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

Mathematics is the common language across STEM fields. Thus, math proficiency can become a barrier for students entering college and those aspiring to earn STEM degrees. Deficiencies in mathematical skills have been considered the major contributing factor to STEM attrition [1], [2], [3], [4]. Given the importance of math preparation, postsecondary institutions typically vet the math skills of incoming students and assign those who score below a designated cut-point on a standardized exam to remediation. Several models have been used at University of Nevada Las Vegas (UNLV) and College of Southern Nevada (CSN) in the past to bridge the math gap for students aspiring STEM fields (Figure 1). As early as 1996 students were required to pass courses on algebra and pre-calculus before enrolling in Math 181-Calculus I. Math 181 is the first calculus required from all engineering and computer science majors at UNLV followed by 3 or four more mathematics courses. Figure 2 shows the math placement of Hispanic and First-Generation Hispanic students at UNLV in 2019. On average, the data show that the majority of Hispanic students, especially those who are first-generation, lacked the math preparation necessary for college. This trend is especially more prevalent for female students. About half of the Hispanic students identified as lacking math preparation is first-generation, and the number of female students lacking college-level math proficiency is approximately double those of male students. Given the math-gap, students entering engineering and computer sciences at UNLV, typically have to spend two to three extra semesters before meeting the requirements to take Calculus I. This practice results in longer times to graduation, attrition, and additional financial burden to students.

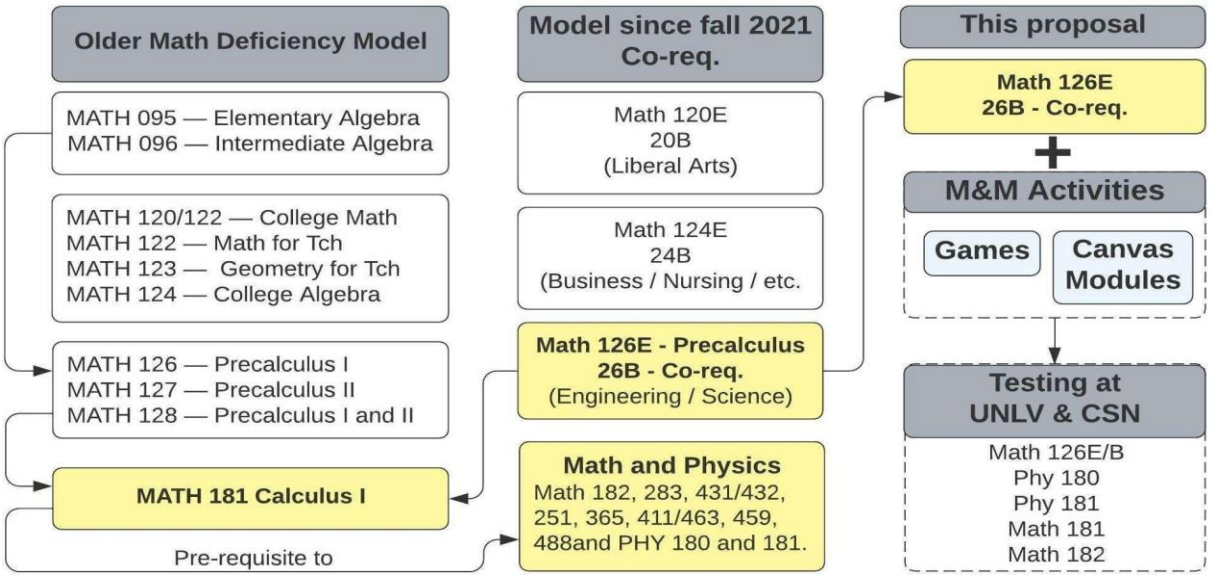

Figure 1: Math Deficiency Approaches at UNLV and CSN: Past, Current, and proposed Practices

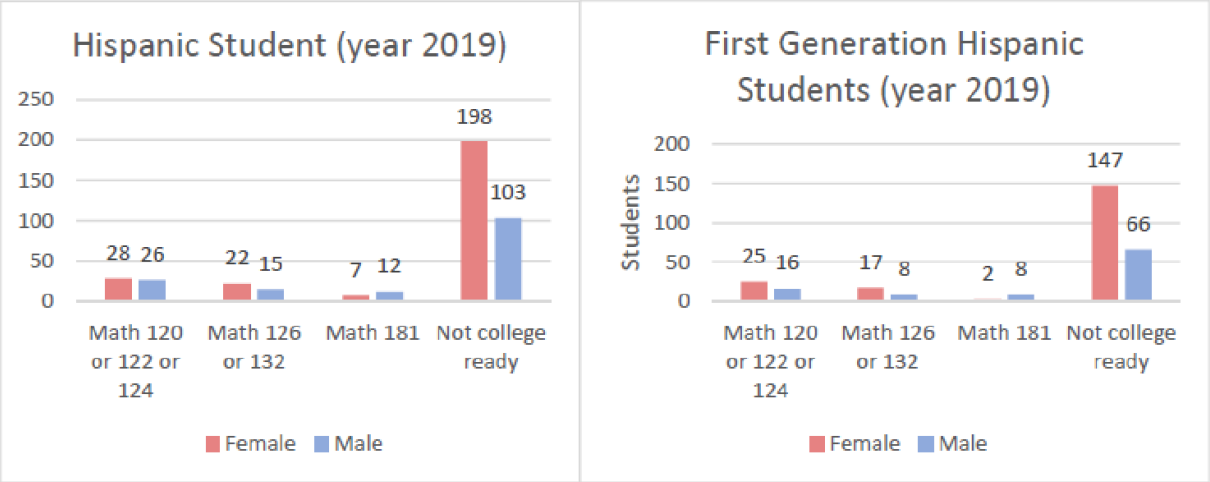

Figure 2. Distribution of Hispanic population (left) and first-generation Hispanic population (right) in math courses based on gender in year 2018, at UNLV

In the past decade, higher education has had to acknowledge that the current modes to deliver remediation coursework may be, at best, inconsequential and, at worst, actually detrimental to attainment [5]. The importance of math preparation to earning a STEM degree heightens the need for effective remediation reform. In addition, placement in lower-level math can delay time to degree which creates additional financial burden and may result in departure from STEM degrees. Therefore, interventions that bridge the gap between high school preparation and STEM degrees within the first years of college are critical to retaining students in STEM, especially underrepresented students who typically attend high schools where advanced math courses and more experienced teachers are sporadic.

Despite the high stakes of math remediation, delivery mechanisms are shown to be problematic [6]. Research has shown that the delivery of remedial instruction mediates academic outcomes [7]. The traditional model bars students from enrolling in college-level courses pending their completion of a pre-college level sequence; this model is shown to inequitably penalize students who attended Title I high schools, a disproportionate number of whom are students of color [8]. While we know very little about what versions of math remediation work in all contexts [9], we do know that any singular approach is insufficient to address Latinx student needs, especially at HSIs[10], [11], [12]. A 2017 paper [13] outlines a literature review of innovations and interventions that intend to improve the outcomes for areas of study based in mathematics. The pedagogical approaches discussed in the reviewed literature included active learning, hands-on projects, mentoring programs, use of technology, one-to-one help, and peer study groups. The paper noted that there is relatively little literature on rigorous evaluations of the interventions. There is a need to devise innovative math remediation methods that are more engaging, effective, and less costly to students. In this National Science Foundation funded project, engineering and math faculty from the large R1 university UNLV and the community college in the Southwest CSN are collaborating to develop engaging methods to teach students the fundamentals of pre-calculus math. Math games and Canvas applications are being developed to supplement the current co-requisite model used by UNLV and CSN for math remediation. The supplement includes games that demonstrate basic math concepts freshmen students are lacking. Because students often perceive math as abstract and they do not see their application in science and engineering, the engineering faculty will prepare Canvas

applications of the specific math concept in civil, mechanical and electrical engineering and computer sciences.

The remediation strategy builds on previous research and extends it in the following ways: 1) building on co-requisite models which compress enrollment time, specialized with engineering content; 2) decomposing math concepts into individual knowledge components that could be intervened upon with modularized games and Canvas applications ; 3) promote student motivation and reduce psychosocial barriers through personally- and culturally-relevant pedagogy, leading to increased engagement and math achievement. In this paper, two Canvas Applications focusing on electrical and computer engineering, "Thru the Wall" and "Break the Circuit," to help students learn elementary functions, such as linear and quadratic functions, will be presented. The Canvas applications are animated and use placed-based and culturally-relevant pedagogy with the large metropolitan city and its surroundings as basis. This approach should let students view themselves as capable and confident members of the STEM community at UNLV and CSN. The effectiveness of these Canvas applications is being evaluated as supplemental exercises in the current co-requisite model used by UNLV and CSN for pre-calculus math. Evaluation started in Spring 2024 and therefore, no evaluation data will be presented in the paper.

This research was funded by the National Science Foundation, Grant #2225226

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