PROJECT CHAMP
Challenges in Applied Mathematics and Physics

A Final Report from the Center for Educational Technologies at Wheeling Jesuit University

Steven McGee, Ph.D.
Senior Educational Researcher
Center for Educational Technologies
Wheeling Jesuit University
Mcgee@cotf.edu
(304) 243-2388

Executive Summary

With funding from NASA, Project CHAMP investigated whether *Astronomy Village: Investigating the University* supports the theory of multiple intelligence. The results indicated that *Astronomy Village* does indeed require students to use aspects of their intelligence that are not normally used in school tasks. In addition to the positive results of the research, CET researchers were able to develop a unique collaborative structure for accomplishing the research. Project CHAMP supported the development of a new framework for linking theoretical ideas, such as multiple intelligence, with their practical implications for the classroom, such as *Astronomy Village*. This framework is called Testing Educational Theory through Educational Practice (TETEP). Through its network of existing *Astronomy Village* teachers, researchers were able to establish a testbed for testing the theoretical ideas in practice. Project CHAMP was also able to take the first steps towards commercialization of *Astronomy Village* through the WJU e-commerce site. Finally, Project CHAMP was supported by a network of national experts in cognitive science, teaching, assessment, and software development. Due to the success of both the research itself and the model of research developed by Project CHAMP staff, the CET is seeking to establish the Institute for Research in the Learning Sciences (IRLS). IRLS will formalize the research model developed by Project CHAMP and help to expand the use of the model to other areas of science education.

Introduction

Do schools prepare students to meet the challenge of solving real-world problems? Dr. Robert Sternberg does not believe so. He has developed the triarchic theory of multiple intelligence, which states that there are three dimensions of intelligence: analytic thinking, practical thinking, and creative thinking. Real-world problem solving usually entails all three of these dimensions. According to Dr. Sternberg's research, most school tasks require only analytic thinking; therefore, students who are especially good at creative or practical thinking do not perform well on these tasks. In order to foster growth along all three dimensions of intelligence, Dr. Sternberg has found that instruction should involve all three dimensions. In that way students can learn to solve problems using their strongest dimension of thinking, while at the same time be exposed to other dimensions of thinking.

Does *Astronomy Village®: Investigating the Universe*™ support Sternberg's triarchic theory? With funding from NASA, Project CHAMP determined that *Astronomy Village* does indeed support all three dimensions of intelligence. Ninety students in a suburban high school were administered Sternberg's Triarchic Abilities Test. After using *Astronomy Village,* students were administered a posttest that measured problem-solving ability in astronomy. Analyses indicate that *Astronomy Village* contains activities that cater to each of the dimensions of multiple intelligence. The students who were especially high in practical intelligence benefited the most from their experience with *Astronomy Village*. For some of these students, it was the first time that they had expertise at solving problems in school. The most significant finding is that not only did they perform well on the posttest, their attitude towards science was also dramatically increased. A description of this and other Project CHAMP studies appears below.

Benefits of Project CHAMP

- Project CHAMP benefited disadvantaged students in Wheeling by exposing them to the wonders of astronomy. In one study, at-risk high school students from Wheeling Park High School were bussed to COTF as part of their Principles of Technology class to use *Astronomy Village*. This experience made science more relevant to their lives by allowing them to investigate compelling questions about the formation of the universe. In fact, their teacher reported that students would often discuss astronomy on their bus ride to and from school. In another study, children from the James Paige Learning Center participated in a specially-designed summer camp focusing on sun spots. Students were exposed to analysis techniques for investigating the Sun. Their overall experience was similar to the students from Wheeling Park in that they walked away with a better appreciation of the wonders of science.
- Project CHAMP benefited psychology students at Wheeling Jesuit University. Over the course of two years, Project CHAMP provided authentic research experience for eight undergraduate psychology interns. These students participated in data collection, data processing, and analysis. Their contributions were invaluable and provided them with practical experience that would enhance their capabilities for graduate study. One intern in particular, Regina Shia, went on to develop her research writing abilities. She presented Project CHAMP research at an undergraduate student research conference and appears as an author on the multiple intelligence research report below.
- Project CHAMP will provide future benefits to the state of West Virginia through the development of an updated version of *Astronomy Village*. Prior to Project CHAMP, *Astronomy Village* was only available on the Macintosh. This provided little benefit to West Virginia because schools in West Virginia primarily use Windows-based computers. Project CHAMP set as an objective to update the software for use on Windows machines to the point that future research projects could be implemented in

West Virginia. Project CHAMP exceeded that objective by reaching the beta stage of a cross-platform version of *Astronomy Village* in December 1998. A beta version means that all of the major components have been implemented, but the product still needs the polish of a finished product. Project CHAMP made it possible for COTF to contribute a relatively small amount of money to complete a full upgrade of *Astronomy Village*.

- Project CHAMP provided benefits to the overall research agenda at COTF. Project CHAMP hosted a mini-Institute, which invited experts in educational psychology, assessment, software publishing, astronomy, and physics education. It is rare that such a diverse panel of experts works together in the design of educational research. These experts conducted a review of *Astronomy Village* and provided concrete suggestions on how to conduct research and evaluation related to *Astronomy Village*. The outcomes of the mini-Institute were specific suggestions for assessing scientific inquiry in astronomy and specific suggestions for conducting large-scale research on *Astronomy Village*. These suggestions provided the basis of the research design behind the Project CHAMP research reports below. In addition, the general principles underlying these suggestions have proved to be instrumental for the overall research agenda. The success of the Project CHAMP mini-Institute has led to designs for a full Institute at COTF. The Institute for Research in the Learning Sciences will provide a mechanism to continue to bring diverse research expertise together within an intellectual center that can fuel the development of general design principles for educational technology.

Project CHAMP Research Reports

This section provides a more detailed description of each of the studies that were conducted under the auspices of Project CHAMP. Full prepublication drafts for each study appear on the CET Web site (http://www.cet.edu/research/papers.html). These reports are being submitted to peer-reviewed journals for publication. However, the submission process can take up to a year from the time of submission to final publication.

Howard, B., McGee, S., Hong, N. and Shia, R. (1999, April). Sternberg's Multiple Intelligences: Accommodating Students' Abilities through Advanced Technology. Paper presented at the annual meeting of the American Educational Research Association, Montreal, Canada.

The purpose of this study was to examine the effect that dimensions of multiple intelligence have on success in using *Astronomy Village* for learning science inquiry skills. Over a three-week period, students used *Astronomy Village* as a resource to conduct research investigations concerning current astronomical questions. Due to the inquiry-oriented nature of the activities, we wondered how this non-traditional learning environment might affect students of differing abilities. In particular, we used the construct of triarchic abilities proposed by Sternberg (1985), which purports that human intelligence is comprised of three primary abilities: analytic, creative, and practical. Sternberg (1985) further proposed that students who are strongest in analytic intelligence usually perform the best in classroom situations because the activities conducted in classrooms require primarily analytic abilities. It was our belief that the activities in *Astronomy Village* would allow students of all three abilities to perform equally well, but that students with stronger creative and practical abilities would demonstrate improved attitudes towards science and astronomy. Categorizing students according to their strongest ability (either analytic, creative, or practical), we examined how they succeeded at cooperative learning tasks and how their attitudes towards science were influenced. Our findings indicated that the use of *Astronomy Village* resulted in equal success for students no matter their strongest intelligence. In addition, we found evidence that students who were more practical or creative in their abilities benefited by developing more positive attitudes towards science.

Hong, N. & McGee, S. (1999). Effectiveness of Astronomy Village Instruction on Scientific Inquiry and Conceptual Understanding in High School Students. Technical Report, NASA Classroom of the Future, Wheeling Jesuit University, Wheeling, WV.

Using the same field setting as the above report, this study evaluates the impact of *Astronomy Village* on student problem solving in astronomy. Students were administered a questionnaire that measured their ability to solve complex problems related to the nearby stars, variable stars, and site selection modules in *Astronomy Village*. Since students selected from all ten Astronomy Village modules, we created posttest only comparison groups between those who completed one of the three targeted modules and those who completed other modules. The results of the study indicate that Astronomy Village does lead to effective learning outcomes. Students who completed the paths had developed a better conceptual understanding and produced better solutions to the problem.

McGee, S., Howard, B., & Hong, N. (1998, April). Evolution of Academic Tasks in a Design Experiment of Scientific Inquiry. Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Project CHAMP funded the third study in a design experiment of *Astronomy Village*. A design experiment is a particular approach to studying the implementation of new educational materials. A design experiment takes place in a testbed and involves a cyclic pattern of designing specific lesson plans to implement educational materials, trying out the lesson plans, and evaluating the results of the implementation. The evaluation is then used to make adjustments to the lesson plans, which are then implemented in a new cycle within the design experiment. In this Project CHAMP-funded third study, at-risk students from Wheeling Park High School were bussed to COTF on a daily basis for four weeks to use *Astronomy Village*. The previous two studies of the design experiment had focused on pragmatic issues related to *Astronomy Village*, such as feedback on Logbook entries and setting deadlines for completion of activities. These studies had also pointed to difficulties students had in engaging in scientific inquiry. Specifically, students had a difficult time integrating activities from one day to the next and connecting an individual activity to the overall research question of the investigation. In this third study, we designed two major enhancements to the implementation of *Astronomy Village*. First, we streamlined each investigation such that students would be able to complete three investigations in the same time that it previously took to complete one. In this way, students would have more exposure to the entire investigation cycle, which we thought would help them to integrate activities from one day to the next. Second, we engaged in whole class discussions about how individual activities were related to the overall question. The results indicated that these enhancements led to increased levels of scientific inquiry. Many of the enhancements that resulted from the design experiment have been incorporated to the sequel to *Astronomy Village—Astronomy Village: Investigating the Solar System*, an NSF-funded middle school version focusing on the solar system.

Hong, N. (1998). The relationship between well-structured and ill-structured problem solving in multimedia simulation. Unpublished doctoral dissertation. The Pennsylvania State University, State College.

This dissertation describes the development of the problem-solving test that was used in the Project CHAMP studies above. Problem solving, especially complicated ill-structured problem solving, has been a major concern in education. Research over the past decade provides qualitative ways of viewing the solution processes of ill-structured problems. Researchers suggest that ill-structured problem solving has to support new, more qualitative, components than those for solving well-structured problems. This study set forth to test the

theory that the problem-solving skills used for well-structured problems are necessary but not sufficient for solving ill-structured problems in the context of an open-ended, multimedia problem-solving environment. Two sets of open-ended questions were posed to reflect students' solution skills in well-structured and ill-structured problems involving astronomy contexts. Additionally, various instruments including domain-specific knowledge, structural knowledge, and justification skills were developed to measure students' cognitive components for problem solving. Finally, inventories such as science attitude, motivation in astronomy, knowledge of cognition, and regulation of cognition were employed to collect the appropriate data of metacognition and non-cognitive variables. The results of this study verified past research conclusions that well-structured and ill-structured problems require different components for reaching successful solutions. Overall, cognition and justification skills were critical components for successful solution in well-structured problem solving. Alternatively, metacognition, non-cognitive variables, justification skills, as well as cognition, were found to be essential components needed to solve ill-structured problems.