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 will introduce 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 use of player data for assessment of learning, the role of narrative in educational games, and the challenges of identifying appropriate concepts for game-based learning will also be addressed.

Overview of the Topic

In this workshop, we will introduce 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 is 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 that will be used in the workshop were developed in two related NSF-funded projects[1] (Horn et al., 2016; Stewart-Gardiner, Carmichael, Gee, & Hopping, 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 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, Smith, Carmichael, Gee & Stewart-Gardiner, 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 that will be played in the workshop have been 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 will be able to share 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 will be 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 will enable the presenters to provide varied perspectives on the design process and potential value of using games to teach CS concepts.

Workshop Format & Activities

Participants will be seated at tables in small groups as they join the session. The workshop will begin 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 will move relatively quickly to an introduction to the games themselves. Each group will play a portion (one or more levels or rounds) of one of the following games:

(a) ***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.

(b) ***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.

(c) ***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.

(d) ***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 will comprise about 20 minutes of the session. Presenters will work with each group to introduce the games and facilitate game play. Following game play, presenters will begin a 10-minute debriefing with small groups focused on the design of each game and then move to a larger group discussion to distill the major insights. Following this, and to support further discussion, the presenters will share their empirical findings so far. In this discussion, we will carve out time of how we have used game play data to understand the educational impact of our games. Following the session, participants will be able to access the games and related materials on our project website.

Endnote

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