Title: Makin' Math Move: An Interactive Educational Video Game for Minority Students to Reinforce Algebraic Concepts

Keywords: STEM education, human computer interaction, video game, STEAM

Background: In a 2010 study by NSF, men represented 72% of the scientists and engineers employed in their field in the United States. Women, of all races, totaled only 28%, while African Americans (of both genders) only contributed to 5% of scientists[1]. The reasons for this disparity is typically studied at the pre-collegiate and collegiate level and has tried to be eradicated with bridge programs and mentorships.[2] These programs have had some success, but it fails to reach those who are affected by a "leak" much earlier in the STEM pipeline. The previously referred research also shows that insufficient K-12 preparation in mathematics and science of low-income and minority students due to unavailability of demanding courses and/or unqualified subject matter teachers has impacted the level of interest. Psychologically, minority students also deal with issues of self-efficacy and overcoming the typecast of the white male dominated STEM industry.[3]

Educational video games have been designed as engaging, yet informative, ways to pique the interest of students. HCI research has shown that STEM-centered educational video games not only increase self-motivation, but also improve causal reasoning, problem solving, and critical thinking.[4] Likewise STEAM, the incorporation of the arts (A) in STEM education, has been shown to increase cognitive abilities and provide many neurological benefits. Studies have demonstrated that it easier to retain and recall information associated with movement.[5] Studying the benefits of music education on cognitive processes via an augmented virtual reality guitar learning system is one way in which the HCI field has explored the idea of STEAM.[6] Yet there lacks research on STEAM-inspired (particularly, dance-specific) educational videogames. A study on the effect of participation in visual and performing arts on different groups of students found that minority participants from low-income families had greater success in mathematics and reading.[7]

Proposed Solution: Makin' Math Move is an educational video game designed for middle school minority students to enhance their algebraic skills. The goal is to stimulate and intrigue these students with a video game akin to Dance Dance Revolution (DDR), which will allow them to hone their math skills through active learning. The software will feature various modes corresponding to different topics covered in a standard Algebra class. Studies dictate that minorities and students of a low-economic status struggle with algebraic material more so than

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[1] National Science Foundation, National Center for Science and Engineering Statistics. 2013. *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2013*. Special Report NSF 13-304. Arlington, VA. Available at http://www.nsf.gov/statistics/wmpd/.

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[3] Chemers, Martin M., et al. "The role of efficacy and identity in science career commitment among underrepresented minority students." *Journal of Social Issues* 67.3 (2011): 469-491.

[4] Tawfik, A., Moore, J., He, Z., & Vo, N. (2012). Human-Computer Interaction Factors in Designing Educational Video Games. *Current Issues In Education, 15*(3). Retrieved October 30, 2013, from http://cie.asu.edu/ojs/index.php/cieatasu/article/view/987

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[6] Keebler, J., Wiltshire, T., Smith, D., & Fiore, S. (2013). Picking Up STEAM: Educational Implications for Teaching with an Augmented Reality Guitar Learning System. *Virtual, augmented and mixed reality systems and applications : 5th International Conference, VAMR 2013, held as part of HCI International 2013, Las Vegas, NV, USA, July 21-26, 2013, Proceedings.* (pp. 170-178). Berlin: Springer.

[7] Fiske, Edward B. "Champions of change: The impact of the arts on learning." (1999).

their Caucasian and affluent counterparts[8]. The student will be able to see the proposed math problem, the answer arrows, as well as themselves on a virtual dance pad. The arrows that the students will step on will be mathematical operation symbols (+,-, x, /) or possible answer choices to the problem displayed on the screen. As the student beats each level within the mode, they will be able to challenge themselves by answering the same amount of questions in a shorter amount of time; seeing how well they think on their feet, literally. Hip-hop instrumental music, with tempos progressing with the students' level, will be playing in the background.

Methodology: This project will be carried out under the supervision of Dr. Juan E. Gilbert, Associate Chair of Research of the Computer and Information Science & Engineering Department at the University of Florida. Participants will likely be recruited from Lincoln and Bishop Middle Schools, two Gainesville-area schools with minority populations of 73% and 61%, respectively.[9]

Phase 1 (Research): I will conduct research on learning technologies as well as take classes such as *Games and Simulations for Teaching and Learning* and *Human Computer Interactivity and the Learner* to help with design and implementation in phase two. During this initial phase, I will create a pre-assessment to measure the students' performance and attitudes towards math prior to interacting with the game.

Phase 2 (Implementation): I will design and implement the video game application using Microsoft's Kinect for Windows sensor. I will use C# programming and the OpenGL API in order to render the graphics. The monitor's display will feature the user's image, an overlay of the four quadrants that the user can choose to step on, directions, the question and the user's score. Using the Kinect sensor (approximately $150) to detect the students' movements provides a cheaper alternative than RM's *Dance to Advance* software, which prices range from $300-$1,000.[10]

Phase 3 (Evaluation): Two Algebra classes of approximately 15-25 students at participating schools will use the software over the course of a semester. I will evaluate the quantitative and qualitative effect of the game on the students' comprehension level of the math skills that the game focused on, by re-administering the initial assessment. The results will be disseminated by publication in IEEE Transactions on Learning Technologies and educational technology conferences such as E-Learn and the Florida Educational Technology Conference (FETC).

Outcomes and Broader Impacts: If effective, Makin' Math Move can be a viable option to help stop the leak in the STEM pipeline for minority students at the middle school level. For schools, where overcrowding is an issue, the technology gives the student extra attention and practice when a teacher cannot. The satisfaction and knowledge gained from independently working with the system will increase the students' confidence in themselves and their ability to succeed in the STEM world. The inexpensiveness of the Kinect will allow for this technology to be available in multiple classrooms in all school districts. While this technology specifically focuses on Algebra, it can be easily adapted to enhance all other STEM areas, including chemistry and programming courses. The versatility provided by this application can revolutionize how STEM concepts are reinforced in classrooms nationwide.

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