Socially Relevant Game Programming to Motivate and Advance STEM Education

V. Scott Gordon, Mark Rodriguez, Kimberly Gordon Biddle, and Jean Crowder
California State University Sacramento

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Purpose and Objectives

The numbers of students choosing Computer Science as their field of study is insufficient to meet the projected demand [BLS12]. Attracting more women and urban students to the field is one way of addressing this impending problem, because those populations are known to be seriously underrepresented [BHE06]. Statistics show that most first computer programming courses act as "gatekeeper" courses that discourage rather than encourage retention [PEB09].

There is a significant body of research indicating that a perception of relevance and social purpose are important in retaining women and urban students in technical fields such as computer science [BF04, WFL07]. First-year programming courses are usually heavily skill-driven, in which students typically learn basic skills as applied to simplified "toy" tasks. We were interested in finding a way of changing this approach to one in which socially-relevant tasks were a part of introductory programming homework tasks.

Our proposed program was subsequently supported by a 3-year NSF ITEST grant.

Our aim was to achieve high levels of student motivation by teaching programming in the context of building instructional computer games. We were confident that students would find game programming fun, and the focus on instructional games would make the games they were building socially-relevant [PEB09]. Having students build instructional games, however, is a significant challenge, because computer games are among the most complex software systems. Creating a game that is socially-relevant – i.e., one that other kids would actually play and learn from – typically requires advanced skills in excess of what is possible to learn in an introductory course. While beginning programmers could potentially produce a simple instructional game, the experience level of most young students – i.e., the target audience of the instructional game – is such that their expectations would far exceed what is feasible for beginning high school programmers to produce.

When we discussed our concerns with elementary school teachers, however, they indicated to us that first and second graders are not generally as picky as students in the third grade and higher, so that our idea could be feasible in the target audience of the games were ages 6-7. We therefore built a program around the idea of high school students learning computer programming by creating an instructional computer game for 6-7 year olds.

The program was built around two 6-week summer sessions. The summer courses were taught by part-time university faculty, and took place at the university. Forty (40) college-bound high school students were selected so as to comprise a diverse demographic, mostly Hispanic and African American, with a 50/50 male to female ratio. They took a district bus to the university at 9:00am, and left at 3:00pm, five days per week. The first summer session focused on basic skills,

using a simplified graphics programming environment (Dr. Racket [TEA09]). In the second summer session they worked as a team to build a single instructional game, and a more industrial programming environment was used (Java/Greenfoot [GRE12]). The game was built around State of California math standards.

The roles of the instructors were dramatically different from the first summer to the second. For the first summer, we selected an instructor with strong experience teaching introductory programming. For the second summer, we selected an instructor with a strong background in software project management. The tasks spread over the second summer mirror those used in an actual development environment: requirements specification, functional design, prototyping, development, testing, packaging and delivery.

During the intervening regular school year, most of the students continued to strengthen their programming skills in their MESA (Mathematics, Engineering and Science Achievement [MES12]) course, in which their teacher incorporated supplementary programming exercises. Curriculum development utilized backward design, and also leveraged existing online learning materials as the students developed their basic skills.

Since the goals of the program revolved around motivation, a number of other interventions were employed. We made heavy use of mutual mentoring [SY09], in which ten (10) undergraduate engineering students were employed as mentors and met regularly with the students during both summers and during the regular school year. We also incorporated a number of supplementary activities and special events – field trips, industry panel, tours, bonding events, parent workshops, etc. To offset many of the students' need to work and earn money in the summer, the NSF grant included a student stipend and daily lunch money.

In order to gauge the effectiveness of the program, we collected data frequently. The students were regularly surveyed using a standard instrument for measuring motivation. We also had them complete an introductory programming placement exam at regular intervals. There were additional surveys after each event, such as parent surveys after the parent workshops.

Testing the quality of the resulting instructional game involves elementary school students from schools aligned with the high school, through the MESA program we were working with. MESA utilizes vertical alignments to coordinate activities across grade levels, and so it was natural to utilize these alignments to select cooperating schools. We took this one step further, and selected eight (8) students from the aligned middle school to help the high school students with testing and delivery of the game. The inclusion of middle school students in this manner makes our program remarkable in its collaboration of an entire vertical academic alignment.

Attendance and retention were high – in the summer close to 100% every day. Students also displayed a high level of concern in their journals for the quality and importance of the product they were creating, and appreciated the critical testing performed by the middle school students in that it was helpful for improving the final product quality. In the end, not only were the successful in creating the instructional game, they also displayed a high level of pride in what they were able to accomplish. The surveys show that many of the students have redirected their college plans towards engineering and computer science, and have greater confidence in finding help and preparing for college.

The final product, while not as polished nor at a sophistication level competitive with commercial products, is remarkably rich, fun to use, and is standards-based. Instructors at the

aligned elementary schools have reviewed it and have expressed strong desire to use it as supplementary material for their 1st and 2nd grade classrooms. We believe that this is the first time high school students have developed an instructional computer game intended for use in an academically aligned classroom. The approach is replicable at any school with a modest computer lab, using free software development tools.

Outline

- Overview of the program and its structure (20 minutes)

- Overview of curriculum as deployed (10 minutes)

- Descriptions of student/faculty/mentor experiences (10 minutes)

- State math standards as software requirements for student programmers (5 minutes)

- Demonstration of educational math game developed by students (10 minutes)

- Question/Answers (5 minutes)

Attendees will be able to play the game and see to what degree our high school students were able to build a game after less than one year of computer programming instruction.

Supporting Research

[BF04]   Berner, E.J. and Ford, M.E. (2004). Motivational Factors Influencing Faculty Computer Use in Schools of Education. *Annual meeting of the American Psychological Association*, Honolulu, HI.

[BLS12] Bureau of Labor Statistics Employment Projections, 2010-2020 (www.bls.gov).

[BHE06] Cassell, G. and Slaughter, J.B. (2006). The Challenge of the New Demographics of Higher Education: Increasing Women and Minority Participation in the STEM Disciplines. *Business Higher Education Forum 2006 Issue Brief*.

[GRE12] Greenfoot homepage. Website (accessed 2012): www.greenfoot.org

[MES12] Math, Engineering, and Science Achievement (MESA) website (accessed 2012): http://mesa.ucop.edu/

[PEB09] Phelps, A.M., Egert, C.A., and Bayliss, J.D. (2009). Games in the Classroom: Using Games as a Motivator for Studying Computing: Part 1, in IEEE Multimedia, vol 16, no. 2, pp. 4-8.

[SY09]   Sorcinelli, M. and Yun, J. (2009). Finding a Mentor. *NEA Higher Education Advocate*., 26 (5) 5-8.

[TEA09] *Teach Scheme, Reach Java*. (accessed 2009): http://www.teach-scheme.org/

[WFL07] Wentzel, K.R., Filisetti L., and Looney, L. (2007). Adolescent Prosocial Behavior. The Role of Self-Processes and Contextual Cues. *Child Development 78*, 895-910.