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Experiential Learning Approaches to Health-themed STEM Education That Addresses Medical Concerns in Hispanic Communities (Work in Progress)

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Introduction

This project will advance middle school student math and sciences progress through its innovative use of non-invasive personal and familial data collection and analysis. Using accessible technologies such as: non-contact infrared thermometers with memory function, pulse oximeters with Bluetooth that painlessly clip on to your finger, electronic digital calipers, and household tools including tape measures, students will learn to collect and analyze their personal and familial health-data. Using laptops and tablets with MS Excel software, students will upload their data and explore it with simulation and modeling tools. Advances in the learning sciences have improved our understanding of how students learn and have clarified how personal and contextual factors can most impact student success [1]. This project is designed to help to close the digital divide by providing Hispanic students STEM achievement opportunities using classroom-friendly health-data tools that can be seamlessly allied with more advanced technologies such as Virtual Reality (VR) and Augmented Reality (AR). Additionally, health-themed modeling and simulation is appropriate for inclusion in designated Makerspaces, wherein innovative maker-themed instruction is the ambition. Through student-parent collaborative learning experiences focused on students' individual and their familial health issues, and with guidance from educators, students will systematically examine their family's health conditions and thus gain the knowledge to be proactive in improving their own health. The participants' experience of monitoring their own familial habits and how these behaviors correlate with their health conditions can enable students to become personally aware of their own family's areas of concern (e.g., body mass index, heart rate, blood pressure, blood glucose) as well as what steps can be taken to remedy any unhealthy conditions. Thus, the participating students and their families will learn how to employ data collection along with intergenerational dialogues to work with their relatives, including parents, siblings, grandparents, cousins, while actively learning about healthcare from a variety of science professionals (e.g., physicians, nurses, pharmacists) and allied health entrepreneurship and innovation leaders (e.g., dietitians, educators, therapists).

Project Design and Outcomes

This project aims to improve both cognitive and socio-emotional student outcomes by: (1) increasing participants' math and science academic achievement, and (2) decreasing participants' anxiety and other negative socio-emotional reactions to STEM instruction. Through new instruction development and accompanying community-based activities that engage intergenerational Hispanic families, this project aims to help bridge the gap between formal and informal STEM engagement and contribute to increasing Hispanic STEM-field enrollment and retention. Science and mathematics in middle school has emerged as a barrier that prevents many minority students from pursuing advanced STEM courses in high school and, therefore, limits their preparation for college and selection of careers in STEM-oriented career paths. Evidence indicates that traditional STEM curricula and instructional methods are not serving all students well [2]; specifically, too few underserved and unrepresented students such as Hispanics are graduating from high school prepared to begin a STEM degree program or career [3]. A major obstacle to engagement and motivation in middle-grade STEM education is math anxiety, which can be a key barrier to STEM achievement and career choices [4][5]. Learning mathematics and science in engaging contexts, as in this project, through inquiry-based modeling and simulation

of their individual and family's health biometrics, supported by familial collaboration, has the potential to reduce students' math anxiety and impact their self-efficacy toward STEM careers.

The underlying motivation for this project is to boost the decision-making processes that influence middle school Hispanic students' confidence in pursuing technology rich STEM career choices through positive interaction with user-friendly math and sciences technologies and associated data collection, analysis, and modeling. Equity and inclusivity in education requires increasing diverse minority students' access to technology rich educational opportunities with a focus on closing achievement gaps by designing new instructional materials, apps, devices, and socioeconomically informed environments that enable access to educational activities for all learners. This project can help remove the barriers to STEM inclusion that minority students face by providing culturally-responsive, informal learning reinforced and sustained through family enrichment. This project will impact decision making processes in middle school Hispanic student's career and health-oriented choices through positive interaction with science technologies and personnel reinforced by family interaction with specific, measurable, achievable, relevant, and time-bound (SMART) goal-directed science instruction. Research shows the importance of schools *and* families working together to ensure student success [6]. While it's never too late to get students engaged in STEM, getting middle school students involved with hands-on technologies learning generally produces a more strategic and inquisitive approach towards STEM as student's advance through high school and beyond [7]. Based on these previous research findings, this project posits that meaningful outcomes in Hispanic student appreciation and understanding of STEM disciplines can best be achieved by engaging middle school students in inquiry-centered after-school programs that are designed to enhance middle school students' engagement, and are reinforced by family involvement. The interdisciplinary approach to STEM education being through this ITEST will support middle school students' use of technologies while overcoming misconceptions about STEM relevancy.

The project aims to advance knowledge by improving middle school Hispanic students' achievement and self-efficacy in science subjects (i.e., biology and chemistry) as well as instill the requisite math needed for success in these subjects. Interdisciplinary researchers in College of Education, STEM Education, and College of Health Sciences leadership will provide customized, culturally-responsive approaches that address the health disparities and STEM exclusion that challenge Hispanic minority populations [8]-[13]. The project also aligns with a current NSF INCLUDES National Network math and sciences resources request for middle school interventions in math and science. The Institute of Education Sciences, one of many organizations working with NSF INCLUDES, is seeking digital interventions in math and science to impact outcomes for at-risk students with historically low performance in science and math. The instructional model being developed, implemented, and assessed under this project could significantly impact math and science outcomes for these and other at-risk minority students. The project period is four academic years, with four cohorts of student participants. Three major learning and instructional theories provide the general theoretical framework for this project: Constructivist instructional theory provides the primary theoretical framework for this research, by articulating the coevolving dynamic between what students are taught and how they use those experiences to internally construct knowledge [14]. Cognitive load theory is also a fundamental component of the overall theoretical framework for this project, and provides an explanation for how cognitive overload leads students to frustration while cognitive underload provides boredom, thus somewhere in between is an optimized cognitive load that best supports learning [15][16]. Additionally, TPACK (Technological, Pedagogical, and Content Knowledge)

instructional theory provides an account of the complex interrelationship between instructors' technological knowledge, pedagogical knowledge, and content knowledge, and the collective impact that these factors have upon student learning [17][18].

The workplan will significantly enhance the existing mathematics and science middle school modules by enabling students to apply mathematics principles to real-time everyday experiences through hands-on data-collection with technology devices such as: Glucose monitoring devices to collect and track data and to identify patterns (Reporting Category 2, 7.3); modeling of collected real-time family health sciences data (Reporting Category 7.14); working with electronic digital calipers and no-touch thermometers in safe and supportive environments to learn number operations and quantitative reasoning including fractions, decimals, and percentages (Reporting Category 1, 7.1 & 7.2); solving problems involving geometry and spatial reasoning, scale drawings and informal geometric constructions (Reporting Category 3, 7.6, 7.7, & 7.8). The theme of Drawing inferences about populations based on samples (Reporting Category 5, 7.10 & 7.11) also underlies each of the experimental activities. Using data-collection materials to help discern properties of operations in action such as generating equivalent expressions by swapping out the order of collected data numbers to get the same result is just one of many planned health-data activities with real-life consequences. Additionally, the project is ideally suited to reinvigorate middle school students' appreciation of random sampling to draw inferences about their unique population. *Understanding that statistics can be used to gain information about a population by examining a sample of the population* (Reporting Category 7.10 *and* CCSS Math Content 7.SP.A.1) will be brought home to students through the project's focus on family-oriented data sampling. Students will learn first-hand how random sampling tends to produce representative samples and support valid inferences, thereby elevating middle school students' interpretive thinking and decision-making potentials.

Research Strategy and Data Significance

This project aims to increase minority-serving middle school academic achievement in math and science by expanding students' mathematical and scientific thinking and decision-making through hands-on investigative reasoning experiences with health-themed activities. This project will equip minority-serving middle schools with new innovative scientific and mathematical reasoning instruction by providing middle school students' families with access and training on how to use basic and accessible health data collection and analysis devices. The project offers an innovative instructional pathway for increasing underrepresented minority participation in STEM disciplines. Additionally, the project has the potential to significantly advance knowledge in culturally-responsive STEM technologies learning interventions by addressing the unique public health concerns that are challenging Hispanic individuals across America's minority landscape.

This project leverages a multi-tiered interdisciplinary approach that involves health sciences educators and STEM educators guiding middle school students and their families while they explore familial health data. Faculty and students will work collaboratively to provide the learning activities: Specifically, educators from our College of Health Sciences will introduce clinical care concepts of anatomy, physiology, and pharmacology through interactive educational experiences using health-themed data collection tools including: no-touch thermometers, stethoscopes, blood pressure monitors, weight scales, glucose monitors (with control solution), pulse oximeters, heart rate monitors, and other portable and accessible biometric tools. Additionally, teacher educators and STEM educators from our College of Education will provide hands-on, parents-involved, inquiry-based learning activities in mathematics, communication strategies for health-data analysis, and nutrition and food sciences exercises, which help students

conceptualize and become interested in STEM topics. Inquiry-based STEM education has been widely examined, including within this project team's research [19]-[23]. Every culture has its own beliefs about health, disease, treatment, and health care providers. Understanding how local Hispanic social, economic, structural, psychological, and cultural factors are affecting student's educational pursuits and physical health can help educators design effective pedagogy that improves health outcomes. By contextualizing STEM learning tasks with culturally-responsive informal family-oriented activities guided by healthcare experts, students can investigate familial health patterns while employing cultural and linguistic resources, such as bilingualism. As an example, students can work with their parents to draw a family tree showing multiple generations while identifying disease patterns across their family health history, which will stimulate their interpretive thinking and decision-making skills. The participants can also aggregate their anonymized data to build a community database, which can then be compared with regional and national results to help identify health disparities.

During this project, portable health-data technologies that can be easily acquired and monitored will serve as the technology learning tools to inspire hands-on engagement with STEM disciplines and careers. While gathering health-based data using these portable and accessible technologies, the middle school students and their families will become trained in proper use of resources for health-data collection, and analysis of that data through hands-on activities with technology-rich resources. This type of authentic engagement has shown to result in middle school students achieving motivation for higher education STEM pursuits [24]-[27]. Data collected through this research project will serve as the groundwork for future lines of research addressing innovative STEM education–pilot iterations of the math and science learning modules are currently being developed and assessed by the research team, and will be further modified during the field-testing and instructional model refinement phases.

The research in this project will be iterative in nature with results from each phase informing the design and implementation of the subsequent phases. For developing the new instructional model, the investigators will include cognitive, affective, and cultural factors as criteria for identifying strategies that will be effectual [28]-[30]. An important underlying goal for the project will be to explore and develop teaching strategies that allow Hispanic middle school students to further develop their conceptual understanding of mathematics and science principles. Through the new learning approaches, students will perform a series of increasingly more complicated STEM learning activities, eventually culminating in collaborative data analysis with the Year 3 cohort of 80 participating students and their families, along with a comparably sized control group. The participating students collecting real data and sharing it (after anonymizing the data) will permit a technology-rich learning experience that is authentic and personally meaningful for the participants. The impacts on students' self-efficacy and engagement with science and mathematics education will be assessed as they move forward in their academic development. Parents that are participants in this project will provide data designed to answer questions about their children's socio-emotional response to the intervention.

Conclusion

This project has the potential to benefit local and national societal concerns of minority population engagement, enrollment, and retention in STEM fields while addressing the unique public health challenges confronting Hispanic community members. The present project can contribute to significantly improving outcomes by adding to the body of knowledge on how specific STEM interventions impact outcomes for Hispanic students and families, and impact minority education as well as public health. The project will also assess the educational approach

for scalability so that the impacts can be broadly disseminated to wider audiences on both local, regional, and national scales. The project team hypothesizes that the integration of family-relevant data collection activities and topics linked with family-oriented inquiry can provide a rich context for intergenerational dialogues, thus enabling a sustainable approach to contextualizing math and science learning as well as making progress toward closing the STEM achievement and STEM career identification gap for at-risk Hispanic students. Family-supported instructional experiences employing intergenerational dialogues as well as peer-to-peer discussions will be implemented to maximize students' attainment and application of mathematics and science knowledge relevant to addressing their individual health concerns.

The project also has the potential to broadly impact the health and educational outcomes of America's largest minority population though its multi-faceted learning approach. El Paso, Texas is the 23rd largest city in America and the sixth largest city in Texas. An important port of entry to the U.S. from Mexico, El Paso is ideally suited to conduct this applied research for implementing and evaluating experiential learning technologies in mathematics and science education. El Paso has a Hispanic population of over 80% and is a high-technology area supporting numerous health industries involved in manufacturing Class I, Class II, and Class III medical-devices for healthcare professionals. The project will engage students with their families as well as health sciences and STEM educators, thereby enabling students to more deeply conceptualize math and science knowledge and skills through a transdisciplinary instructional model supported by family involvement.

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