had family members who were, or personally knew, engineers. The students in the *No-change* group had more family members as engineers and knew the second highest number of engineers of the groups. The only group that was statistically different in the number of engineers with personal relations than the *No-change* group were the students in the *No-degree* group ($p<0.0005$). Such demographic information may help departments identify students at risk of not graduating from the university and target additional support to help these students succeed in engineering.

Students were also asked to rate their confidence in their abilities in several academic areas as well as specific skills used in engineering. Average responses are shown in Table 3. As in Table 2, higher numbers indicate higher confidence in their abilities. Across all groups, students report highest confidence in their math and science abilities. Those that did not change majors had the highest confidence in both of these areas, and the differences in the confidence levels were significant for three of the four groups in math ability and two of the four groups in science ability. Students who obtained a *Non-similar Degree* had the highest confidence in their writing ability, but the lowest confidence in all the abilities related to engineering except for their science ability.

Table 3: Comparison of confidence in academic abilities

	No-change **group (n = 677)**	***Slight-change*** **group (n = 95)**	***Engineering-change*** **group (n = 71)**	***Non-similar Degree*** **group (n = 132)**	***No-degree*** **group (n = 434)**
Math	3.96	3.71**	3.90	3.66***	3.82**
Science	3.86	3.69*	3.85	3.70*	3.78
Writing	3.34	3.39	3.27	3.56*	3.37
Speaking	3.33	3.44	3.18	3.37	3.26
Use of computers and software	3.59	3.61	3.59	3.37*	3.78**
Use of math and science to solve real-world problems	3.68	3.72	3.63	3.55	3.70
Use of graphics tools such as CAD	3.08	3.09	3.37	2.83*	3.18
Understanding engineering drawings and 2-D representations of 3-D objects	3.72	3.72	3.66	3.56	3.79

* $p < 0.05$ ** $p < 0.005$ *** $p < 0.0005$: Statistical significance of difference from the *No-change* group

Student confidence in their *preparation* in the same academic areas was also compared. Similar to confidence in their abilities, the most significant differences in student confidence in preparation between the *No-change* and other groups were in the areas of math and science preparation. The *Slight-change* group had the lowest confidence in their math and science preparation. Since 75% of this group earned degrees outside of engineering, their change in major may have been due to academic struggles in the math intensive engineering curricula.

In addition to students' perceived confidence in various academic disciplines, students were asked if they had completed a calculus course before entering the university. Notably, the *No-change* group had a higher rate of taking calculus prior to matriculation than the other groups and the No-degree group had the lowest rate of the groups.

Table 5 compares responses regarding the number of hours students spent studying in high school and their expectation of study time in college. Interestingly, the *Engineering-change* group had the highest averages in these areas, with their number of hours being statistically

greater than the *No-change* group. While the *Engineering-change* group noted the highest number of hours studying in high school, students in the *No-degree* group reported a lower statistical average of studying than the *No-change* group. These results suggest students who ended up with an engineering degree may have been more prepared to put forth considerable time towards the completion of their degree. It may be interesting to further study the demographics of students who change engineering disciplines during their college career, perhaps their additional time studying in high school gives them more confidence that they will be able to successfully change majors. Alternatively, it may indicate students who struggle more with general curriculum and may change their major to a less demanding discipline.

Table 5: Comparison of time students spent studying in high school and expected study time in their first semester in college

	No-change **group (n = 677)**	***Slight-change*** **group (n = 95)**	***Engineering-change*** **group (n = 71)**	***Non-similar Degree*** **group (n = 132)**	***No-degree*** **group (n = 434)**
Number of hours per week spent studying in high school	0.65	0.55	0.92*	0.52	0.52*
Expectation of number of hours they would spend studying their first semester in college	2.27	2.13	2.58**	2.19	2.21

* $p < 0.05$ ** $p < 0.005$ *** $p < 0.0005$: Statistical significance of difference from the *No-change* group

Students' confidence in time-management skills and their comfort in accessing and initiating support were also compared for the groups. The only significant difference was the *No-degree* group had significantly lower confidence in their time management skills than the *No-change* group ($p < 0.005$). The *No-change* group had the highest confidence in their time-management skills, but the *Slight-change* and *Engineering-change* groups had the highest comfort in accessing and initiating support.

Conclusion

Overall, students who graduated in the same major as they matriculated in had the highest confidence that engineering was the career for them and in their declared major than the other groups. They were also the most confident in their math and science preparation and abilities and time management skills. A higher number of them completed a calculus course prior to entering the university than students in the other groups, and they had more personal connections to engineers than other groups.

The purpose of this study was to begin to examine if high confidence in engineering as a career and in their chosen engineering major translated to higher graduation rates within their chosen major, and it appears this study confirms that. Many first-year curricula expend a lot of effort on educating students on the different engineering disciplines in order to help their students choose an engineering major. At Michigan Tech, some effort is made in this regard. At the time of this study, about 17.2% of the engineering students entered the university as Engineering Undecided. However, out of the 1559 students in this study, only 4.6% of the students changed to a non-similar engineering major and 9.7% matriculated with an Engineering Undecided major and graduated with an engineering degree. Thus, it appears that course efforts to help students confirm an engineering major may have helped at most 14.2% of the students. Meanwhile, almost as many (13.0%) students earned degrees outside of engineering, and almost twice as many (27.8%) did not earn any degree. It may be that first-year engineering programs could better focus their efforts on identifying and assisting students who may be at risk for leaving school and/or deciding to not pursue engineering, rather than solely on helping confirm an engineering major.

From this study, students who are less confident in their choice of engineering as a major as well as their choice of discipline within the field of engineering were found to be less likely to complete their major in their initially declared field. The same is true for students with lower confidence in their math and science abilities, students who spent less time studying in high school, and those with fewer personal connections to engineers. While this result may not be surprising, it does suggest this information could identify students who may be more susceptible to leaving engineering, which could help focus efforts on increasing the retention and success of these students.

References

Borrego, M.J., Padilla, M.A., Zhang, G. Ohland, M.W., & Anderson, T.J. (2005). *Graduation rates, grade-point average, and changes of major of female and minority students entering engineering.* Paper presented at the 35th ASEE/IEEE Frontiers in Education Conference, Indianapolis, IN.

Brus, C. Zhao, L. & Jessop, J. (2004). *Visual-Spatial Ability in First-Year Engineering Students: A Useful Retention Variable?* Paper presented at the 2004 ASEE Annual Conference & Exposition, Salt Lake City, UT.

Budny, D., LeBold, W., & Bjedov, G. (1998). Assessment of the Impact of Freshman Engineering Courses. *Journal of Engineering Education, 87*(4), 405-411.

Chamberlain, J. Benson, L. & Crockett, E. (2008). *Work in progress - first year engineering student responses on exit surveys as indicators of program effectiveness*. Paper presented at the 38th Annual Frontiers in Education Conference, Saratoga Springs, NY.

Meyers, K. (2016). A Course to Promote Informed Selection of an Engineering Major Using a Partially Flipped Classroom Model. *Journal of STEM Education: Innovations and Research*, *17*(3), 14-21.

Zahorian, S., Elmore, M., & Temkin, K.J. (2013). *Factors that Influence Engineering Freshman in Choosing Their Major.* Paper presented at the 2013 ASEE Annual Conference & Exposition, Atlanta, GA.

Zhang, G., Anderson, T.J., Ohland, M.W. & Thorndyke, B.R. (2004). Identifying Factors Influencing Engineering Student Graduation: A Longitudinal and Cross-Institutional Study. *Journal of Engineering Education, 93*(4), 313-320.

Appendix: Survey Questions (possible responses)

1. How many engineers do you know personally? (none, one, two, three, four or more)
2. How many engineers do you have in your family – parents, grandparents, aunts, uncles, siblings? (none, one, two, three, four or more)
3. Currently, how confident are you that engineering is the right career for you? (Completely confident, very confident, moderately confident, slightly confident, not at all confident)
4. What is your declared major in engineering (biomedical, chemical, civil, computer, electrical, environmental, geological, materials science and engineering, mechanical, general)
5. How confident are you that your current major in engineering is right for you? (Completely confident, very confident, moderately confident, slightly confident, not at all confident)

6 – 21: Rate your self-confidence in your ability in the following academic areas (possible responses: completely confident, very confident, moderately confident, slightly confident, not at all confident). After rating their self-confidence in their abilities in these areas, they were asked to rate their preparation in the same areas (possible responses: completely prepared, very prepared, moderately prepared, slightly prepared, not at all prepared).

   a) Math
   b) Science
   c) Technology (use of computers and software packages)
   d) Engineering (using math and science to solve real-world problems)
   e) Graphical tools (use of programs such as CAD)
   f) Graphical communication (understanding engineering drawings and 2-D representations of 3-D objects)
   g) Writing
   h) Speaking

22. Had you completed a calculus class (not pre-calc) prior to starting coursework in the College of Engineering (yes or no)
23. How confident are you about your time-management skills? (Completely confident, very confident, moderately confident, slightly confident, not at all confident)
24. How comfortable are you with accessing support: tutoring, math lab, professors? (Completely comfortable, very comfortable, moderately comfortable, slightly comfortable, not at all comfortable)
25. How comfortable are you in initiating support: organizing study groups, etc.? (Completely comfortable, very comfortable, moderately comfortable, slightly comfortable, not at all comfortable)
26. How many hours per week, on average, did you study during high school? (0 – 5 hours, 6-10, 11-20, 21-30, more than 30 hours per week)

27. How many hours per week, on average, do you expect to study this semester? (0 – 5 hours, 6-10, 11-20, 21-30, more than 30 hours per week)