A Study of the Effects of Teaching Avatars on Students’ Learning of Surveying Mathematics

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ABSTRACT

The paper reports a research study aimed at investigating the appeal and pedagogical efficacy of animated teaching avatars. Specifically, the goal of the study was to determine whether animated characters could be effective and engaging teachers in the context of undergraduate surveying mathematics. The study included two forms of evaluation: formative and summative. Findings from the formative evaluation with forty-four undergraduate students show that three animated lectures delivered by a teaching avatar that speaks, gestures and points to a virtual board were perceived as engaging and useful for learning surveying mathematics concepts and procedures. Results of the summative evaluation with fifty-two undergraduate students show that watching the animated avatar lectures led to an increase in subjects’ mathematical competence by 31%. The study also compared the animated avatar lectures to interactive 2D visualizations illustrating equivalent surveying math concepts. Findings show that watching the teaching avatar lectures led to significantly higher learning gains.

KEYWORDS

Computer Animation, Educational Technologies, Mathematics Education, Surveying, Teaching Avatars

1. INTRODUCTION

Surveying is the science of studying the 3D shapes of the earth’s curvature and surveying concepts are founded in geometry and vectors principles. In the context of construction layout, angles, distances and elevations are used to set up the building footprint at the correct location, establish level elevations and plumb vertical surfaces. Traditionally, in a surveying course, instructors teach the theoretical foundation of surveying, which includes math, trigonometry, geometry and physics concepts. These concepts are often explained in lecture through examples from textbooks and illustrations on the chalkboard. One major problem in teaching surveying is what R. Elgin calls “The Demise of Basic Surveying Mathematics”. Elgin reports “…a distinct decline in the math skills of students taking surveying courses...”, and a decline in the students’ ability to transfer these concepts into practice in the context of surveying (The American Surveyor May, 2007).

The goal of our research is to use emerging computer graphics technologies to develop and validate innovative educational technologies that support students’ learning and lead to effective instructional approaches in mathematics education. The specific objective of the work reported in the paper was to investigate whether computer animated characters that speak and gesture can improve students’ attitude and competence in surveying mathematics. Although a few studies exist on the efficacy of
teaching avatars, there is a need to investigate their role within the context of undergraduate math education. If proven effective, computer animation characters could serve as believable and effective virtual instructors for delivery of eLearning content not only in the context of mathematics, but also in many other subject domains.

In current examples of teaching avatars, the computer animation characters often appear robotic, with mechanical motions and without personality; learners fail to connect with such teaching avatars and fail to engage in the learning activity. On the other hand, avatars that captivate and engage are now possible, as demonstrated by the enormous popularity of computer graphics applications in entertainment, such as movies and games.

In an effort to overcome current challenges and improve on the state-of-the-art, the paper presents the development of a teaching avatar that is animated with life-like quality because it adheres to fundamental character animation principles (Johnston & Thomas, 1995). His gesture repertoire is based on recent research on gestures for math learning (Alibali et al., 2014). The gestures help the student parse what the teaching avatar says, help clarify the educational content presented, and help define and convey the avatar’s personality.

The paper is organized as follows: in section 2 we report prior research on animated avatars and in section 3 we discuss surveying mathematics. Our research study is presented in section 4, and future work and conclusion are included in section 5.

2. TEACHING AVATARS

Computer-animated characters, also called embodied agents or avatars, have been used in interactive computer interfaces to communicate information through speech, facial expressions and body gestures. Animated avatars have been incorporated into general information systems, for instance to read the news, present tourist information, and discuss book reviews, e.g. Jack (Noma et al., 2000) and PPP Persona (Andre et al., 1996). They have also been used in e-commerce applications to advertise and sell products and in e-learning environments to teach and supervise. Early examples of pedagogical avatars are Cosmo (Lester et al., 1997) a cosmonaut who explains how the internet works, Herman a bug-like creature that teaches children about biology, and STEVE (Johnson & Rickel, 1998), who trains users in operating complex machinery using speech, pointing gestures, and gaze behavior. In Virtual Human project (Reithinger et al., 2006) a virtual teacher gives astronomy lessons by following different pedagogical paradigms and shows a variety of nonverbal behaviors that reflect different parameterized personality settings.

PETA is a 3-D computer animated human head that speaks by synthesizing sounds while moving its facial effectors to convey different facial articulations (Powers et al., 2008). Users can converse with PETA by speech or keyboard input, and PETA responds by matching this input against the most appropriate verbal and nonverbal responses. PETA allows children to acquire a new language in a spontaneous, unconscious manner. A similar example is the “Thinking Head” (Davis et al., 2007), a virtual anthropomorphic software agent able to speak and to display emotion through complex facial expressions, vocal prosody, and gestures. Gesturing avatars have also been used to teach mathematics, and science to young deaf children using sign language, e.g. Mathsigner and SMILE (Adamo-Villani & Wilbur, 2008). The ASL software system (Hayward et al., 2010) allows educators to create and add animated signing avatars to e-learning materials.

Rigorous empirical testing was used to assess the contributions of pedagogical agents to problem solving, to higher-order learning, and the affective impact on students. Many studies confirm the intended positive influences on education by systems using these agents (Lester et al., 1997; Holmes, 2007; Lusk & Atkinson, 2007). Students appear to attend primarily to agents’ faces much like they attend to the faces of live conversational partners (Louwerse et al., 2009). For example, a study demonstrated that the use of avatars with facial expressions resulted in a more interesting and motivating learning experience and improved students’ learning performance (Theonas et al., 2008).
Development and Analysis of an Enhanced Multi-Expert Knowledge Integration System for Designing Context-Aware Ubiquitous Learning Contents
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