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Board 300: Greater Equity, Access, and Readiness for Success in Engineering and Technology (GEARSET) - An Alternate Pathway to Engineering and ET

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Introduction

The Greater Equity, Access, and Readiness for Engineering and Technology (GEARSET) Program, an NSF funded S-STEM program was developed to address several institutional needs at the university. The original target population for the GEARSET program was identified as a subset of the students who applied to the College of Engineering (COE) at the University of Toledo (UToledo) and do not meet all the admissions requirements and are admitted to an Exploratory Studies major in the university's University College. Historical data indicates that approximately 170 students per year with a high school GPA of 3.00 or higher are admitted to Exploratory Studies because they do not meet the College of Engineering admissions criteria. Of those, roughly 78 students remain at the University after one year. Of those 78, only about 45 students per year transition to College of Engineering majors by the end of their first year, with the majority of these students transferring to engineering technology majors. The low transfer rate for students to the College of Engineering in general and to engineering majors in particular does not accurately reflect the ability of these students, but rather is due in part to curricular bottlenecks, lack of institutional support, and lack of significant relevant exposure to material meant to engage these students' engineering future selves. This data motivated the creation of the GEARSET program. In this paper we describe the program, summarize the results to date, and discuss the impact of the recent global pandemic and the subsequent transition to test optional admissions criteria on the definition of the GEARSET cohort, program implementation, and student participation.

Program Description

The central objectives of the GEARSET program are:

1. To increase recruitment, retention, student success, and transfer rates into engineering of students who are not admitted directly to engineering but who are instead admitted to the university's University College.
2. To increase meaningfulness and engineering relevance of pre-engineering curriculum.
3. To increase diversity within the student population of various engineering departments in the College of Engineering.
4. To remove bottlenecks in curriculum and improve access to engineering and decrease time to degree completion.

All GEARSET students have access to advisors within the COE to help them better understand the programs, curriculum, and professional outcomes of each of the engineering and engineering technology disciplines offered. A key aspect of the program is a curated one-year curriculum. In addition to the courses required to fulfill the transfer requirements for admission into their COE major of interest, all students in the GEARSET program take additional courses historically proven to promote better understanding of the key areas of Math, Chemistry and Physics needed to be successful engineers. GEARSET students take Engineering Applications of Mathematics (GNEN 1880), Introduction to Engineering (GNEN 1000), and Professional Development (GNEN 1010). Both GNEN 1000 and GNEN 1010 were developed specifically for the

GEARSET program. GNEN 1800 was an existing course, however prior to GEARSET access to this course was restricted to COE students.

The descriptions of these three courses and the rationale for including them in the GEARSET curriculum are provided below.

• GNEN 1800 Engineering Applications of Mathematics will provide an overview of the salient math topics most heavily used in the core physics and engineering courses. Students will learn to solve problems from engineering applications using mathematical concepts ranging from algebra to differential equations. Examples from the first two years of engineering coursework are solved in class and explored in corresponding laboratory experiments. The objective of this course is to provide an engineering context for subsequent courses in mathematics. Intended for students prior to taking Calculus I.

GNEN 1800 Engineering Applications of Mathematics was developed as part of an NSF-funded consortium to adopt and assess the Wright State Model for Engineering Mathematics Engineering. The Wright State model for Engineering Mathematics Education has been adopted by many institutions including the University of Toledo, and is described here [1]. Historically at UToledo the course is recommended for students admitted to engineering who do not place into MATH 1850 (Calculus) and instead begin their mathematics sequence with MATH 1330 (Trigonometry). Our data shows that when students take GNEN 1800 with MATH 1330 it significantly improves performance in physics and subsequent math coursework. Students taking the course also have improved retention over those of similar preparation who do not take the course. Despite the course's proven success in enhancing students' preparation or subsequent mathematics, physics, and engineering courses, GNEN is only recommended and not required for students who are admitted directly into their majors in the COE who no not place into calculus. However, we felt it was critically important to include GNEN 1800 in the GEARSET curriculum to enhance the students' mathematics preparation and to remove bottlenecks in the transfer pathway.

At UToledo, the majority of the students admitted to the COE take calculus (MATH 1850) as the first course in the mathematics sequence. There are some students who do not place into MATH 1850 and who take Trigonometry (MATH 1330) as their first mathematics course. At UToledo. The UToledo mathematics department has waived the MATH 1320 requirement for students who test into MATH 1330 and take GNEN 1800 concurrently with MATH 1330. The physics department also accepts MATH 1330/GNEN 1800 as an alternative to MATH 1850 (Calculus) as the prerequisite to PHYS 1230, thus enabling students to take calculus and physics in the same semester. Giving GEARSET students who test into MATH 1330 access to GNEN 1800 means that they will also not be required to take MATH 1320. GNEN 1800 also provides them with enhanced preparation for calculus, and allows them to take physics and calculus concurrently in the spring of their pre-engineering year. They are therefore able to transfer to the COE a semester earlier than a non-GEARSET student in Exploratory Studies. They will also have earlier access to engineering courses for which physics is a prerequisite.

Since MATH 1330 is the first course in the mathematics sequence in the GEARSET pre-engineering pathway outlined above, admission requirements to the program (and thus the definition of academically talented for the S-STEM grant) was set at High School GPA of 3.0 or above and enrollment in MATH 1330. To take MATH 1330 students must have either a 22 ACT mathematics subscore, an SAT math score of 540 or a score of 61 on the online Assessment and LEarning in Knowledge Spaces (ALEKS) system.

• GNEN 1010 Professional Development will provide students with information about professionalism, ethical responsibility, the engineering code of ethics, the importance of, and the need for, lifelong learning, contemporary issues, the impact of engineering in a global and societal context, working on multi-disciplinary teams, and what it's really like out in the business and engineering world. Students also gain experience in resumé preparation and interviewing skills.

At UToledo students in engineering majors are required to complete three semesters of co-op experience in order to graduate. Engineering students are required to take a professional development course before their first co-op experience, and are not permitted to attend the career fairs hosted by the COE in the Fall and Spring semesters until they have completed professional development. Since the GEARSET student would have completed enough engineering coursework to be eligible for their first co-op experience in the summer after their second year, the GNEN 1010 course ensures that students fulfill the professional development requirement ahead of COE career fairs.

• GNEN 1000 Introduction to Engineering. This course will explore the various disciplines of engineering in historical, present, and future context while incorporating basic design principles in an interdisciplinary model. At the end of this course the student should have a significant understanding of all areas of Engineering, the emerging technologies, career prospects, and research possibilities therein.

At UToledo most students admitted to the COE are placed directly in their major and take an introduction to engineering course that is specific to their major during their first year. Students working towards the transfer requirements for the COE therefore did not have access to a course that introduced them to the different majors in the COE prior to GEARSET and the development of GNEN 1000, and they are ineligible to enroll in the introductory course in their major of interest prior to transferring to that major. The new course GNEN 1000 thus enables students to better identify the engineering or engineering technology major that best matches these interests, and aids in the development of their engineering identity and their sense of belonging in the engineering college and profession.

It was anticipated that GEARSET might also serve to increase the recruitment of academically talented, low-income students. Instead of receiving notification that they have failed to gain admission to engineering and that they have been admitted to Exploratory Studies, assets-based language will be used to communicate that they have been selected for the GEARSET pre-engineering cohort. Participation provides access to the curricular programming described above as well as co-curricular support and the opportunity to shorten the time to transfer to COE by one semester (over those admitted to Exploratory Studies who are not part of the GEARSET cohort). Another key component of the program is that low-income students in the GEARSET cohort who successfully transfer to a major within the COE after one year receive scholarship support. Finally, in addition to the curriculum and scholarships, GEARSET as proposed including co-curricular components that were to include a learning community and alternate Fall break; however the global pandemic impacted the implementation of these parts of the program.

Although the majority of the students admitted directly to the COE are admitted to their major of choice, students who apply to an engineering major and no not meet all the admission requirements for that major but satisfy the admission requirements are admitted to the COE as

Undecided Technology (UNDT). When the proposal was developed, this population was originally intended to be the comparison (control) group for the GEARSET program.

Impact of the Covid-19 Pandemic on GEARSET

The start date of the NSF-funded GEARSET program was January 2020, and the first cohort of students entered the university in the Fall of 2020. In the Spring of 2020 the university, like most other institutions in the country was impacted by the Covid-19 pandemic and the university classes went fully online. The pandemic also severely affected the university enrollment, and the number of students in the first GEARSET cohort was much smaller than had been expected based on historical trends. Restrictions limiting in-person gatherings and extra-curricular activities prevented the co-curricular activities of the grant, from being executed. The most significant impact of Covid-19 on the GEARSET program as the decision of the university and the College of Engineering to adopt test optional admissions criteria starting in Fall 2020. This resulted in many students who would have been admitted to Exploratory Studies in University College being admitted directly to the College of Engineering but as Undecided (UNDT), i.e. they were admitted to the COE, but not directly to a major. The university has retained the test admissions criteria and we have redefined the GEARSET cohort 2021 to include students who meet the original GEARSET admissions criteria (i.e. HS GPA of 3.0 and testing into Trigonometry) and who are admitted to the COE as UNDT. Thus Cohort 2 (Freshmen class of 2021) and subsequent courses are comprised primarily of students who are in the College of Engineering but not in their majors.

The year prior to the receipt of NSF funding (and before the pandemic), GEARSET was run as an internally funded one-year pilot. We define the students in this pilot as Cohort 0. The pilot did not include scholarships or co-curricular components, so Cohort 0 students' experience with GEARSET was only the curriculum and the engineering advising. For the Fall of their freshman year (Fall 2019) and most of the Spring 2020 semester they were in face to face classes together and were able to interact and build a community with others in their cohort in a way that Cohorts 1 and 2 were not.

Results

Tables 1 and 2 show the first year retention and transition to major rates for GEARSET students in Cohorts 0 – 2 students admitted to the COE but not directly to an engineering major (i.e. UNDT), respectively.

GEARSET STUDENTS					
	Enrolled	Retained		Transition to Major	
	Number	Number	Percent	Number	Percent
Cohort 0 Fall 2019	32	26	81.3%	19	59.4%
Cohort 1 Fall 2020	15	11	73.3%	9	60.0%
Cohort 2 Fall 2021	33	24	72.7%	17	51.5%

Table 1. GEARSET first year retention and transition to major data.

		UNDT STUDENTS				
		Enrolled	Retained		Transition to Major after 1 year	
Cohort	HS GPA	# of Students	# of Students	%	# of Students	%
Fall 2019	Total	40	23	57.5%	12	30.0%
	Above 3.00	23	18	78.3%	10	43.5%
	Below 3.00	17	5	29.4%	2	11.8%
Fall 2018	Total	43	28	65.1%	11	25.6%
	Above 3.00	27	20	74.1%	9	33.3%
	Below 3.00	16	8	50.0%	2	12.5%
Fall 2017	Total	25	17	68.0%	8	32.0%
	Above 3.00	15	12	80.0%	5	33.3%
	Below 3.00	10	5	50.0%	3	30.0%
Fall 2016	Total	13	10	76.9%	4	30.8%
	Above 3.00	9	7	77.8%	2	22.2%
	Below 3.00	4	3	75.0%	2	50.0%
Fall 2015	Total	20	13	65.0%	7	35.0%
	Above 3.00	7	4	57.1%	3	42.9%
	Below 3.00	13	9	69.2%	4	30.8%

Table 2. UNDT (Control Group) first year retention and transition to major data.

Comparing the retention rates of the Fall 2019 Freshmen in GEARSET students (Cohort 0) who were all enrolled in Exploratory Studies with those of the Fall 2019 UNDT Students of similar academic qualifications (i.e. HS GPA above 3.0) we not that both the retention and transfer rates to major were higher for the GEARSET students. This is a clear indicator of the effectiveness of the GEARSET curriculum. We conjecture that the sense of community and engineering identity that students in Cohort 0 were able to develop during that first year was also a factor in their success. Despite the pandemic, Cohorts 1 and 2 also had a higher rate of transfer into the major than the pre-GEARSET UNDT students did. This is further indication that the GEARSET curriculum is effective in preparing students for their chosen majors.

Discussion

As shown in the data, the GEARSET program has effectively increased the retention and transfer rates for students with a minimum high school GPA and a certain level of mathematics preparation who do not meet the criteria of direct admission to a major in the College of Engineering. This effect persisted into the 2020-21 academic term where we expected significant declines in both values due to the web-based instruction and lack of structured fall programs due to University restrictions pertaining to the Covid-19 Pandemic.

The data for Cohorts 0 – 2 provides significant evidence that the instructional adjustments and curricular-based portions of the program have made strong impacts on producing positive results in the key areas of retention and transferability of these students. As an additional note, in both Cohort1 and Cohort2, the underrepresented minority (URM) populations (31% and 33%

respectively) far outpaced those of the College of Engineering as a whole (17% and 18%) in the same academic terms, thus achieving our secondary goal of increasing the recruitment and retention of URM students within the College of Engineering.

Acknowledgement

References
1. https://engineering-computer-science.wright.edu/research/the-wright-state-model-for-engineering-mathematics-education