Math Edutainment Game for Girls Grades 1–6

Emily Clarke
Computer Systems Lab 2008–2009

June 10, 2009

Abstract

The purpose of this project is to create an engaging and educational game for girls in elementary school. This game will be driven by a comprehensive plot, a diverse cast of characters, and six different mini-games. Through an all-female cast of scientists, a feedback system, a stereotype–free presentation of science in the real world, and rewarding game play, this game will encourage girls to have higher confidence in their abilities as well as pursue higher-level math, science, and technology classes.

1   Introduction

Despite progress in recent years, girls as a whole are still behind in math and science enrollment and scores. Many girls feel unmotivated to continue their educations in math and science past the level required to graduate. As such, girls are underrepresented in college-level math, science, and technology classes ([3]). Many girls do not feel confident in their ability to perform math and, as such, avoid it whenever possible. Other girls find math impersonal, uncreative, and based in memorization alone([2]). This project is attempting to overturn these beliefs and behaviors and encourage girls in elementary school to have higher confidence in their abilities, a greater understanding of math and science, and continue their educations in math, science, and technology.

This project involves creating a web-based "edutainment" game – a piece of educational software that is meant not only to teach but also to keep the

1

student engaged, entertained, and interested in the subject – and making it available to elementary schools in Fairfax County. Students' beliefs before and after game play will then be compared. This game will implement a series of features to help counter several common problems with girls' beliefs, behaviors, education, and attitudes towards math.

2   Background

Many girls shy away from taking advanced science, math, and technology classes. Research done by the Girls, Math & Science Partnership states that despite recent advances boys still outperform girls in primary science, math, and technology classes. Girls are severely under enrolled in Advanced Placement Computer Science and Physics classes, and eighth grade boys typically have higher performances than girls in fractions, number sense, and the core sciences, in addition to a higher scientific confidence.

Concerned with this problem, several groups have created suggestions to help encourage girls both in the classroom and out. The Girls, Math & Science Partnership suggests making math more personal, helping girls appreciate math and science for its virtues instead of its utility in school; giving girls the feeling of control over their abilities in science and math; creating a "New Science Girl" archetype to break the "math is for geeks" stereotype; reminding girls that math and science can have rewarding, inspirational, elegant, and humanitarian aspects; and encouraging girls to explore what they can do with math and science. The Institute of Educational Sciences suggests teaching girls that their cognitive abilities are not fixed; giving girls specific feedback; providing strong female role models; linking math, science, and technology to unusual (non-stereotypical) and interesting careers and activities; creating opportunities for research; and providing spatial skills training. The Commission on Technology, Gender, and Teacher Education suggests implementing strategy, personal interactions, diverse and interesting characters, narrative plots, non-stereotyped creativity, and appropriate challenge into "edutainment" games.

3 Design and Progress

To counter common problems in girls' math educations, this game will implement features based on several of the solutions suggested above. These include:

- Evolving, narrative plot

- Score tracking

- Feedback, suggestions, and the ability to "study"

- Cast of female characters

- Presentation of female role models

- Links to interesting math, science, technology activities

- Presentation of science in the real world

- Spatial skills training

- Engaging characters with social interactions

- Diverse cast and character customization

- Creative opportunities

- Stereotype-free

One common problem with edutainment games is keeping players interested and motivating them to play a game through to its ending. A narrative, engaging plot in which the player's progress causes the plot to advance has been implemented to counter this problem. The plot of "Journey to the Stars" sends the player to a research base on the newly discovered and fictional planet Freya staffed by a multiethnic cast of female scientists. The player arrives after an unusual and unexplained accident has caused several problems on the base. In order to return to Earth, the player must help the scientists fix the various problems and help them discover the cause of the accident. The more mini-games the player completes, the more the plot is revealed to the player, thus motivating students to complete all the activities. After completing four initial mini-games in any order, the player is given a

fifth and then a sixth to complete, each followed by a short cut-scene that lead to the conclusion of the game. As mentioned, most of the action will be convey through simple animated cut-scenes, although character interactions will also play a role. The player may also track their scores in the initial four mini-games at any point during the initial stage in order to gauge their progress. Seeing a tangible record of their progress will help players feel as if they are making strides not only in-game but also in their math abilities.

Another common problem is the lack of perscriptive feedback in most edutainment games. In this project, when the player answers a problem incorrectly, a suggestion will be provided to the player, such as "Try writing it down on paper" or "Look at the tips in the Engineer's Notebook for more help". Although this is not terribly specific feedback, it is more helpful to coach players on how to learn from their mistakes than the ever-present "Try again" or "Better luck next time". The player will also have resources for "studying" and additional information through the aforementioned "Engineer's Notebook". One character will have an interactive "book" that will provide common math tips and tricks, information about famous female scientists , a look at popular jobs in science and math, and links to interesting science, math, and technology activities. Through this feature girls will be provided with not only female role models but also information on science outside of the classroom and opportunities for continued research and experimentation. This information will be informative (and hopefully fun) while helping girls realize that they can engage in science and math in many different ways.

The characters are also a very important part of the game. In commercial edutainment games, characters are majority white males, leaving female and non-white players without characters that they can relate to. The cast of "Journey to the Stars" is entirely female and contains a number of different ethnicities. These characters are presented free of typical stereotypes (such as those in "pink" games) and are designed in an age-appropriate manner, making them accessible older "friends" instead of older, harder to reach adults. Since many female players believe that edutainment games do not have enough social interactions, each of the characters "talks" to the player during game-play; many of them have names and each has a different personality. The player is also asked to create a character as the very first stage of the game. Although the cast is diverse, it is unlikely that the player will find a character who is exactly like them. In the character creator, the player is given a base character who looks very similar to the scientists. The player
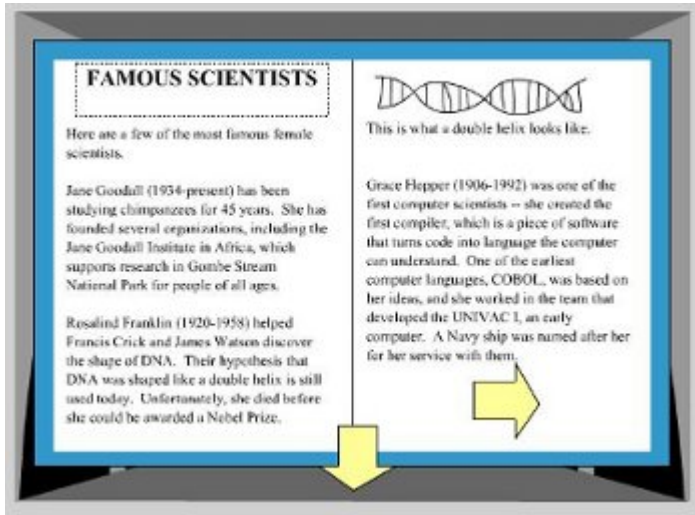
Figure 1: Engineer's Notebook

may then customize this character with four skin tones, twelve clothing colors, two hairstyles in four colors each, and their own name. Although this charcter does not show up during game play, at the end of the game the player is presented with a certificate showing them their character design again.

Several of the mini-games were created to address specific problems. One of these is a game designed to train girls in spatial skills. Boys typically outperform girls in spatial skills tests, and strong spatial skills can be a major advantage in studying math, science, and technology. In one of the initial four mini-games, the player will be shown a folded cube and asked to match it with one unfolded cube out of three to help them visualize better 2D objects into 3D objects. Female players often also complain that there is no oppotunity for creativity in edutainment games; what is provided is stereotypical activities such as dress designing or paint-by-numbers. Originally a mini-game where the player was asked to add components to a robot to carry out a mission was planned to give the player an opportunity for creativity combined with a logic game. However, it was removed from the game later on due to the fact that very little progress had been made on it. There is currently no element to provide creative activities for the player outside of character creation.

At the end of the first quarter, about a fourth of the project has been completed. All the menus, the loading screen, character customization, in-
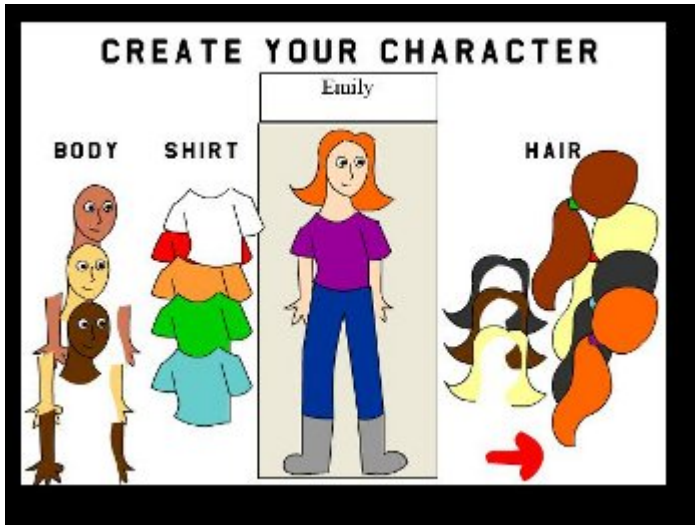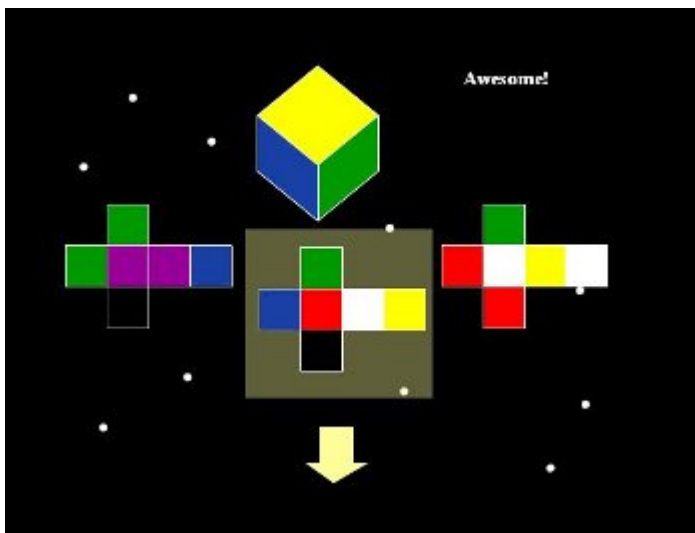
Figure 2: Character customization

Figure 3: Spatial skills game

teractive characters, two mini-games, and the notebook feature are in various stages of completion. In second quarter it is planned to finish the other five mini-games, animate a few cut scenes, and flesh out the notebook feature with some common math tips and links to research and a few girls in math and science websites. To test the program at these stages, the author will play through the game to make sure that all games can be completed and all scenes can be accessed.

In second quarter, over half of the project has been completed. In addition to the features mentioned above two more games (the fifth game is in the debugging stage), two more menus, two more interactive characters, score tracking, a name feature as part of character customization, and about one quarter of the notebook feature's content have been completed. A website at TJHSST.edu has also been created to host the project. In the third quarter it is planned to complete the last three games and animate the cut scenes. There will be four cut scenes – one before the title screen, one after the first five games, one after game six, and one final cut scene.

In the third quarter, this game has almost reached completion. Although the fifth game was removed from the project, the sixth and seventh were completed successfully. There were minor fixes on previously undetected bugs, character identities, and menus. The notebook feature is almost completed and simply needs to have final information included. Unfortunately, no animation was able to be done; however, that will be the main goal for the fourth quarter.

In the fourth quarter, the game was completed. All bug errors were fixed, and simple animated cut-scenes were added to convey the plot. The notebook's content was uploaded successfully, complete with links to science sites for students, biographies of famous scientists, basic math hints, and information of various fields of math and science. The character creation tool was revamped to use mostly buttons instead of all drag-and-drop elements. A final scene was also added where the player was presented with a "Congratulations" screen on which a picture of their character was shown. Since animations were not accompanied by voice-overs, subtitles were added. Also created were several HTML pages to host the game and direct the students, parents, and teachers to their appropriate surveys.

4 Preliminary Testing and Analysis

In order to test the effectiveness of this project, three surveys were created. The first was for students to take before they played the game that was designed to test their confidences and interests in science, math, and technology, as well as their age, what subjects they enjoyed, and what sort of computer games they would normally play. The second was for students to take after they played to guage possible changes in their confidences or interests as well as their response to the content of the game itself. The third was a parent and teacher survey to gather opinions about gameplay, educational value, and any changes in the child's interests and confidences. These three surveys were released through the site SurveyMonkey and linked to from a website previously set up at tjhsst.edu/ eclarke.

A group of 25 third, fourth, and fifth grade girls were selected by Fred Allard, a technology teacher at Cardinal Forest Elementary School in Fairfax County, Virginia, to test this project. Mr. Allard gave his comments on gameplay and educational value over the phone instead of in a survey; sixteen "after" surveys were collected as responses from the students. Unfortunately, the students were only able to complete four "before" survey due to time constraints, so comparison of confidences and interests is difficult. However, with the data collected it is also possible to guage students' preferences in regard to the game to be used in future development. The data given below is where the majority of the responses lie; due to financial constraints this data was not available for download from the site itself.

The four students who completed the "before" survey were all third graders. Three of the students "loved" math, and two of them "liked" science, while they were divided between "liking" and "loving" technology. Three of the students said that they were "great" at math, two of them are "okay" at science, and they were again split between being "okay" and "great" at technology. Three-fourths of the students wanted to keep learning about these subjects across the board. Half of the students identified math as their favorite subject.

Of the sixteen responses on the "after" survey, eleven of them stated that the student "loved" math, eight that the student "liked" math, and nine that the student "liked" technology. Twelve students thought that they were "great" at math, eight that they were "okay" at science, and students were evenly split between being "great" and "okay" at technology. Twelve students wanted to keep learning about math, and eight wanted to keep

learning about technology, while 9 are tentative about learning more science.

Eleven students identified the game as "very" fun, and 12 liked the characters "very" much. Nine said that the game was "a little bit" difficult, with more students saying that it was not difficult than that it was too difficult. This indicates that this difficulty level is appropriate for late elementary school students; however, it could be made a little more difficult to balance out the distribution to create more of a bell curve. The overwhelming favorite game was the simple flash card style game. The favorite character was the doctor character who ran the flash card game, although, interestingly enough, the most common response to "Who was your favorite character?" was "me". This could mean that students are either not identifying with the characters in the game or are empowered by their own abilities and control over design. Only 1 student said that they would not play this game again.

5   Future Development

Based on the data seen above, this game has strong potential for future development due to the overwhelmingly positive response of the students testing the program. One consideration for future development would be the popularity of the flash card game. It would appear from this data that the students enjoy simple games with clear objectives. In future versions the difficulty level would be more fined-tuned to specific grade level objectives, and the player character would show up throughout the game instead of just at the beginning and the end. The lack of confidence and interest in technology was very interesting; future versions of the game would include more technology training to encourage girls in that field as well. A creative game would also be included, as was originally intended in this version of the project. this project is a good base model of an edutainment game, but there is room for future development in terms of what subjects are stressed and what games are the most fun for students to play.

References

[1] "Encouraging girls in math and science:IESpractice guide", Institude of Educational Sciences, 2007.

http://www.braincake.org/files/EncouragingGirls_IES2007–03.pdf
(September 10, 2008)

[2] "Girls' beliefs", Girls in Math and Science Partnership, 2004.
http://www.braincake.org/files/RE_GirlsBeliefs.pdf   (September   10,
2008)

[3] "GMSP stats and data", Girls in Math and Science Partnership, 2007.
http://www.braincake.org/files/GMSP_StatsData.pdf (September 10,
2008)

[4] "Tech-savvy: educating girls in the new computer age", Commission on
Technology, Gender, and Teacher Education, 2000.
http://www.aauw.org/research/upload/TechSavvy.pdf (September 15,
2008)