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Pilot Strategy to Enhance Mechanical Engineering Student Retention Through Active Academic Advising and Early Engagement

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Abstract:

Student retention and recruitment represent persistent challenges in mechanical engineering education. Retention is closely linked to the appropriate placement of students in foundational first-year courses such as mathematics, chemistry, and physics—subjects that heavily influence academic persistence and success. Standardized test scores and placement exams are frequently employed to allocate students into these courses. However, these traditional systems are often plagued by limitations, including biases inherent to standardized tests, delays in transcript processing, and insufficient communication regarding the importance of placement assessments.

Underrepresented student groups often encounter these challenges more acutely, receiving critical placement test information while still completing high school, a time when competing priorities can obscure the significance of these assessments. As a result, students may be misplaced into courses that do not align with their academic preparedness, compromising their ability to succeed and progress.

This study introduces a new strategy to enhance retention by implementing a structured, proactive advising model that emphasizes early, personalized engagement between students and faculty advisors. This advising framework prioritizes frequent and clear communication regarding placement and academic progress through personalized emails, one-on-one Zoom meetings, and in-person advising sessions. Mathematics placement, given its foundational role in engineering curricula, serves as the centerpiece of this advising model. The framework provides students with academic planning support, fosters meaningful student-faculty interactions, and cultivates student ownership of their educational pathways.

Additionally, the model encourages early research engagement to strengthen student retention. Faculty advisors actively guide students to explore research opportunities within their first two years, recognizing that research participation enhances critical thinking, fosters academic networks, and deepens students’ commitment to their discipline. Through early academic involvement, students are offered a customized path toward long-term academic success and professional growth.

Our pilot implementation demonstrated substantial improvements in both initial course placements and four-year retention rates, particularly among students who initially struggled with mathematics. By addressing placement challenges and promoting early academic involvement, this strategy fosters an inclusive, supportive educational environment designed to retain diverse talent in mechanical engineering.

Introduction:

Retention and recruitment remain pivotal challenges within engineering education, particularly in mechanical engineering, which often experiences lower retention rates than other engineering disciplines. The demanding curriculum requires mastery of core subjects, especially mathematics, chemistry, and physics, within the first year, and early academic success in these subjects is strongly correlated with long-term retention and degree completion [1], [2]. Misplacement into inappropriate courses can impede student progress, undermining both academic outcomes and persistence.

Mechanical engineering programs typically rely on standardized test scores such as the SAT and ACT, alongside placement exams, to assess student readiness for these gateway subjects. However, research indicates that standardized assessments introduce structural biases that disproportionately affect underrepresented groups [3], [4]. Furthermore, high school transcripts and standardized test results are often delayed, complicating placement processes and increasing the risk of students being enrolled in mismatched courses. These factors necessitate the adoption of placement systems that are both more equitable and reliable.

For many underrepresented students, communication about placement tests arrives during the final stages of high school—an already stressful period, marked by competing obligations. As a result, these students may not fully appreciate the significance of these assessments, which leads to misplaced enrollments in courses that do not align with their preparedness [5], [6]. This misalignment can lead to frustration, lower academic performance, and, ultimately, higher attrition rates.

Moreover, the transition to college often presents additional non-academic challenges that require comprehensive support. Academic advising systems must extend beyond initial placement by offering ongoing mentoring and support throughout students' first academic year to optimize retention outcomes [7], [8]. Recent research has highlighted the need for proactive advising approaches that foster academic engagement, build community, and mitigate common barriers to student persistence [9], [10].

Research highlights that retention in STEM disciplines is strongly influenced by early engagement and proactive advising strategies. Tinto's model of academic and social integration emphasizes the importance of supportive academic environments to foster persistence[11]. Similarly, the concept of intrusive advising, first introduced by Glennen, advocates for preemptive faculty interventions to address potential student challenges before they escalate [12].

For underrepresented groups, targeted advising is particularly crucial, as these students often encounter systemic barriers that impede their progress. Museus and Ravello highlight how culturally responsive advising practices improve retention for minority students [13]. These findings align with Pascarella and Terenzini's work identifying advising as a cornerstone for retaining diverse talent in higher education [14].

Moreover, early placement in appropriate mathematics courses, as discussed by Bahr, plays a foundational role in determining a student's ability to navigate and persist in engineering curricula [15]. Studies by Hodara and Jaggars further connect proper placement strategies to improved progression in STEM pathways, reinforcing the critical intersection of advising and academic preparation [16]. Guided by these frameworks, this paper presents a pilot strategy that integrates proactive advising, early engagement, and equity-focused interventions to enhance retention in mechanical engineering. By addressing placement challenges and fostering inclusivity, the proposed strategy aims to cultivate a more supportive educational environment.

This paper introduces a structured advising model designed to address these issues in mechanical engineering education. Our advising framework spans the recruitment stage through the end of the second academic year, with a strong emphasis on proper course placement and early engagement in research activities.

Advising Model: Active and Structured Advising Framework

The previous advising model and the control group for this study was a fairly typical advising structure that is used for mechanical engineering students. The faculty advisor would be assigned first year students at the beginning of the Fall semester, the first semester the students would be block scheduled typically by an administrative assistant based on test scores and placement tests, and then the faculty advisor would meet with the student once a semester for the rest of the student's academic career to advisee the student on the next semesters courses. This is a fairly standard model that is used at many different institutions and is one that allows for one on one personal interactions with the student and minimizes the workload on the faculty advisor. However, in order to address the issues of mechanical engineering student retention, recruitment, and the initial math placement of these students the new active and structured advising model was created as seen in Fig. 1. The structured advising model integrates multiple touchpoints between students and faculty advisors, beginning with the initial recruitment phase and extending through the first two academic years. This proactive model ensures consistent communication regarding placement tests and curricular requirements, empowering students to make informed decisions about their academic pathways.

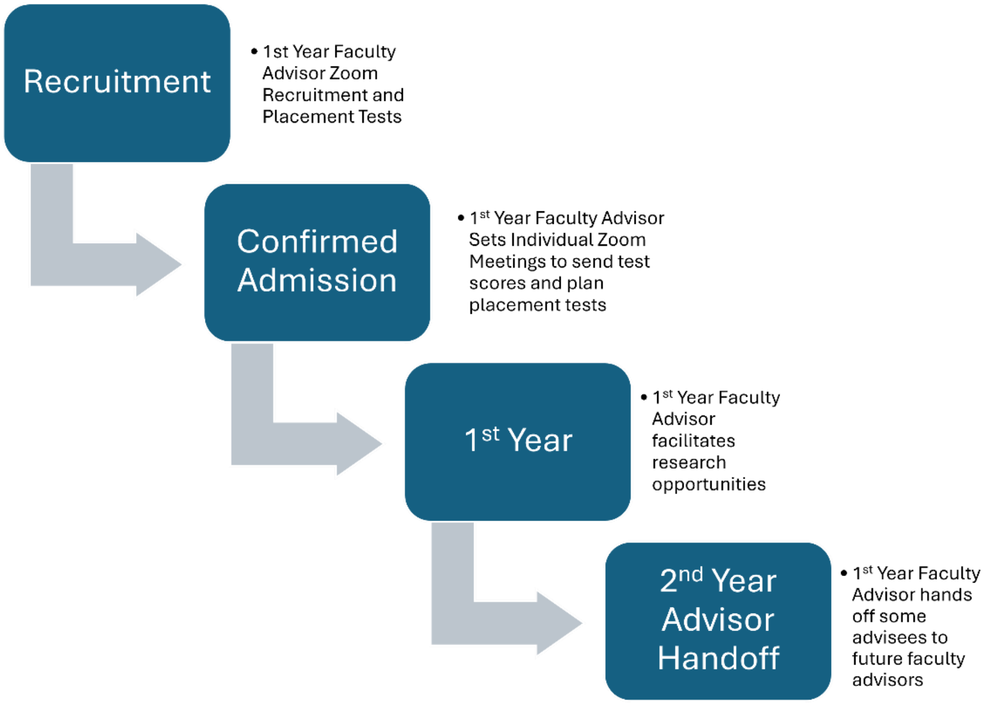

Figure 1: Active Faculty Advisor Model Schematic. Active advising begins in the recruitment stage and ends at the 2nd year. Throughout this time period there are multiple advisor-student interactions to emphasize and clarify curriculum, placement tests, and undergraduate research opportunities.

The faculty advisor engages with prospective students personalized meetings (virtual or inperson) during the initial recruitment phase. Faculty advisors volunteer for this particular role and ideally shadow a previous faculty advisor to learn the process. Additionally, in the summer before there is a training session to explain the model and responsibilities of the advisor. The faculty advisor is also compensated for this additional summer work, the service workload is also recognized for the faculty member, and there are previous faculty support mentors for the faculty member as well. These introductory interactions serve a dual purpose: to offer a comprehensive overview of the mechanical engineering program and to underscore the critical role of placement tests in shaping students' academic trajectories. Emphasizing the significance of appropriate placement—particularly in mathematics and physics—ensures students understand how these tests influence their course sequence and long-term progression.

Faculty advisors are equipped with multiple curriculum pathways tailored to students' placement outcomes. These pathways provide a clear academic roadmap that adapts based on students' initial math and physics placement results, offering flexibility while keeping students on track for timely degree completion.

The second interaction between faculty and the student occurs upon the student's formal acceptance into the program. At this stage, the advisor re-engages with the student—either virtually or in person—to congratulate them on their admission and to detail the logistics, timelines, and expectations for placement testing. Advisors also introduce additional preparatory resources, such as review materials designed to reinforce foundational knowledge before the placement assessments, helping students approach these tests with confidence. Faculty advisors have also been trained by admission on the interpretation of placement test scores both eternally, i.e. SAT, ACT, as well as math placement tests like ALEKS. This is of particular importance for faculty advisors that may not be familiar with high school courses in the united states.

At the start of the first semester, the faculty advisor meets with students once more to discuss their course placement and provide information about early research opportunities within the department. Early exposure to research is regarded as a cornerstone of professional development, as it fosters critical thinking, strengthens academic engagement, and helps build professional networks within the discipline. Participation in research activities not only supports student retention but also enhances their preparedness for careers in mechanical engineering.

After the first year of enrollment, students may be re-assigned to other faculty advisors to ensure equitable advising workloads across the department. This reallocation also aims to align students with faculty members who share similar backgrounds or research interests, fostering a sense of community and belonging within the program. Such mentorship relationships contribute to both retention and the overall well-being of students as they navigate their academic journeys.

The pilot advising program was implemented and evaluated over four academic years, with three key metrics used to measure its effectiveness: the percentage of students initially placed in Calculus I, four-year retention rates before and after the pilot, and the percentage of students actively engaged in undergraduate research. This multi-year pilot provides actionable insights into the role of structured advising in promoting academic success and persistence.

Results

The impact of our advising model is evident in several key metrics. As illustrated in Figure 2, prior to the implementation of our pilot advising program, approximately 31% of first-year mechanical engineering students in Fall 2019 were initially placed in Calculus I. This pre-pilot placement rate was consistent with historical trends observed within the program. However, following the implementation of the active advising model—and without introducing any changes to placement exams or evaluation criteria—the percentage of students placed in Calculus I increased significantly. Over the four years of the program’s implementation, Calculus I placements consistently exceeded 78%, underscoring the effectiveness of the advising strategy in motivating students to complete placement tests and improve course alignment. This data was collected by looking at the mechanical engineering student enrollment in math courses in the first semester.

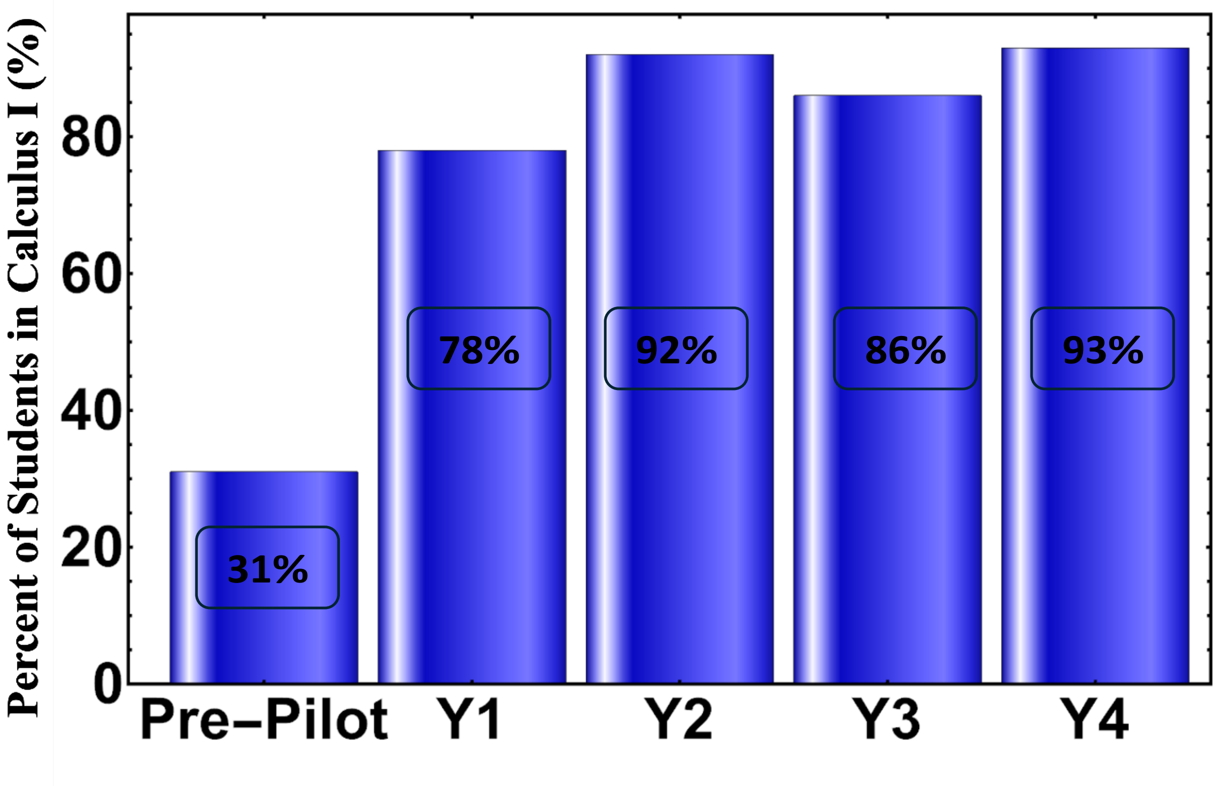

Figure 2: Percentage of Students Initially Placed in Calculus I. The pre-pilot year shows that 31% of students were placed in Calculus I. Post-implementation, the percentage steadily surpassed 78% across the four subsequent years of the pilot (Y1-Y4).

This increase in Calculus I placement was strongly correlated with improved student engagement in placement testing, demonstrating the impact of proactive, structured advising in guiding students toward appropriate course enrollments. The model's focus on personalized communication and early mentorship effectively addressed common barriers to proper course alignment, helping students start with appropriate coursework.

In addition to improving course placement, the advising model led to a significant rise in student retention rates (Figure 3). Before the pilot program, only 28% of first-year students persisted through to their fourth year, a rate reflective of typical trends in mechanical engineering programs. However, the first cohort completing the advising pilot program exhibited a retention rate of 76%—a substantial improvement that highlights the importance of early intervention and consistent faculty-student engagement throughout the academic journey. This data was only collected for the control group and the first cohort of the new advising model as there have only been four years of data collection. It will be very informative to measure the 4-year, 5,-yuear, and 6-year graduation rates of the cohort and that data will be available in the coming years but it appears to be strongly correlated with retention rate and a significant improvement over the prepilot cohort.

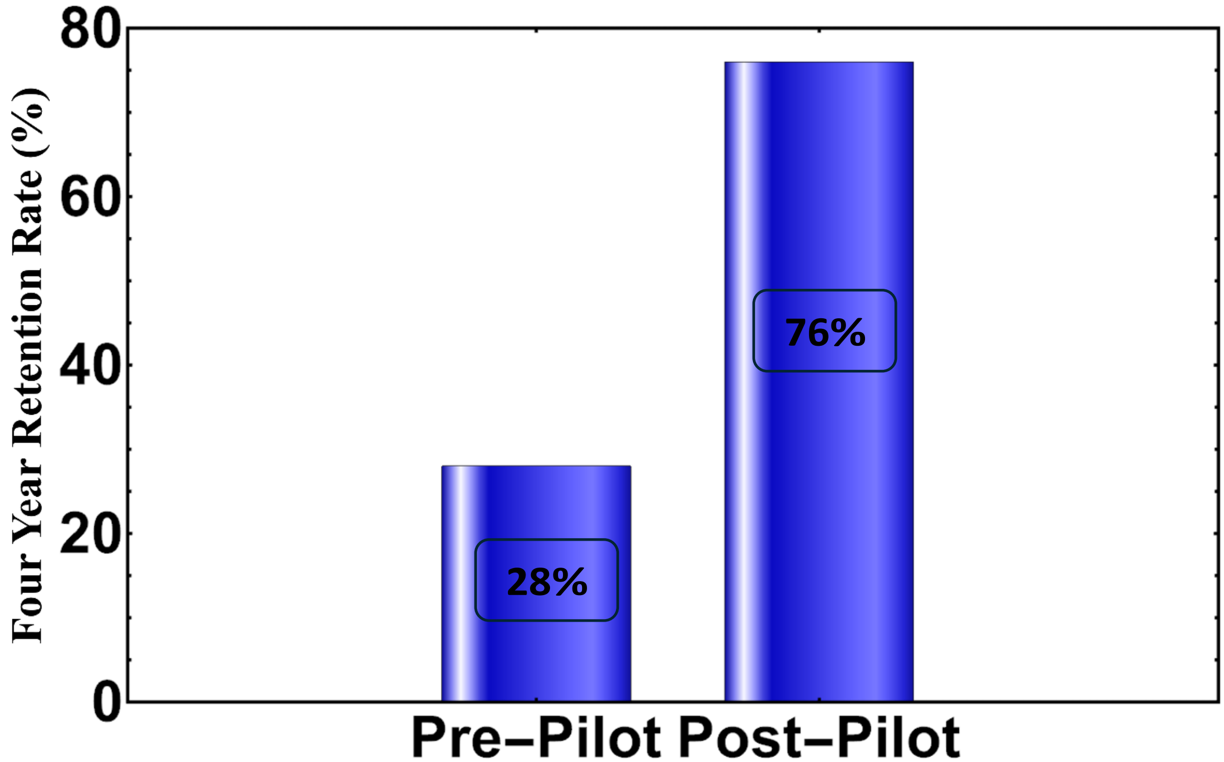

Figure 3: Four-Year Retention Rates of Mechanical Engineering Students. Pre-pilot, the retention rate was approximately 28%. After the implementation of the advising model, the retention rate increased to 76% for the first cohort completing the program.

The improved retention observed in the pilot program can be attributed to two interconnected mechanisms facilitated by the advising model. First, with a greater proportion of students placed directly in Calculus I, they were able to engage with engineering-specific coursework earlier in their academic journey. This early exposure minimized delays caused by prerequisite or general education fatigue, enabling students to maintain academic momentum.

Additionally, the advising model fostered stronger cohort progression and community-building. As students advanced together through foundational courses, they developed a sense of belonging and mutual support, both of which are essential for retention. In contrast, the pre-pilot cohorts experienced fragmentation, with a significant portion of students placed in pre-calculus or supplementary courses. This misalignment not only delayed their entry into engineering courses but also diminished opportunities for peer interaction and community cohesion, further contributing to the lower retention rates observed prior to the pilot program.

Beyond course placement and retention, the pilot program dramatically increased undergraduate research participation (Figure 4). Prior to the program, only 23% of students engaged in research activities during their four years in the program. However, after the pilot was implemented, 83%

of students participated in research at some point during their academic journey. This data was collected by examining the number of students that registered for an undergraduate research course.

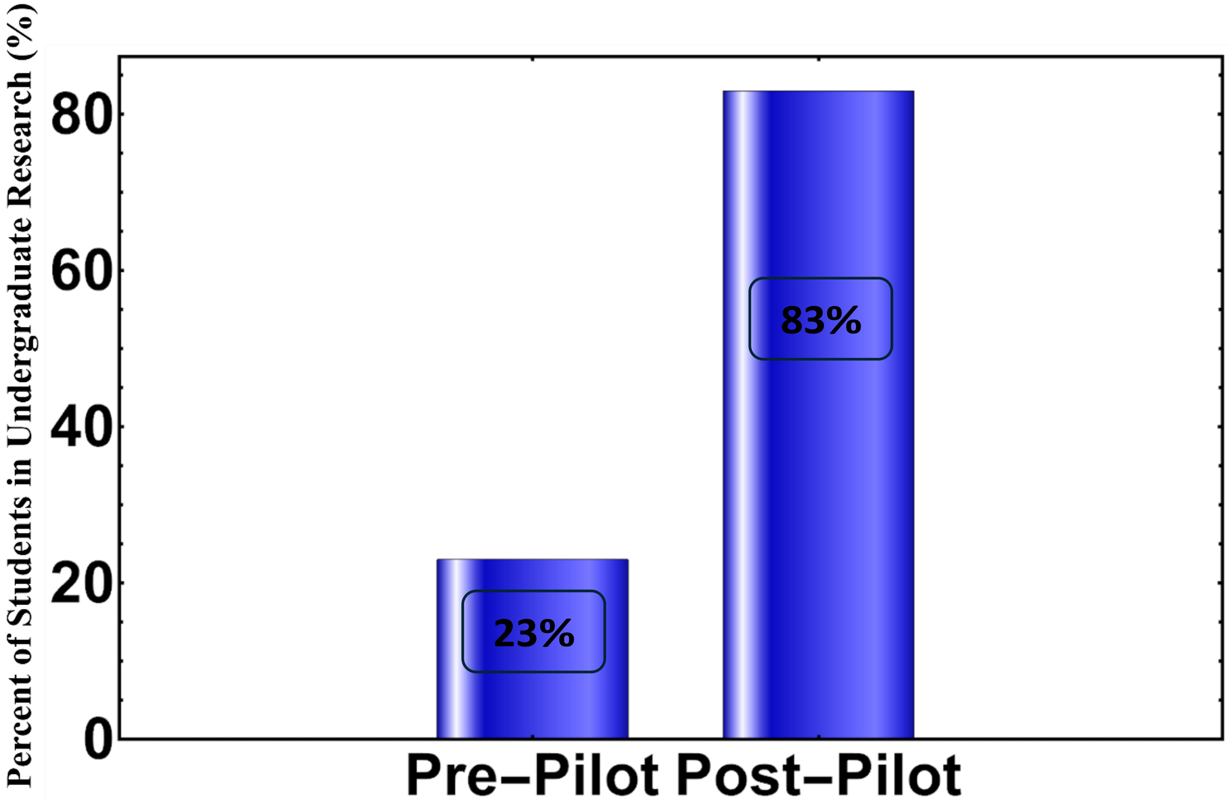

Figure 4: Percentage of Students Engaged in Undergraduate Research Opportunities. The prepilot program saw only 23% of students participating in research, while the first cohorts of the advising model achieved an 83% participation rate.

This dramatic rise in research participation can be attributed to two interrelated factors. First, the early academic placement in Calculus I reduced the burden on students by minimizing the need to enroll in remedial or supplementary courses, freeing up time for them to pursue research opportunities. Second, the advising model prioritized early communication about research opportunities, ensuring that students were aware of the professional benefits of research engagement early in their academic careers. The personalized guidance provided by faculty advisors was instrumental in matching students with research projects aligned with their interests and career aspirations, further promoting sustained engagement and academic satisfaction.

While these findings clearly illustrate the implementation of this new active structured advising model have improved mechanical engineering student initial math placement, four-year retention rate, and engagement in undergraduate research there are some difficulties in implementing this advising model. This advising model depends heavily on the time, work, and availability of the faculty advisor and this adds a heavy additional workload to faculty that are already overburdened with teaching, scholarship, and service. To attempt to compensate the faculty for this additional workload the faculty in this pilot program the faculty were given additional service workload units however many of the faculty mentioned that this was not sufficient considering the workload expected of faculty advisors. In future iterations of this program it would be beneficial to provide the faculty with an additional stipend or better yet a teaching course release considering the results of this advising model.

Conclusion

This study demonstrates that structured, proactive academic advising plays a pivotal role in enhancing student retention and academic success within mechanical engineering programs, particularly by addressing the challenges associated with proper placement in first-year mathematics, chemistry, and physics. Early and consistent communication between faculty advisors and students ensures that students fully grasp the significance of placement tests and receive the targeted support necessary to navigate these foundational courses effectively.

The pilot program yielded notable improvements in key metrics, including an increase in Calculus I placements, four-year retention rates, and undergraduate research participation. These outcomes emphasize the critical importance of personalized advising not only for academic achievement but also for promoting early involvement in research—a factor integral to long-term student success and professional development within the discipline.

Our findings further suggest that scaling this advising framework across other engineering disciplines could yield similarly positive outcomes, particularly for underrepresented student populations, who often face disproportionate challenges during the transition to higher education. Proactive advising offers an effective means to close these equity gaps by providing the guidance and community support necessary to foster persistence.

Future research should focus on refining and optimizing the advising model for broader implementation, while also exploring additional strategies to deepen student engagement in both academic and extracurricular activities. It would also be very informative to compare the trends in engineering to other programs. By fostering an inclusive, supportive educational environment, mechanical engineering programs can more effectively nurture, retain, and empower diverse talent—critical for driving innovation, promoting equity, and advancing progress in the field.

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