

# **Accelerating Computer Science Education**

Final Report

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The goal of this project was to develop a new type of online educational environment into a viable system for Computer Science Education. The system, ProgrammingLand, existed prior to the grant, but had only been used by the PI in one course. It had only anecdotal proof that it could be used in a suitable fashion. Since that time the system has been greatly enhanced in many different areas, has been used in other courses and other institutions and there are two studies indicating its value. Like any other high risk proposal with a first-time PI, this grant had both failures and successes, both of which are elaborated on in succeeding paragraphs.

## **Problems.**

The problems started before the grant was even awarded. The proposal named, William Reynolds, at United Tribes Technical College (UTTC) as a partner. The intention was to exercise the system in a tribal college environment. Unfortunately, UTTC suffered serious stability problems from which it did recover, however Bill Reynolds chose other employment. The department did get back on its feet but had changed direction somewhat, no longer emphasizing the programming as much as it had in the past. The PI continues to maintain the relationship that was formed with the new chairman, Jeff McDowell there but it was not in time to be of much help in this grant. This caused us to search for an alternative site and it seemed like Turtle Mountain Community College (TMCC), another tribal college would also be suitable. The CS person there, Chad Davis, was amenable to doing a comparative study but there were problems here as well. TMCC was scheduled to teach a C++ class in the spring semester of 2003-2004 which would use the system. The schedule was rearranged and this ended up being taught in January of 2005 instead. Late in 2004 Chad Davis had been made acting CIO at the college, so hired an adjunct, Travis LaRocque to teach the C++ class. This was the first class that Travis had taught, so he was not enthusiastic about using ProgrammingLand after a meeting with Chad Davis and the PI. Thus the TMCC portion of the project ended cancelled. Although this ended in an undesirable way as far as the grant is concerned, this relationship has also been maintained to the degree that the PI was named as a consultant in a grant submitted by TMCC.

A first-time PI will always have unforeseen administrative issues and this grant had most of those. The most serious was the change of institutional ERP system. VCSU was one of the test sites for a system to be adopted by all of North Dakota State Government including the university system. The support for grant accounting was one of the last pieces to function. This was a great distress to more research oriented institutions such as NDSU, with which there was a subcontract. The effect was an uncertainty about grant expenses. This resulted in the grant coming in under budget, according to the belief of the PI. This was also partially due to the fact that one of the Co-PIs, Brian M. Slator, was unable to devote the time that had originally been budgeted for his work. He did come in

over the 160 hour threshold, was able to consult on the project and manage some of the graduate students, but this was somewhat short of the proposal expectations.

There seems to have also been a marketing failure. ProgrammingLand has been available for free distribution for some time. This fact has been mentioned in most of the recent papers and presentations. Although these papers and presentations have received good reviews there have been no inquiries on obtaining the system.

### **Successes.**

The list of accomplishments of the project should not be overlooked. The system has been greatly expanded in both functionality and content. It has now been used for three courses at VCSU as well as the introductory Java class at Concordia College of Moorhead, Minnesota. Besides an increase in content, agents have been introduced to help students stay on track in their usage of the system and the interactivity of the system has been increased so that students will use active learning. There have been two studies evaluating the effectiveness of the system as well as many papers presented at respectable conferences.

Developing content material is of comparable difficulty to writing a textbook. The content includes both the text displayed by the system, the organization of that text, the development of exercises and visualizations to support the text and the evaluation of student learning. At VCSU the MOO is used in lieu of a textbook for CSci 160 and 161. CSci 242 has an optional textbook. At Concordia College the Java class, CSC 125, has also been taught with ProgrammingLand substituting for a textbook. The content material has approximately doubled during the grant.

There have been two studies concerning the effectiveness of the system. The first compared four institutions that had an introductory C++ class. The classes were taught by four separate instructors. The PI used ProgrammingLand and no textbook, the rest used the textbook of their choice. The results of the instruction were tested using common questions and a common project. The results showed that the ProgrammingLand students were not behind their counterparts, despite having no textbook.

An alternative experiment was conducted at Concordia College. In one semester two sections of Java were taught by the same instructor. One section used ProgrammingLand and the other the previously used textbook. Results from this experiment also support the notion that the system performed as well as a textbook. This experiment was performed using the Java wing of ProgrammingLand, before the lesson structure was applied. (the lesson structure requires students to accomplish certain things in the system before awarding points or assignments.) Therefore we believe a better showing of the system could occur with that missing aspect supplied.

The system has been enhanced with numerous objects that make the system easier to use. Prior to grant the goalie agent delivered assignments to students who completed certain lessons. During the grant period the lost, aimless and quiz agents were implemented. The lost agent finds students who are not in lessons that are appropriate to their course or their level. It offers to transport them to an appropriate room. This offer may be declined by the curious, but most students accept the offer. The aimless agent makes a similar offer, but to those students who have made no progress on their current lesson. The quiz agent offers a quiz to satisfy a lesson. The quiz agent is intended to help those students who may know the material from other sources.

The initial version of ProgrammingLand was like most MOOs, that is completely text-based. Since programming is mostly a text-based activity that is not necessarily a problem. However, the students do not remember punch cards like the researchers, so a MOO client usable by a web browser has been employed. This gives a familiar point and click interface, but the content is still mostly textual. This has been enhanced as well so that graphics images may be placed within the text, slide shows may be started from the system and specially modified Java applets may be used. The slide shows are a series of web pages external to ProgrammingLand. They may be started from within the system and as far as the student is concerned are completely contained by ProgrammingLand. Perhaps most important they may be required by a lesson, which allows the system to monitor that the student did indeed view the entire sequence. The MOOApplet is a modified Java applet. It may also be started by the student from within the system. Each of these signals the system when the student has performed sufficient interactions to gain credit for the experience. The MOOApplet may also may be optional or a requirement of a lesson.

The main focus on the project has been on the student experience. Clearly, if the experience is difficult for the students, they will not spend as much time on task as desired. Historically the students have liked the system, as evidenced by informal feedback and surveys. However, the instructor interface has been cumbersome. An instructor needed a substantial MOO experience to effectively use the system or customize the course or content material. In particular Vijayakumar Shanmugasundaram has pushed for an easier interface for the instructor. This has been greatly improved so that the instructor has a much easier time of it than previously. Along the same lines, the facilities that are standard in a Learning Management System have been developed in ProgrammingLand as well. Tests and surveys are relatively easy to develop and administer, grades may be maintained in the system with a variety of weighting schemes and the students may access only their own grades as well as their assignments. Two program graders have or are in the process of development. TorqueMOODa is a Windows specific program that may grade student programs using black box testing of arbitrary executables. Rinchwind is a corresponding Java program for grading Java applications. Both load their scripts from the MOO based upon the program that the student has received from the system.

## **Personnel.**

The following faculty members have all devoted more than 160 hours to this grant:

Curtis Hill (PI) – VCSU

Brian Slator (Co-PI) – NDSU

Lisa Daniels (Co-PI) – NDSU

Vijayakumar Shanmugasundaram – Concordia College

The latter was not named in the original proposal, but was a happy addition to the group. His contributions include much of the development of the Java wing of ProgrammingLand as well as the second experiment.

Other faculty members that contributed in some way include:

Chad Davis – Turtle Mountain Community College

Erik Sand – Jamestown College

Dustin Brandt – Mayville State University

Deepak Rautella – NDSU

The following students have also worked on this project, **bold** signifies that they worked more than 160 hours:

Garrett Hoff – NDSU

**Yui Cui** – NDSU

John Opgrande – NDSU

**Martina Miteva** – VCSU (undergraduate) and NDSU (graduate)

**Justin Bearinger** – VCSU

David Kawasaki – VCSU

Benjamin Ford – VCSU

David Treleaven – VCSU

Gregory Broge – Concordia

Ryan Johnson – Concordia

Deb Kinzler – VCSU

Thomas Niedzielski – Concordia

John Tofteland – Concordia

The first four were graduate students when they participated and the rest undergraduate. The case of Martina Miteva is worth noting. Her experience working on the grant as an undergraduate at VCSU contributed to her entering graduate school at NDSU. Justin Bearinger is also considering graduate school, partially because of his work on the grant. One last person, Carla Kelly, also worked on the project. She is not a student, but a wonderful proofreader. She worked for less than 160 hours proofreading exhibits in the system.

## **Publications.**

Hill, Curt, Vijayakumar Shanmugasundaram and Martina Miteva. Use of Agents in ProgrammingLand. In Proceedings of The Eleventh Annual Conference on Innovation and Technology in Computer Science Education (ITiCSE 2006). University of Bologna, Italy 26-28 June 2006.

Hill, Curt, Brian M. Slator, Lisa M. Daniels and Vijayakumar Shanmugasundaram. An Online Computer Science Instructional Resource. In Proceedings of the Sixth International Conference on Web Based Education (WBE 2006). CD, ISBN: 0-88986-543-4. <http://www.actapress.com/proceedings.aspx>

Hill, Curt, Vijayakumar Shanmugasundaram and Martina Miteva. *Database Tools to Administer Programming Land*. ISCA 18th International Conference on Computer Applications in Industry and Engineering (CAINE 2005) in Honolulu, Hawaii, November 2005. [CD-ROM]

Hill, Curt, Brian M. Slator, Lisa M. Daniels. The Grader in ProgrammingLand. In Proceedings of SIGSE 2005, St. Louis MO., (March. 2005).

Slator, B., C. Hill and D. Del Val. May 2004. Teaching Computer Science with Virtual Worlds. *IEEE Transactions on Education*. New York. IEEE Press. Vol.47, pp. 269-275.

Hill, Curt, Brian M. Slator, and Lisa M. Daniels (2004). *Using and Validating ProgrammingLand*. Proceedings of the 7th IASTED International Conference on Computers and Advanced Technology in Education (CATE-04), V. Uskov (Ed.), August 16-18, Kauai, HI, pp. 291-296.

Hill, Curt, Brian M. Slator and Lisa M. Daniels. An Online Resource for the Introductory Programming Class. In Proceedings of the 2nd International Conference Information Technology Research and Education (ITRE '04) (London Metropolitan University, London, UK, June 28 -July 1, 2004). IEEE, Piscataway, NJ 08855-1331.

Hill, Curt. *Progress towards Automatic Grading of Programs in ProgrammingLand*. Midwest Instructional and Computing Symposium 2004. April 16-17, 2004 Morris, MN. [CD-ROM]

The following paper has been submitted for consideration.

Hill, Curt, Brian M. Slator and Vijayakumar Shanmugasundaram. Visualization Deployment in ProgrammingLand. Submitted for publication to SIGSE 2007, Covington KY, (March. 2007).

The project web site also includes internal documentation, such as student and instructor guides. This may be found at:

<http://euler.vcsu.edu/pland.htm>

### **Final Thoughts.**

Although the grant funding has ended, the project will continue. Two things need to continue: the incremental refinement and distribution of the system. We will continue to use the system and this will unquestionably show us bugs and minor enhancements. These generally can be fixed as they are found. The distribution is somewhat more problematic but we will continue to look for meaningful ways to make the system available.

Despite the problems we believe the project has been successful. It was the plan to enhance the content material of the system so that it would be usable in more separate classes and this has been done. It was also in the plan to enhance the ease of use and capabilities of the system and this also has been accomplished. However, most of these enhancements were not conceived when the proposal was written. Instead these opportunities became clear as the people worked together on the project. This is another example of synergy derived assembling people of diverse background. This team of people would like to thank National Science Foundation for the opportunity to work together on this project.