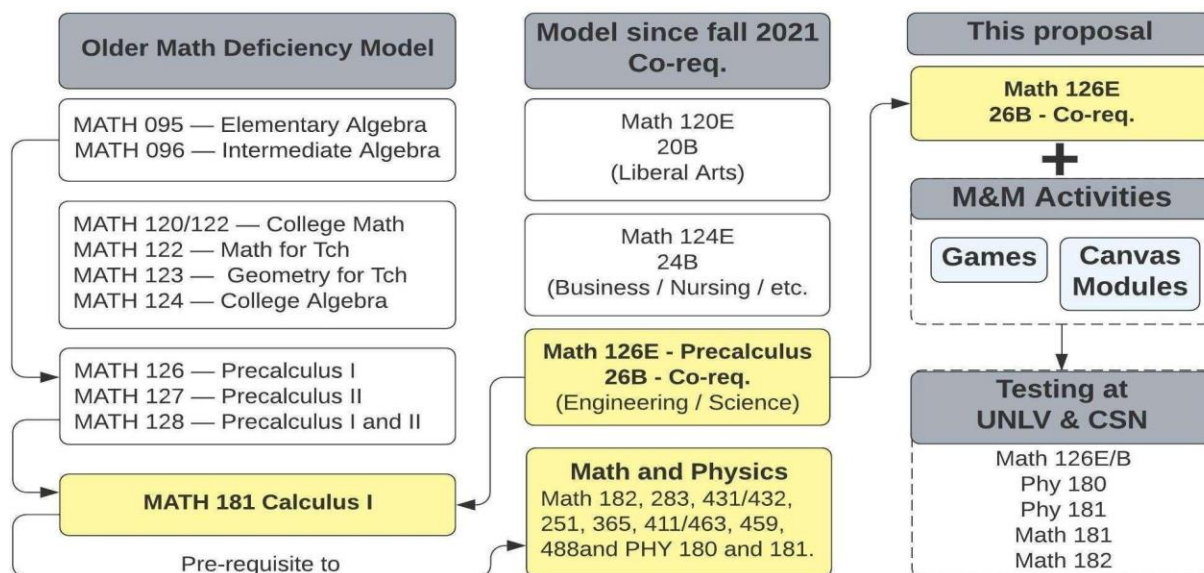# Enhancing Fundamental Math Skills of STEM Students Through Math Games Instruction

This study centers on implementing an intervention program aimed at addressing mathematics remediation for engineering and computer sciences majors at University of Nevada Las Vegas (UNLV), as well as STEM students (pre-engineering and pre-science) at College of Southern Nevada (CSN). Examining data from the 2020-2021 academic year within a Southwest School District, it's evident that only 21% of high school students entering UNLV and CSN demonstrated proficiency in math [1]. This issue is particularly pronounced among Latinx students, who are disproportionately represented in Title I schools with limited access to experienced math educators and advanced math coursework.
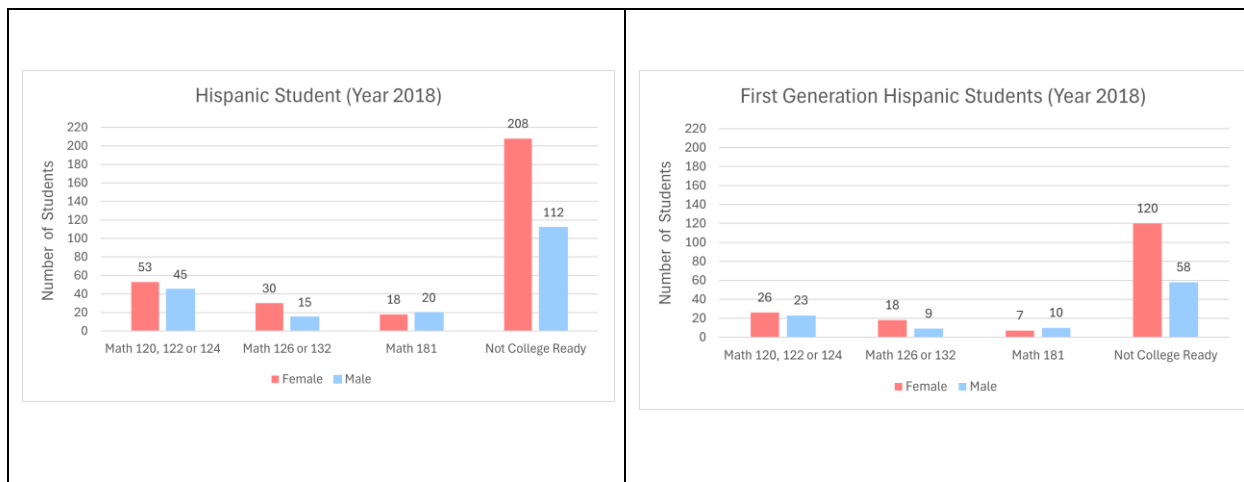
At UNLV, all engineering degrees necessitate completion of three calculus courses, alongside differential equations and statistics. Notably, calculus I (Math 181) serves as the introductory math course for engineering and computer science majors. However, a strikingly small proportion of incoming freshmen meet this prerequisite, resulting in aspiring engineering and science students spending an average of 1.5-2.0 years on math preparation before being eligible for Calculus I enrollment. Consequently, this leads to extended wait times for major-specific courses, elevated attrition rates, prolonged time to graduation, and increased financial strain on students.

To address the issue of math under-preparation, UNLV and CSN have instituted math deficiency mitigation strategies dating back to 1996 (as illustrated in Figure 1). These initiatives mandate successful completion of algebra and pre-calculus prior to enrollment in Math 181-Calculus I, aiming to provide a foundational framework for student success in advanced math coursework.

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

The initial strategy entailed utilizing placement testing and practice exercises through the ALEKS PPL software [2]. This assessment comprehensively evaluates a wide range of fundamental mathematics topics, drawing from an extensive pool of objectives. Based on our data, more than 50% of students who underwent the ALEKS placement testing are from Title I high schools within the Clark County school district, which serves as the primary feeder for UNLV and CSN. Notably, these high schools are situated in regions characterized by substantial Hispanic populations. While ALEKS testing isn't obligatory, it's highly recommended. Many students opt to take it to assist them in determining which math class would be most suitable for them.

Figure 2: UNLV's Distribution of Hispanic population (left) and first-generation Hispanic population (right) in math courses based on gender in 2018.

Data from the ALEKS placement test administered at UNLV for the years 2018 and 2019 reveal that the majority of test takers were Hispanic, followed by White, Asian, and Mixed-race students. While the representation of other underrepresented groups was minimal, it aligned proportionately with their overall enrollment in the UNLV student population. Notably, over 60% of the students who took the ALEKS test are from Title I schools, with Non-Title I and magnet schools following in descending order. Clark County High School accounted for over 61% of test takers, with approximately 40% coming from out-of-state schools. Of particular concern is that more than 60% of test takers required remedial math placement, indicating a significant need for additional support. Over half of the Hispanic and first-generation Hispanic students demonstrated a need for further math instruction, with females exhibiting lower scores compared to their male counterparts (see Figure 2). Approximately half of the Hispanic students lacking math readiness were first-generation, and the number of female students lacking proficiency in college-level math was notably higher than that of male students. Notably, over 70% of female Hispanic students were placed in remedial math, in contrast to around 58% of male Hispanic students. This discrepancy persists across both years, irrespective of generational status, underscoring the urgent need to address the lower placement of Hispanic females, particularly those aspiring to STEM majors. These findings underscore the imperative to prioritize meeting the math deficiency needs of incoming freshmen, especially focusing on supporting female Hispanic students pursuing STEM disciplines. Currently, the representation of

female engineering students at UNLV stands at only around 17%, highlighting the necessity for targeted intervention and support initiatives.

Since fall 2021, UNLV and CSN have implemented a co-requisite model for gateway math courses to address the math deficiencies observed in incoming students (see Figure 1). Under this model, students pursuing engineering and science degrees identified as needing additional math support are placed in a specialized section of the pre-calculus course, Math 126E (3 credits), supplemented with the co-requisite component Math 26B (2 credits at UNLV and 3 credits at CSN). Within Math 26B, students engage with tailored concepts aimed at bridging their math proficiency gap to excel in Math 126E (Pre-calculus). Consequently, in a co-requisite pre-calculus setting, students receive an additional two hours of instruction dedicated to learning algebraic fundamentals. A comprehensive review of current literature on innovations and interventions targeting enhanced mathematics outcomes underscores several promising remediation approaches. These include active learning methodologies, hands-on projects, inventive interventions resembling comic books, mentorship programs, integration of technology, personalized one-to-one assistance, and peer study groups [3]. Based on [4], successful methods directly tackle identified math skill deficits.

The research outlined in this study centers on the creation of Math Masters (M&M) games, a collaborative effort between the UNLV Center of Game Innovation and academic experts. Employing an iterative design process, mathematicians, STEM educators, and educational psychologists work alongside game designers to seamlessly integrate essential math concepts into engaging game structures. These games are designed to complement the existing co-requisite model utilized by UNLV and CSN for pre-calculus mathematics, with a focus on fundamental arithmetic operations, various functions (including linear, quadratic, square root, and inverse), logarithmic and exponential modeling, and systems of equations. This paper presents the development of a game specifically aimed at teaching functions, more precisely, linear and quadratic functions. The game is structured to break down mathematical concepts into discrete knowledge components [5], facilitating targeted interventions while fostering student motivation and dismantling psychosocial barriers through culturally and personally relevant pedagogical approaches [6]. It is hypothesized that these strategies will enhance student engagement and improve mathematical achievement levels. The game on functions consists of six subgames that introduce the math concepts behind coordinate system, lines, slope, linear equation, parabolas, and vertex form equation, respectively. Each part starts with linking famous local landmark or the city's natural surroundings to how the math concept can be visualized in that setting.

The research plan entails an initial phase of testing the games within the co-requisite pre-calculus Math 126E/26B courses at UNLV and CSN during the Spring and Summer semesters of 2024, followed by iterative refinements based on feedback. A pilot study of the game focusing on basic arithmetic operations and linear and quadratic functions was conducted with a smaller student cohort during the Summer of 2023. Moreover, we have piloted/tested for usability and classroom integration logistics in Summer 2023 in 5 pre-calculus I courses at UNLV and CSN. The results helped us refine the delivery mechanism of the games and Canvas application activities. We are

currently collecting data from a larger cohort of 8 pre-calculus I courses in Spring 2024. We are collecting qualitative data on students' game play as well as embedded surveys tapping the following outcomes, such as usability, value beliefs, self-efficacy, personal relevance, cultural relevance, situational interest, engagement and math knowledge. Overall, formative evaluation processes are integrated into the research methodology to continually enhance the effectiveness of the games. A diverse array of measurement strategies is employed to assess the impact of Math Masters (M&M) on various facets of students' academic experience. These include quantitative and qualitative methods designed to gauge improvements in math knowledge, motivation, academic achievement, and persistence in engineering and other science majors. By triangulating data from different sources, we aim to gain comprehensive insights into the efficacy of M&M and refine it accordingly.

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