CodeTracesure—Combining Gaming, CS Concepts, and Pedagogy

Olivia M. Nche
School of Computing
Clemson University
Clemson, SC, USA
oncheey@g.clemson.edu

John Welter
School of Computing
Clemson University
Clemson, SC, USA
jcwelter@g.clemson.edu

Megan Che
College of Education
Clemson University
Clemson, SC, USA
sche@clemson.edu

Eileen T. Kraemer
School of Computing
Clemson University
Clemson, SC, USA
etkraem@clemson.edu

Murali Sitaraman
School of Computing
Clemson University
Clemson, SC, USA
murali@clemson.edu

Victor B. Zordan
School of Computing
Clemson University
Clemson, SC, USA
vbz@g.clemson.edu

***Abstract*—This paper presents an overview of the objectives and design of a video game, CodeTracesure, that we have used in a summer camp for elementary school African-American children. The game is designed to help children practice CS concepts as they play and to help teachers learn about their difficulties. It combines engaging elements of good games with pedagogy to provide a platform where students can practice CS concepts learned in class. It covers such concepts as assignment, variables, sequencing, and operators. The game is equipped with a database to facilitate collection of data that can be analyzed for trends and patterns. The current goal is for it to be a supplementary tool that can help the students practice while allowing teachers to collect useful data that can help improve the learning process. An initial study was conducted using this game with about 40 African-American elementary school children. Findings show that the game was useful in motivating the students to practice code tracing and learn CS concepts. The backend end data that was collected on the performance of the students helped to identify potential pitfalls.**

Keywords— Broadening participation, K-12 education, coding, game, summer camp, coding concepts

I. Introduction

It is increasingly becoming critical to research and experiment with effective methods of instilling computational thinking skills and engaging students of all ages, especially those from underrepresented populations in computing [4][7]. The goal of this research effort is not only to experiment with interesting ways of engaging many children but also to pinpoint potential pitfalls that these children might encounter as they learn programming and fundamental CS concepts in a summer camp [8]. Findings from recent studies indicate that students need to be able to read and understand code in order to be more effective in writing code [5]. This in part is the reason why we include code tracing activities in CodeTracesure—a video game that has been specifically designed to engage children in learning by encouraging them to answer questions related to fundamental concepts and to practice code tracing. The name of the game highlights the fact that it offers code tracing activities in conjunction with a classical treasure hunting game. In this game, we attempt to weave together gaming, CS concepts and pedagogy (Fig. 1). Video games can be instrumental in developing essential intellectual skills as well as for improving the sensor-motor capabilities of children who play video games regularly [2]. Thus, besides learning CS concepts, the children also learn other important skills. Our groundwork study has focused on African-American elementary students with the aim of broadening participation. The state of South Carolina has recently established K-12 standards for computer science, which include programming concepts even for elementary school children. We therefore seek to introduce the concepts through CodeTracesure to help advance this cause.

II. Motivation for Gaming

Benefits of educational games are documented in [10]. Other studies also indicate that video games have cognitive importance as they can help students develop particular skills [3][6]. Ball studied the impact of video games on the spatial abilities and basic aspects of the intellectual development of children. He concluded that video games are beneficial to learning several intellectual skills [1]. Lee and Ko conducted a study in which they found that video games helped students learn programming [6]. Our video game therefore offers the students the opportunity to hone important skills and practice code tracing. In the game (Fig. 2), a little panda moves around in a maze as it hunts for treasure and encounters code tracing

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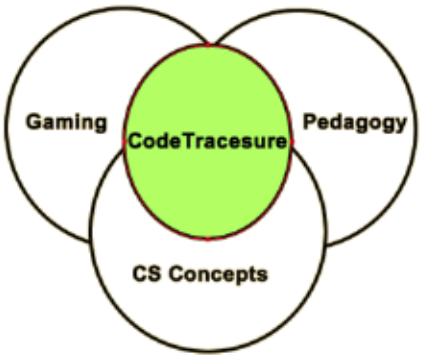

Fig. 1. Interplay Between Gaming, CS Concepts, and Pedagogy

questions in its path. It has to answer the questions before it is allowed to proceed. The students are rewarded for effort and correct answers in order to keep them motivated. The video game includes a database to collect data on the students' performance. The data includes a time stamp on when students answer the questions, how many attempts they make, and which answer choices they select. This provides facilitators with important performance data that could be used to provide further assistance to the students.

III. CS Concepts

The CS concepts covered in this game include assignment, sequencing, Booleans, arithmetic and Boolean operators, self-referential variables, if/else statements, relational operators and loops. Drawing from Rich, *et al*., we designed a taxonomy of concepts, which guided game questions [9]. The taxonomy is fine-grained and allows an incremental approach to focus on specific concepts. This design is intended to help us identify where students might have trouble.

IV. Pedagogy

CodeTracesure was thus designed to act as a support tool that helps to sharpen the code reasoning skills of elementary school children and possibly reduce cognitive overload. Studies show that cognitive overload can prevent further learning. However, using supplementary tools in education can help to reduce cognitive overload [10]. During the game, students are required to trace and reason about code snippet questions and try to apply what they learnt in the class to accumulate more points. All questions within a particular level of the game focus on one concept. Each level in turn has five questions, all of which test the same concept. So, a student has five attempts to answer questions pertaining to a particular concept. This pedagogical approach encourages practice and performance evaluation.

V. Summary and Results

It is imperative to research alternative ways to communicate knowledge to diverse learners as we attempt to include as many students as possible in the quest for computing knowledge. Since support systems play a relevant role in the learning process, we have conceived of CodeTracesure, a videogame that can help students practice code tracing and CS

Fig. 2. Sample Game Playing Screen

concept as they play. The performance data collected in the backend can be useful in advising future curriculums and instructional decisions. Preliminary studies with a group of African American elementary school children in a summer camp show that the game is promising in helping students practice code tracing, learn CS Concepts and assist in pinpointing potential obstacles that these children face.

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