ANIMATED PEDAGOGICAL AGENTS AS VIRTUAL SCIENTIST MENTORS. C. D. D. Bowman[1], P. V. Graff[2], [1]Harvard University Graduate School of Education, 13 Appian Way, Cambridge, MA 02138 and Raytheon ITSS, NASA Ames Research Center, bowmanca@gse.harvard.edu, cbowman@mail.arc.nasa.gov, [2]Arizona State University Mars Education Program, Moeur Building Rm 131, Tempe, AZ 85225-6305, paigev@asu.edu

Introduction: Student-scientist partnership programs (SSPs) attempt to address calls for improved scientific literacy and science inquiry [1]. SSPs involve students in authentic scientific investigations as they work alongside scientist mentors engaged in research. While research suggests outcomes and benefits to participants in terms of enhanced content learning and gains related to motivation and self-efficacy [2], SSPs are limited in scope because they are resource-intensive (finanacial, personnel, and time) and difficult to scale up. Science inquiry programs, on the other hand, provide potentially large numbers of students in classroom settings with opportunities to pursue investigations of their own design involving current scientific data. One drawback, however, is that they often do not have a mechanism for providing students with more than brief exposure to professionals in the field, potentially limiting the cognitive and affective gains that are realized through prolonged engagement with a scientist mentor.

Advances in current computing and educational technologies may provide some avenues for enhancement of such programs through the use of animated pedagogical agents (APAs) as virtual scientist mentors. This abstract describes a dissertation study undertaken by Bowman to test one such APA with over 500 middle school students in the context of the Mars Student Imaging Project (MSIP: http://msip.asu.edu), a project of Arizona State University and NASA.

Mars Student Imaging Project: The Mars Student Imaging Project (MSIP), an inquiry-based program, was created to provide teams of students in grades 5 through 14 with an opportunity to conduct authentic research about Mars. *NSES*-aligned curricular materials assist teachers in mentoring their students as they design and conduct a scientific investigation. Teams can submit a proposal and potentially command the Thermal Emission Imaging System (THEMIS) aboard the *Mars Odyssey* spacecraft. By participating in MSIP, students experience how the process of science works in real time.

MSIP students can interact with scientists by participating in a multi-day on-site MSIP program at Arizona State University. They can also participate in monthly distance learning events led by the ASU Mars Education Program. These national events are designed to provide an opportunity for multiple classrooms to connect with and learn from scientists currently studying Mars.

MSIP can be implemented in classrooms in numerous ways and over various periods of time. For the purposes of Bowman's study and for future MSIP teams, a 3-week, step-by-step MSIP implementation guide was created for participating teachers.

Site Selection: Middle school (7th and 8th grade) teachers who had previously participated in MSIP were approached to be a part of this study. These educators had experience with many of the activities that made up the three-week MSIP process and had full support of school administrators as well as necessary access to technology, including in-classroom computers and Internet connections. An online training was provided for teachers as an overview and training of the step-by-step MSIP implementation guide and also to introduce them to the use of the virtual scientist mentor.

Figure 1. Dr. C.

Animated Pedagogical Agent: APAs are "lifelike autonomous characters [that] co-habit learning environments with students to create rich, face-to-face learning interactions" [3]. Current research suggests that APAs can fill various roles of mentorship, including expert, motivator, collaborator, and learning companion [4]. With the help of computers developers at NASA's Jet Propulsion Laboratory, Bowman created "Dr. C.", a computerized scientist based on Dr. Phil Christensen of ASU, the main scientist involved with MSIP (see Figure 1). "Dr. C" was programmed with a database of almost 2,000

Mars and science-related questions and answers as well as almost three hundred personal questions (with answers provided by Dr. Chistensen himself). Set up like an "Instant Messenger" chat window, students can type questions and receive text responses. Details on "Dr. C.'s" creation and programming can be obtained by contacting the first author.

Study Implementation: The study consisted of 534 students in 7th and 8th grade classes at seven different middle schools in CA, AZ, IL, and MN. The teachers used a modified version of the MSIP curriculum developed by Graff and designed to be implemented over three weeks. Each teacher in the study taught one class as a control (used the curriculum with computers, but without Dr. C.) and the remaining classes as treatment classes (using Dr. C.). Classes using Dr. C. logged in to the system each day during the study. Students worked in groups of 3-4 and the treatment classroom groups were assigned to one of two Dr. C. treatments: either a version of Dr. C. that could only answer scientific questions (V1) or a version that could answer both science and personal questions (V2). These treatments were driven by the study's research questions:

1. Can working with an APA designed as a virtual scientist mentor produce gains in project-related content learning and/or motivation in science? Does this differ based on access to Dr. C. V1 or V2?

2. How do students in each of the two treatment groups describe and understand the benefits, if any, of interacting with an APA designed as a virtual scientist mentor? How do the benefits they cite and their perceptions of these benefits align or diverge within and across the treatments?

Two pre/post instruments were developed for this study. Bowman and Graff developed the Content Survey, which consists of 17 multiple-choice or true-false questions aligned to the MSIP curriculum specifically. Bowman adapted the Motivation Survey, which consists of 35 mainly Likert-type items, from the CRESST General Science Survey for Students [4], the Self-Efficicay in Technology and Science (SETS) measure [5], and work done by Brown, et al. [6]. All students completed these measures online before and after participating in the MSIP curriculum. Additionally, a subset of 70 students from both control and treatment classrooms were interviewed by Bowman to investigate students' impressions of their experience in MSIP and with Dr. C. Finally, log files of over 7500 students interactions with Dr. C. were collected, showing individual patterns of use.

Analysis: Analysis of the data is underway and will be completed in February 2008. Multilevel regression analysis is used to regress students' survey gains on use (or not) of the two versions of Dr. C. during MSIP. Multilevel modeling is necessary because the students are nested within teams, classes, teachers, and schools. The model includes variables such as grade, race, SES, first language, class attendance, previous science grades, and frequency of Dr. C. use. Qualitative data, in the form of interviews, addresses the question of student perception and experience. These data are analyzed through open coding, the identification of categories and themes, followed by the creation of participant profiles and comparison matrices. Finally, the log files are being organized and coded to provide a look at individual students' patterns of use.

Limitations and Future Research: Working with a great scientist mentor should be better than working with an APA designed as a virtual mentor, at least in the forms possible with current technology. It seems equally possible, however, that working with a good virtual scientist mentor is more fulfilling than working with an unengaged actual scientist or no scientist (real or virtual) at all. Though this study will provide findings specific to MSIP, it hopefully will reveal whether the use of an APA designed as a virtual scientist mentor might provide benefits for science inquiry programs in other contexts. Once benefits are established, future studies may explore how the APAs hold up against mentoring provided by actual scientists—and whether they might even provide advantages unachievable by human mentors.

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