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A Longitudinal Study of the Impact of a First-Year Honors Engineering Program

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Background

The honors program for first-year engineering students at The Ohio State University (OSU) began approximately twenty years ago, based upon successful curricular developments at other schools, particularly the E^4 (Enhanced Educational Experience for Engineering) program at Drexel University.[1-6] Part of the driving force for its development was a retention study conducted in 1988, showing that only 38 percent of first-year engineering students went on to earn an engineering degree from Ohio State.[7] At OSU, students considering engineering enter as pre-majors and enroll in a common first-year sequence, regardless of intended major within engineering. Those who are designated as honors by the university have the option of taking the more challenging honors version of the sequence. After taking additional prescribed courses such as math, physics, and chemistry, students apply to be accepted into their specific major departments.

Both the standard and honors sequences have similar goals, but because the honors track has almost double the contact hours of the standard track, these students pursue some topics in more depth and also learn additional content. Both programs have a hands-on lab experience about once a week, designed to give students exposure to a variety of engineering disciplines, as well as to teach them how to use particular tools, employ some data techniques, and write technically.[8] Content that is common between the two tracks include engineering graphics (both by hand and with a software package), MATLAB, design, and engineering ethics. They also address an array of professional skills, including teamwork and oral reporting. The major additional content area for the honors students is computer programming in C and C^{++}. Further, with the additional contact time, the honors students are able to engage in a more challenging and substantial design project.[9] The honors program reserves ten weeks at the end of the program almost exclusively for this project, while the standard track integrates their design project with additional new content over a slightly shorter time period.

In the mid-to-late 1990's, an internal evaluation of the honors program was conducted. The honors cohort was compared to a matched group of equally academically talented students on measures such as first-year GPA (both by term and cumulatively throughout the year), time to acceptance into the major, retention in engineering, and time to graduation. Analysis showed clearly that students who chose to participate in the honors program outperformed those who did not on every metric.

The percentage of students choosing the honors sequence at that time was still relatively small, and so the cohorts involved in that study contained only between 30 and 60 students. As the honors program's reputation has grown, a larger and larger percentage of the students who have been eligible for the program have elected to participate. In recent years, the percentage of eligible students opting for honors has been greater than 90%, resulting in honors cohorts of several hundred students. Further, the institution's retention rate in engineering has improved significantly, to as high as 65 percent of students graduating within 6 years with a degree in engineering.[10,11]

Also during this period, the first-year engineering program has made improvements to both the honors and standard sequences.[13-15] At the same time, the university's criteria for being an honors student have become more rigorous. Another recent change is the growing student belief that those who participate in the engineering honors program earn lower grades. Since some departments have capped their enrollment and use GPA as the primary criterion to determine who to accept into their programs, students fear that choosing the honors sequence puts them at a disadvantage when they apply for acceptance into their majors. They feel this might translate into increased time to degree.

Motivated by these changes in curriculum, student population, and student perception, a new set of comparisons were conducted with two recent first-year engineering cohorts. As before, the comparisons focused on first-year GPA, time to acceptance to major, time to graduation, and retention in engineering. The new study also looked at grades for specific introductory mathematics and science courses.

Study Design

The new study focused on students who started at the university in 2005 and 2006. These years were chosen because they are the last two cohorts who had the opportunity to complete their undergraduate education at Ohio State before the university switched from quarters to semesters. The research team wished to avoid any extraneous factors due to possible irregularities in scheduling as students navigated the transition. (Whether one cohort fared better than the other through the transition is a topic for a different study.) For each incoming class, all of the students who were eligible for the honors sequence but who did not choose it were matched to students of equal academic ability who *did* choose honors. Therefore, the number of students not choosing the honors sequence determined the sample sizes. The matching was performed based on incoming ACT scores, plus gender and ethnicity. The total number of incoming students analyzed for this study was 190 (two groups of 53 from 2005 and two groups of 42 from 2006). The distribution of these students is shown below in Table 1.

Table 1. Demographic Description of Student Samples

Cohort	2005 N = 106 (2 groups of 53)		2006 N = 84 (2 groups of 42)	
Average ACT Comp	29.8 ± 2.1		29.8 ± 1.9	
Average ACT Math	30.8 ± 2.2		30.3 ± 2.2	
Female	6	11%	5	12%
Male	47	89%	37	88%
White	49	92%	39	93%
Asian/Pacific Island	2	4%	1	2%
African American	0	0%	2	5%
Hispanic	2	4%	0	0%

The specific composition of these samples was driven by the group who was honors-designated, but chose to take the standard track of courses. The gender and ethnicity demographics are fairly typical of the enrollment of the incoming honors-designated students in those years.

Retention and Graduation

Given that retention was one of the factors leading to the development of the first-year engineering program, counts were made of the number of students from each of the four groups who

a) graduated within four, five, and six years
b) graduated with a degree in engineering
c) graduated with a degree in any STEM field

Table 2 shows these results. In this table, as well as those that follow, "honors" will refer to the students who chose the honors sequence, while "standard" refers to those who were eligible for the honors sequence but opted to take the standard track instead.

Table 2. Summary of Graduation Data

	2005		2006	
Year & Track	Honors	Standard	Honors	Standard
Grad in 4 yrs or less	36%	34%	45%*	21%*
Grad in 5 yrs or less	89%	89%	81%	83%
Grad in 6 yrs or less	93%	93%	88%	90%
Grad in Eng	72%	76%	76%	74%
Grad in other STEM	6%	2%	3%	5%
Total grad in STEM	78%	78%	79%	79%

* significant difference

The data show that the overall graduation rate for these students is significantly higher than the 65% reported earlier; however, it must be remembered that these are all students who qualified for the honors program, and the previous statistic included all first-year engineering students. The most striking characteristic of this analysis, though, is that there is no significant difference in terms of overall graduation rate between any groups. The only significant difference is that for the group entering in 2006, the honors students had a substantially larger fraction of the cohort graduate in 4 years or less (Mann-Whitney test, $p < 0.008$).

Whether students chose to co-op or not could affect this data. The student records were examined to see how often they reported being on co-op. While this is the only way to get an idea of this potential effect so many years after the fact, it is not a completely reliable measure, as students who find co-op opportunities without using the college's career services office do not always fill out the paperwork to inform the university. Roughly twenty-five percent of each group reported at least one co-op experience. The honors students had slightly more terms on co-op than the standard students, but it was not a significant difference.

Acceptance to Major

Next, the quarter of acceptance to major was recorded for each student, and the number of terms between initial enrollment as a first-year student and getting into the major was calculated. These results are summarized in Table 3. In this table, and in those that follow, note that while averages are presented to give the reader an idea of general trends in the data, most of the data distributions are not normally distributed, and so the appropriate non-parametric tests were used on the entire data distributions for these statistical comparisons.

Table 3. Time From Enrollment to Acceptance to Major

	2005		2006	
Year & Program	Honors	Standard	Honors	Standard
Avg. # of quarters	5.7	6.3	6.3	6.6

While it is noticeable that the honors-enrolled students tended to get into their majors sooner, the differences are not statistically significant.

Comparisons of First-Year GPAs and Introductory STEM Grades

In the previous assessment of the program, it was found that students who chose to participate in the honors sequence started with slightly lower GPAs, but by the end of the freshman year, they had higher cumulative GPAs than their counterparts in the standard track. The analysis was repeated for this study; the average GPAs for the cohorts are shown in Table 4.

Table 4. Comparison of Cumulative GPAs in First Year

	2005		2006	
Year & Program	Honors	Standard	Honors	Standard
First qtr. GPA	3.45	3.37	3.3	3.29
Second qtr. GPA	3.48	3.44	3.43*	3.25*
Third qtr. GPA	3.44	3.39	3.48*	3.28*

* statistically significant difference between honors and non-honors cohorts

Note the general stability of the grades for any particular cohort. While the students in the honors track always averaged slightly higher GPAs than those choosing the standard track, the only significant differences were between the honors and standard students in the second and third quarters of the 2006 cohort (Mann-Whitney, $p<.03$ and $p< .01$, respectively).

To get an even more matched comparison, the grades for introductory math and science courses were compared. (Due to the significant differences in the engineering courses taken by the two cohorts as outlined above, a comparison of those grades would not be meaningful.) Most engineering majors require two terms of physics and two terms of chemistry, so grades were collected for those four courses and compared for each year's cohort. However, there is significant variation in the mathematical content required by different departments, as well as in the courses students may choose to take to satisfy these requirements. Consequently, the grades for any calculus or differential equations course taken by members of a cohort were collected and analyzed as one group for the purposes of this comparison. These numbers are presented in Table 5.

Table 5. Comparisons of Grades in Introductory Math and Science Courses

	2005		2006	
Course(s)	Honors	Standard	Honors	Standard
Physics I	3.37	3.38	3.24	3.09
Physics II	3.22	3.15	3.17	2.95
Chemistry I	3.30*	3.00*	3.33*	2.89*
Chemistry II	3.21	2.90	3.42*	2.71*
Math courses	3.18	3.13	3.28*	3.05*

* statistically significant difference between honors and non-honors

Again, the data seem to indicate a slight grade advantage for the honors-enrolled cohort, but there are only statistically significant differences on four of the eight comparisons: the 2005 cohort in Chemistry I ($p < .05$) and the 2006 cohort in Chemistry I ($p < .006$), Chemistry II ($p < .002$), and math ($p < .01$). The instructors of the honors sequence give several potential reasons for these differences, though none of them can be further researched this many years after the courses have been offered. One is simply that the honors sequence is more rigorous, and that the study skills students must develop in order to be successful are carried with them into subsequent courses, resulting in better academic performance. Another is that the honors program explicitly encourages students to work and learn together, and that this support structure leads to greater overall success in further STEM courses.

While these data indicate that something was different between the two years, there is nothing in the student records or in instructors' recollections of those years that would indicate why the difference exists.

Summary

When the results of all the comparisons presented above are combined, it may indicate that participation in the honors program gave students a slight advantage, in terms of grades earned and time to graduation. There was no difference between the cohorts in terms of retention to graduation, graduation with an engineering degree, or graduating in a STEM discipline. One result that is clear from this work is that participation in the honors program does not put students at an academic disadvantage, contrary to current student belief.

Future Directions

The team will expand this analysis to include additional cohorts, which may help to determine whether the trends that appear here are actually consistent differences or not. With the expanded data set, it may also be possible to conduct meaningful comparisons of grades in specific subsequent engineering courses (e.g., circuits, statics, thermodynamics). Additionally, more information is going to be collected about how the chosen samples compare to the overall honors population in the college of engineering, to determine whether these samples are representative of the honors program or not. Further, a comparison of final graduating GPAs will be done.

Also, an effort will begin to collect more data in real-time regarding student co-ops, to better know if there is a relationship between co-op and graduation time; this will also give a more accurate view of whether one group is more successful in gaining co-ops and internships than the other. In addition, collecting and analyzing data in real-time will give the team a better chance to identify factors that may be behind any apparent differences between the two sequences.

Finally, student opinion among those who choose and complete the honors sequence is that they are better prepared for technical writing than their counterparts who take the standard sequence. As all students are required to take a writing course sometime after their first year, a collection and comparison of those grades would help determine whether this student belief is founded or not.

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