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Using Games to Teach Computer Science Concepts

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Abstract

Games that help players develop an understanding of computer science concepts are a promising alternative to the current emphasis on programming. This workshop introduced participants to digital and analog games that demonstrate how CS concepts can be integrated with game play and engaging story contexts. Relevant issues such as the value of analog games for use in classrooms and informal learning environments, the role of narrative in educational games, and the challenges of identifying appropriate concepts for game-based learning were addressed.

Overview of the Topic

In this workshop, we introduced participants to digital and analog games designed to help players develop an understanding of several core computer science concepts. The games are intended to be appealing to middle school age girls, and have been tested in a variety of informal educational settings, including libraries, after school programs, and summer enrichment workshops. Our plan for the workshop was to (a) briefly introduce the rationale for the games and provide and overview of the game design process, (b) give participants a chance to play a few levels of the games (described below), (c) debrief and discuss participants' reactions to game play, and (d) engage in a broader discussion of issues of interest to attendees.

The games used in the workshop were developed in two related NSF-funded projects[1] (Horn et al., 2016; Stewart-Gardiner et al., 2015) aimed at exploring different aspects of games to teach CS concepts. A myriad of educational efforts are aimed at increasing young people's interest in and ability to succeed in computer science (CS) by using game *design* as a means of introducing them to basic programming skills (Gee & Tran, 2015). Often such approaches intend to attract girls and boys from currently underrepresented groups to computer science (ibid). These approaches, while valuable, take a rather

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narrow view of the potential of games to facilitate computer-science related learning, tending to treat game design as an appealing means of learning programming rather than, for example, leveraging the affordances of games for supporting CS understanding and skills. Even games designed to introduce computer science through play tend to focus on teaching programming (Harteveld et al, 2014).

Our games take a different approach, by marrying game mechanics and goals to fundamental concepts in computer science. Our approach is aligned with the guiding assumptions of the Computer Science Principles curriculum from the College Board and NSF (The College Board, 2014) that computer science education must go beyond a primary focus on programming, and introduce students to fundamental concepts and the wide range of their potential impact. In selecting concepts as the focus for our games, we relied on the following criteria: (a) Can aspects of the concept be taught in an age-appropriate way? (b) Is the concept general enough to be understood by a student with no prior computer science training? and (c) Does the concept have the potential to be explicated through a puzzle-type game format? Each project had a different research focus: the team based at Northeastern University is exploring how the use of procedurally generated puzzles affects the educational effectiveness of a digital game focused on one CS concept, while the joint Kean University-Arizona State University team is investigating the role of story in promoting girls' engagement with and learning from analog games addressing three different CS concepts (see our project website for more information: http://www.northeastern.edu/gramshouse/).

The games played in the workshop were developed and tested over the last 18 months in a variety of settings with middle school age youth. In addition to involving workshop participants in playing the games, we shared game play data and learning outcomes from the games, including the methodologies and tools we used to collect this information.

Presenters

The presenters and workshop facilitators were members of the two research and design teams for each project. They represent a wide range of backgrounds, including researchers, educators, game and educational media designers, and computer scientists. This diversity enabled presenters to provide varied perspectives on the design process and value of using games to teach CS concepts.

Workshop Format & Activities Participants were seated at tables in small groups as they join the session. The workshop began with a brief 10-minute introduction to the rationale for the games, our guiding assumptions about the use of games for learning, and key steps in our game design process. We moved relatively quickly to an introduction to the games themselves. Each group played a portion (one or more levels or rounds) of one of the following games:

- ***GrACE***, a digital puzzle game focused on the common CS problem of finding a graph's minimum spanning tree (MST). Players coordinate the actions of animals who are trying to collect vegetables while expending the least amount of effort.
- ***Algorithm Relay Race*** is an analog game that helps players understand algorithms as series of clear and concise directions to solve a simple problem. This game is designed as a collaborative relay race in which partners and teams collaborate on writing and following directions to complete tasks and progress in the game.
- ***Hidden Image Game*** is an analog game that demonstrates how data can be represented in many different ways and still have the same meaning. Players compete to encode and decode images,

while learning about related concepts such as binary code and run length encoding. Participants also had the opportunity to try a digital version of the game created by project team members.

- ***Organize & Search*** is an analog card game that helps players understand the importance of well organized data for data retrieval. Players take turns using "action cards" representing different sorting strategies to arrange a card deck with the goal of isolating their target cards.

Game play and small group discussion much of the session. Presenters worked with each group to introduce the games, facilitate game play, and discuss reactions to the games. We planned to conclude with a large group discussion, but changed plans due to participants' interest in trying more than one game. We allowed participants to circulate to a second table and game. One common theme across our small group discussions was the appeal of analog games for classroom situations in which access to computers or game consoles might be limited. The final versions of the games and facilitator guides will be available on the project website (noted above) by June 2017.

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