Can embodied interaction and virtual peer customization in a virtual programming environment enhance computational thinking?

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***Abstract*—To address the problem of underexposure, underrepresentation, and underproduction of diverse professionals in the field of computing, we target middle school education using an idea that combines computational thinking with dance and movement choreography. This lightning talk delves into a virtual reality education and entertainment application named Virtual Environment Interactions (VEnvI). Our in vivo study examines how VEnvI can be used to teach fundamental computer science concepts such as sequences, loops, variables, conditionals, functions, and parallel programming. We aim to reach younger students through a fun and intuitive interface for choreographing dance movements with a virtual character. Our study contrasts the highly immersive and embodied virtual reality metaphor of using VEnvI with a non-immersive desktop metaphor. Additionally, we examine the effects of user attachment by comparing the learning results gained with customizable virtual characters in contrast with character presets. By analyzing qualitative and quantitative user responses measuring cognition, presence, usability, and satisfaction, we hope to find how virtual reality can enhance interest in the field of computer science among middle school students.**

I. Introduction

Starting in middle school, students can make decisions about courses of study and career paths that can affect their desire and ability to pursue careers in STEM [1]. Middle school girls show less interest in STEM topics than boys of the same age, and this dearth propagates into a skewed gender ratio in professional STEM fields [2]. We address this problem with a novel approach to computer science education that will appeal to both genders through the medium of dance.

Taking inspiration from technologies such as Alice [3], Looking Glass [4], and Scratch [5], we developed Virtual Environment Interactions (VEnvI), which uses movement choreography to convey computer programming fundamentals. Students use an intuitive drag-and-drop interface within VEnvI to programmatically create dance choreography for a virtual character, using programming concepts such as sequences, loops, variables, conditionals, functions, and parallel programming in the process.

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VEnvI provides first-person, embodied experiences using self-avatars, which facilitates engagement, excitement and interest in computational thinking. Since dance is an embodied activity, providing a unique first-person perspective that places the students in the same space as the virtual character facilitates natural embodied thinking and cognition. The result is an enhanced creation process that allows students to critically think via physical actions and apply this feedback to the programming interface. We wish for students to view the VR metaphor as an integral part of the programming process, through which they visualize their programmed choreography, use embodied cognition to validate their choreography, and return to the creation process to perhaps make changes and improve the choreography further. This two-stage approach inspires students to continue learning and allows us as researchers to analyze the creation process.

In an empirical evaluation, we are comparing the immersive virtual reality metaphor to a non-immersive desktop based VEnvI to see how virtual reality affects learning, presence, usability, and satisfaction among middle school students. We also empirically examine the effect of character customization within VEnvI by allowing one group of students to customize features such as gender, skin tone, height, weight, clothing, hair color, and eye color while the other group chooses from three pre-configured characters: an anthropomorphic alien, a gender neutral teenager, and an experienced mentor granny.

II. Related Work

There is a large body of work that employ visual programming environments for computer science education. Alice [6],

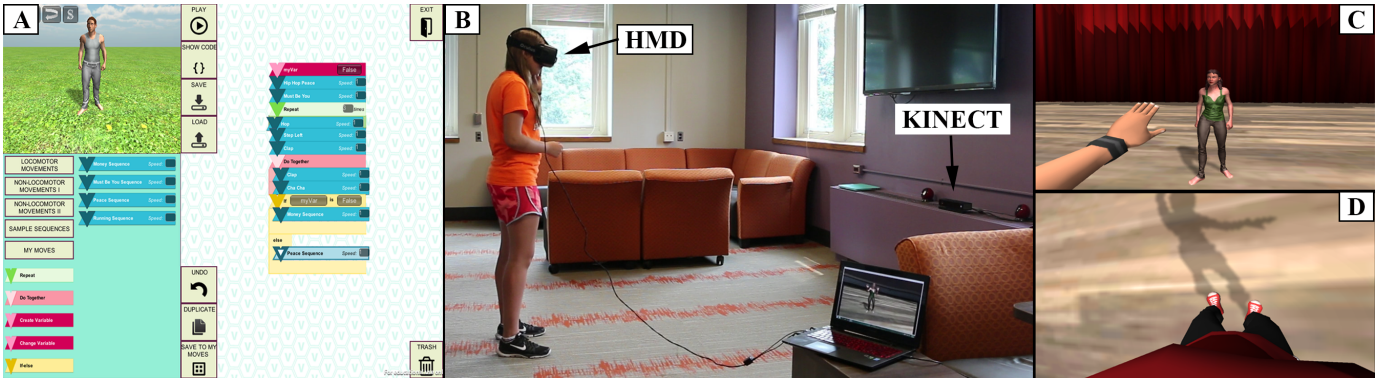

Fig. 1. (A) The VEnvI user interface (B) The immersive embodied interaction experiment setup with the head-mounted display (HMD) on the user's head, and a Kinect sensor in front of the user. (C) Screen capture of the virtual character that dances in front of the user. (D) The first-person view of the user's virtual body.

a 3D tool for introductory programming concepts, provides a scripting and prototyping virtual environment for 3D object behavior and is aimed at teaching programming concepts. Taking this further, Kelleher et al. [3] introduced Storytelling Alice, a version of Alice 3D programming environment that uses 3D animated stories to introduce middle school girls to computer programming. Another visual programming environment called Scratch [5] allows users to learn computer programming while working on projects such as animated stories and games. The key design goal for Scratch is to support self-directed learning through tinkering and collaboration with peers.

VEnvI draws key aspects from previous work including intuitive drag-and-drop interface, customizable characters, user generated programs driving actions within the virtual environment, and use of computational techniques to foster creativity and learning. However, VEnvI represents animations as a more realistic and user-friendly medium of interaction. Pose-based keyframed animations provided by related technologies are not conducive for representing the complexity of dance. Further, VEnvI provides an immersive virtual reality component which follows and complements the programming interface, which sets it apart from existing technologies.

III. Expected Outcomes

We hope to find positive effects of virtual reality and character customization in garnering interest for the field of computing among the middle school students. Virtual reality (VR) can be a powerful tool in supporting and facilitating STEM education. Research has shown that VR can be a more memorable learning experience than laboratory based demonstrations [7], that students may prefer virtual learning environments over traditional classroom lectures and discussions [8], and can result in increased performance. Research also shows that customizability of character avatars can make gameplay experience more enjoyable [9], can increase satisfaction among users and foster loyalty towards the software [10]. Based on these foundations, we propose the following hypotheses:

1) Presence of virtual reality will increase interest in learning, and will result in higher sense of presence, usability, and satisfaction within VEnvI.
2) Ability to customize characters will increase user attachment and social-presence, leading to higher interest in learning through VEnvI.

References

[1] C. R. Warren, "An exploration of factors influencing the career preferences of junior high students." 1990.

[2] K. Modi, J. Schoenberg, and K. Salmond, "Generation STEM: What girls say about science, technology, engineering, and math," *A Report from the Girl Scout Research Institute. New York, NY: Girl Scouts of the USA*, 2012.

[3] C. Kelleher, R. Pausch, and S. Kiesler, "Storytelling alice motivates middle school girls to learn computer programming," in *Proceedings of the SIGCHI conference on Human factors in computing systems*. ACM, 2007, pp. 1455–1464.

[4] P. A. Gross, M. S. Herstand, J. W. Hodges, and C. L. Kelleher, "A code reuse interface for non-programmer middle school students," in *Proceedings of the 15th international conference on Intelligent user interfaces*. ACM, 2010, pp. 219–228.

[5] J. Maloney, M. Resnick, N. Rusk, B. Silverman, and E. Eastmond, "The scratch programming language and environment," *ACM Transactions on Computing Education (TOCE)*, vol. 10, no. 4, p. 16, 2010.

[6] S. Cooper, W. Dann, and R. Pausch, "Alice: a 3-d tool for introductory programming concepts," in *Journal of Computing Sciences in Colleges*, vol. 15, no. 5. Consortium for Computing Sciences in Colleges, 2000, pp. 107–116.

[7] T. Nadan, V. Alexandrov, R. Jamieson, and K. Watson, "Is virtual reality a memorable experience in an educational context?" *International Journal of Emerging Technologies in Learning (iJET)*, vol. 6, no. 1, 2011.

[8] J. Cecil, P. Ramanathan, and M. Mwavita, "Virtual learning environments in engineering and STEM education," in *Frontiers in Education Conference, 2013 IEEE*. IEEE, 2013, pp. 502–507.

[9] R. Bailey, K. Wise, and P. Bolls, "How avatar customizability affects children's arousal and subjective presence during junk food–sponsored online video games," *CyberPsychology & Behavior*, vol. 12, no. 3, pp. 277–283, 2009.

[10] C.-I. Teng, "Customization, immersion satisfaction, and online gamer loyalty," *Computers in Human Behavior*, vol. 26, no. 6, pp. 1547 – 1554, 2010.