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Engineering Canvas Applications to Improve Fundamental Math Skills in Pre-Calculus Math

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Recent research indicates that the retention rate within US engineering schools averages at 56%, dropping even lower to approximately 20% for underrepresented minorities [1]. Furthermore, statistics reveal that around 40% of STEM students switch their majors to non-science or non-technical fields, with 50% leaving physical and biological sciences, and 60% departing from mathematics programs [2]. In the 2020-2021 academic year within a Southwest School District, only 21% of high school students demonstrated proficiency in math [3]. This trend is particularly pronounced among Latinx students, who are overrepresented in Title I schools where experienced math teachers and advanced course offerings are scarce. Deficiencies in mathematical skills have been identified as a major barrier to pursuing STEM degrees [4], [5], [6], and [7]. To bridge the math gap, various models have been implemented at XXX and YYY, including mandating prerequisites such as algebra and pre-calculus before enrolling in Math 181-Calculus I, a requirement for all engineering and computer science majors at XXX. However, despite these efforts, students often spend two to three semesters addressing math prerequisites before progressing to Calculus I, resulting in prolonged graduation times and increased financial burden.

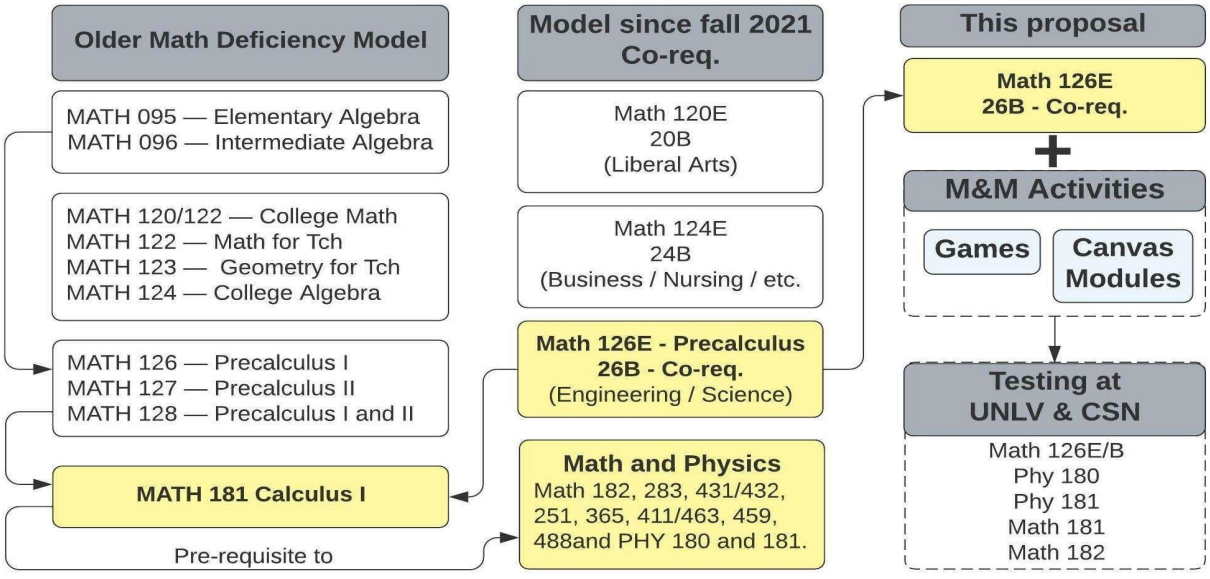


Figure 1: Math Deficiency Approaches at XXX and YYY: Past, Current, and proposed Practices

To address these challenges, a co-requisite model was adopted at YYY and XXX in fall 2021 to enhance incoming students' fundamental math skills and reduce time to degree attainment [Figure 1]. Under this model, students aspiring to engineering and science degrees receive additional math instruction through Math 126E (3 credits) pre-calculus, supplemented with the

co-requisite Math 26B (2 credits). Figure 2 illustrates the math proficiency levels of students entering the XXX College of Engineering from 2010 to 2021, highlighting the prevalence of students enrolled in lower-level math courses such as Math 126 and Math 127, pre-calculus I and II, respectively.

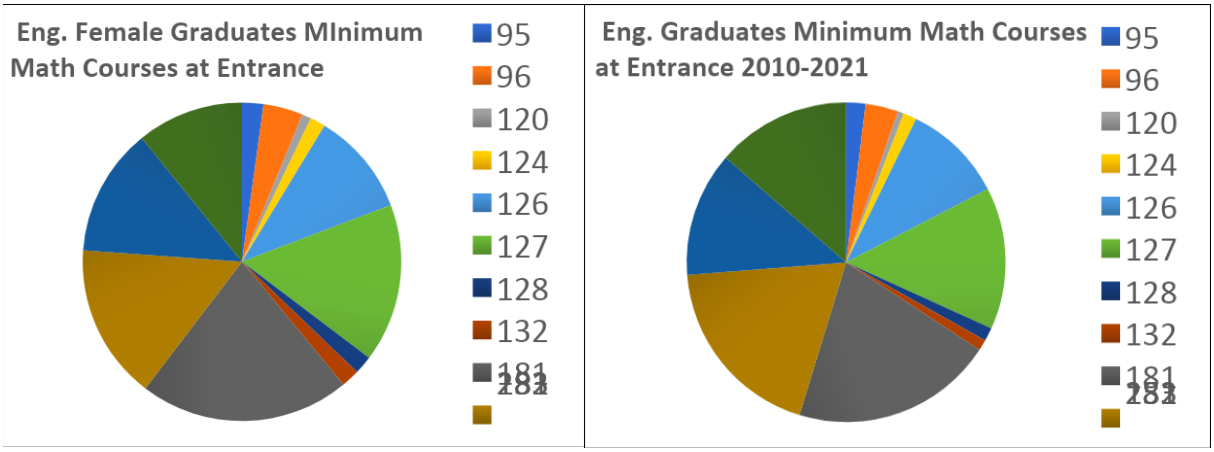
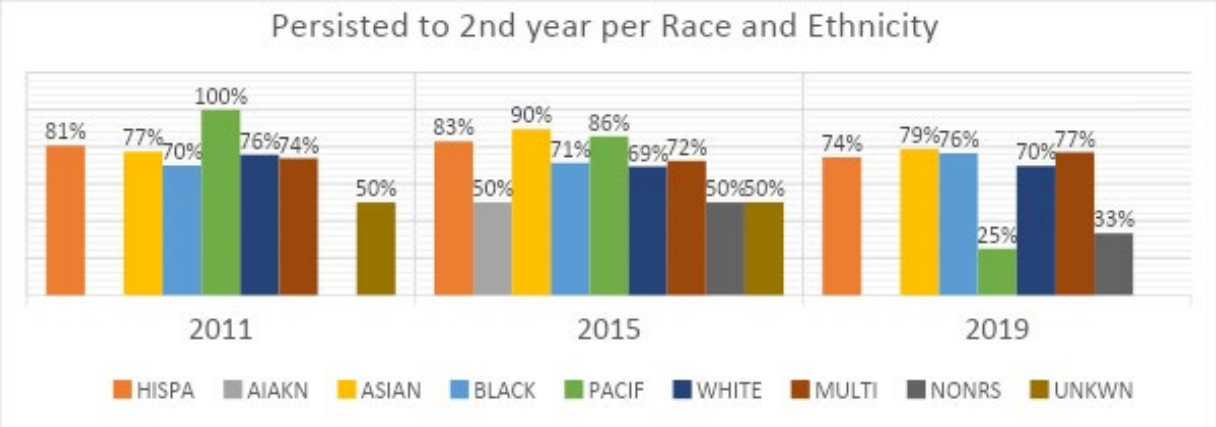


Figure 2- Math level entrance at XXXX for engineering and computer science graduates, 2010 to 2021.

The persistence and graduation rates, Figure 3, point to the impact of math under-preparation on delaying graduation for engineering and computer science majors at XXXX.



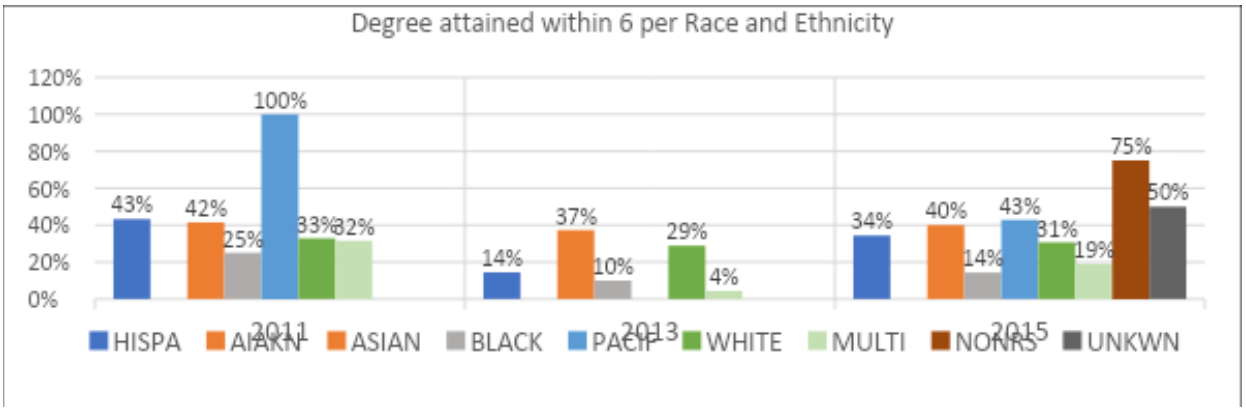


Figure 3: Persistence at year 2 and Graduation of Students within 6 Years by Ethnicity

Current literature reviews suggest various innovative interventions to improve math outcomes, including active learning, hands-on projects, mentoring programs, and technology integration [8], [9]. To address these challenges, a National Science Foundation (NSF)-funded project was initiated to enhance the fundamental math skills of pre-engineering students at XXX and a community college in the Southwest (YYY). Conceptually-rich applications were developed to demonstrate the practical application of fundamental math concepts in engineering and computer science fields, aiming to bridge the gap between abstract math and real-world engineering contexts.

Two Canvas applications, "Let's build" and "Viva Las Vegas" were created to illustrate the application of elementary functions, such as linear and quadratic functions, in civil and mechanical engineering. They were accompanied by a set of practice exercises. These applications are currently being tested within the co-requisite model employed by XXX and YYY in spring and summer 2024 for pre-calculus I math. Data on students' motivation and knowledge gains will be collected to evaluate the efficacy of these applications in assisting students aspiring to STEM majors. The research utilizes a design experiment approach, emphasizing an iterative cycle of development, refinement, and evaluation, with the goal of both improving the applications and understanding their impact on students' STEM outcomes.

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