CaFE Play: A Customizable Mobile Phone Game Framework for Enhancing English Literacy

Senior Honors Research Thesis

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Abstract

English proficiency is an invaluable skill in many parts of the world. It often helps individuals improve their quality of life and contribute more to society. However, for various reasons, many individuals have difficulty learning English, often simply due to a lack of guided practice. To help address this issue, the TechBridgeWorld research group (www.techbridgeworld.org) through their TechCaFE program (http://www.techbridgeworld.org/techcafe/) has developed the CaFE Phone tool: a prototype mobile-phone-based game for enhancing English literacy. The purpose of this thesis is to improve and build upon the game by creating a game customization framework, CaFE Play, which can be used to not only customize the existing game, but also to create other such customizable games. These games should increase the user's motivation to practice English literacy, and thereby better improve the user's English proficiency, a hypothesis that this thesis also aims to test.

Acknowledgements

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English Proficiency

Many people, both within and without the United States, have difficulty with English for various reasons. For example, because of the differences in the grammar and structure of English compared to American Sign Language, many Americans who are deaf or hard of hearing lack proficiency in English. The median reading level of deaf high school graduates is that of a fourth grader (1).

Another group that tends to have difficulty with English is the refugee population within the United States. Many refugees arrive in the United States with nothing more than the clothes they are wearing. They receive help to meet their immediate needs, but are usually given one year to become self-sufficient (2). During this period, they are extremely busy and many lack the time to receive formal English language training, but knowledge of the English language would be one of the most valuable skills for helping them adjust and become self-sufficient in their host country.

Improved proficiency in English would be a major benefit to these and other groups. Perhaps most importantly, it would allow them to find and secure better paying and more enjoyable employment. For example, immigrants who are literate in English are more likely to have continuous employment and earn more than those who are literate only in a language other than English (3). English literacy would also help them socially, by allowing them to make more friends and acquaintances, thereby also providing networking opportunities. They would have the foundation necessary to learn and acquire other skills, both in and out of formal education, and they would be better able to benefit from help offered by others. In general, they would be better able to prosper in society, and, in turn, contribute even more to society.

In order to help such groups, the purpose of this thesis has been to enhance the CaFE Phone mobile-phone-based tool designed for enhancing English Literacy. Mobile phones provide an ideal platform for such an educational tool. They are widely used, and, for many people, they are the only accessible computing technology. Many groups that might be thought not to use mobile phones, in fact, can and do use them. For example, many mobile phone service providers have data-only plans, specifically designed for the deaf and hard-of-hearing (4; 5). Also, many low-income Americans are eligible for a free wireless phone plan and a free phone (6).

Related Work

TechBridgeWorld has created a prototype mobile-phone-based tool, called CaFE Phone, for enhancing English literacy in developing communities. It currently also provides customized content authoring, allowing teachers to create their own questions.

Mobile-phone games are being used elsewhere to enhance English literacy, such as in the Mobile and Immersive Learning for

FIGURE 1. PROTOTYPE CAFE PHONE TOOL

Literacy in Emerging Economies (MILLEE) project, run by Dr. Matthew Kam at CMU. The project uses language-learning mobile-phone games based on traditional rural village games to improve literacy. While the project adapts well to local conditions and cultures, it does not give teachers and students the opportunity to directly customize the games (7).

Game customization frameworks have also been used previously. For example, a group at the Multimedia University in Malaysia created a prototype game customization tool that teachers can use to create educational computer games of certain types that include question content chosen or created by the teacher (8).

The CaFE Play framework builds upon all these ideas and enhances and improves the CaFE Phone mobile-phone tool, increasing control and customization for teachers and students, and including an API that developers can use to create new customizable games.

Customization, Motivation, and Learning

The central way this thesis aims to improve the existing CaFE Phone tool is to introduce more customization and control. Customization and control play an important role in games and learning, as they have a significant impact on effectiveness and motivation. While research has shown that giving learners control over parts of instructional programs has had mixed results on achievement, such control has given consistent, positive results on motivation and user reactions (9). One study by Cordova and Lepper found that giving students control over instructionally irrelevant aspects of a learning activity increases their motivation and learning (9). By creating a game framework that gives students control over various aspects of the game, including their avatar, and allowing games to offer their own customizations based on user interaction, it is our hypothesis that students will show more interest and motivation, and increase their learning. This will also provide another test of Cordova and Lepper's findings, specific to an educational game. Similarly, teacher customization should increase effectiveness by allowing the teacher to target the game for a specific learning activity, and by allowing the teacher to customize the content for the students. The teacher is the education professional, and knows what it best for his or her students. With teacher customizations, a game can be targeted to the level of knowledge of the students, and can be used to practice whatever the teacher is covering in class at the time.

CaFE Play: Framework Design

To enhance the degree of customization in the CaFE Phone tool, we designed and implemented a game customization framework named CaFE Play. CaFE Play makes it possible for developers to create games that give teachers and students customization and control options to increase motivation and improve the effectiveness of the game. The framework is divided into three categories, based on a user's role in the process: Developer, Teacher, and Student.
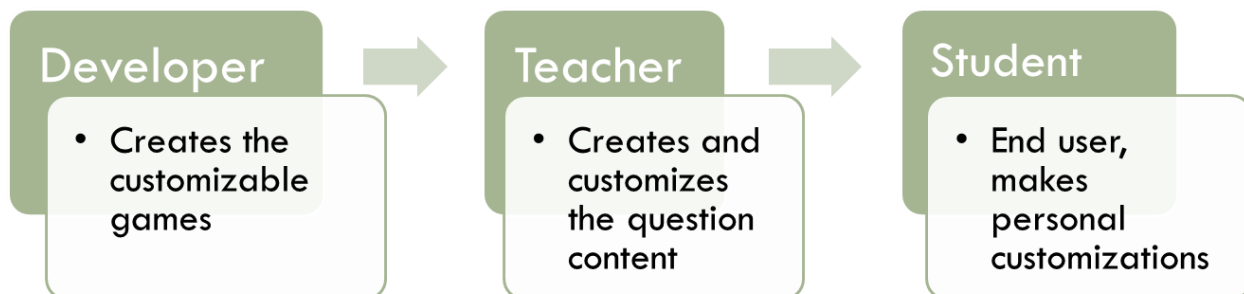
Each role is distinct, and a person in one role can be completely separated from those in other roles. It is possible, for example, for those who are not students, but want to practice English independently, to fulfill the role of student.   They should be able to download a game that a developer created, and download question content that a teacher created, in order to practice English, but without having any personal contact with the developer or the teacher. While this scenario is both feasible and likely, it is not optimal. Developers working in conjunction with teachers and students would be more effective than working independently. Teachers and students know much more about the students' specific needs, interests, and abilities than a developer would. Needs, interests, and abilities of one group of students are also likely to be shared by other students. In the likely case that a developer is creating a game for general use, working with a teacher and a set of students would provide a useful window into the needs, interests, and abilities of a much larger group of students.   More important than the developer's relationship with the teacher and students is the students' relationship with the teacher. The teacher's ability to assist the students can have a significant impact on the students' learning. It has also been shown that being debriefed by a teacher, after playing an educational game is a crucial aspect of a gaming or simulation experience, since it helps in reflection, understanding, and application (9).

The Role of the Developer

The developer uses our Application Programming Interface (API) to create games that are based on the model shown below.   The developer does need to be able to program in Java, but the API documentation and examples should allow someone with somewhat limited Java experience to create a new game for the framework. More experienced Java developers, however, would be able to create more advanced and complex games.

Start-up
- Set options
- Load saved game
- Customize Avatar

Ask Question
Particular to game, or from teacher created content

Shutdown
- User exits
- Game completed

Show Animation
Can include avatar

Depending upon the answer, and optionally randomly, an animation is shown, and game state data is updated.
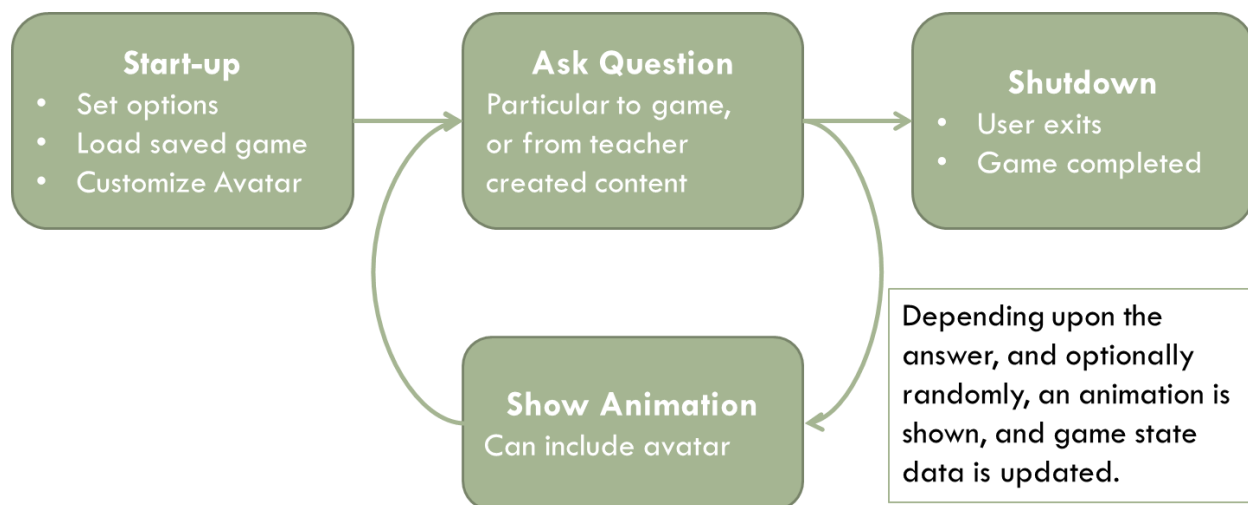
FIGURE 3: GAME DESIGN OVERVIEW

The API includes a standard main menu and standard options. From the main menu, the user can customize an avatar, using a screen that the developer can create using the API. The developer creates question stages, and their ordering, which are shown to the user when the game is started. There are two standard types of question stages that the developer can create: Game question stages and instructional question stages. Game question stages present questions that are particular to the game and are created by the game developer. Depending on the game, this type of question stage could ask questions such as to which player the avatar should pass the ball, or down which path the avatar should walk. Instructional question stages ask questions created by a teacher and are loaded into the instance of the game. The developer has no control over the specific questions asked in instructional question stages. The developer uses the API to create animations that are shown after a question is answered, and depend on the answer the user gave. For an instructional question stage, the developer can create one or more animations for a correct answer, and one or more animations for an incorrect answer. For a game question stage, the developer can create one or more animations for each of the answers. If more than one animation is given for an answer, an animation will be played randomly. After an animation is played, the next question stage is shown. The ordering of question stages is also chosen by the developer, and, similarly to the animations, can depend on the answer given and can be chosen randomly from options given by the developer. In this way, the developer can create a flow of question stages, which could be represented by a directed graph or a flow chart. This gives the developer the flexibility to include other good educational game practices and give the user more control in the way the game unfolds. The game can also be made to update and retrieve game data, such as the current score, the current level, or data specific to the game. Questions and animations can be updated based on the game data.

The Role of the Teacher

The teacher's main role is to create and customize sets of questions to be asked in a game, by using the CaFE Teach content authoring tool. CaFE Teach also lets the teacher specify a question's difficulty level and optionally provide a hint and explanation for a question. The presentation of the questions can be

customized, including ordering (random ordering is also possible), repetition, and whether or not all questions must be asked or only a subset of the questions should be chosen. These options also give the teacher the opportunity to use the game as a testing mechanism, with every student being asked the exact same questions, in the order the teacher specifies.

The Role of the Student

Students not only play the games created by developers with the questions created by teachers, but also exert their own control over the game. At the beginning of the game, the student customizes the avatar, either by selecting a premade avatar, or creating an avatar from composite parts. Depending on the game, the student can also customize the opponent. For example, in a soccer game, the user can select for the avatar a uniform with the colors of the student's favorite team, and select for the opponent a uniform with the colors of the corresponding rival team. Students can also customize game options, including whether or not sounds and animations should be played. Beyond these customizations possible in all games, students will be able to exert control and make customizations unique to a specific game. Developers can make this possible using game question stages and through tracking game data, as explained in the section about the role of the developer.

Implementation Details

Changes were made to the existing game code, which was also split into a general API that developers can use and code specific to the soccer game implementation. The API consists of three main parts: graphical objects, question processing, and game stages.

Graphical Objects

In the previous version of the game, the animations consisted solely of animated GIF files. These were easy to create externally, but any customizations to the animations, including any customized avatar, would require entirely new animations as animated GIF files. In order to allow for graphical customizations to the animations and the avatar, a new implementation was chosen, which includes customizable animations and sprites. Animations are now created using new classes that use LCDUI, a graphics package native to Java ME. Developers can create an Animation object by specifying a background image, and adding moving sprites to the

FIGURE 4: CHARACTER SPRITE IMAGE

animation, which appear and move based on which step the animation is on. The MovingSprite class extends the LCDUI Sprite class, and allows for pre-programmed movement and appearance of the sprite on the screen, in addition to the standard sprite options, such as creating a sprite with multiple frames from a single image.
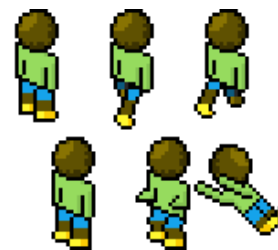
Developers can have the user select an avatar and an opponent, if desired, in one of two ways: Whole avatar selection and composite avatar selection. The developer can offer one or both types of avatar selection. With whole avatar selection, the user selects a complete pre-made avatar, such as the one shown in Figure 3. This is done with a screen similar to the one in Figure 4. With composite avatar

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selection, the user creates an avatar by selecting from various parts. In the example shown in Figure 4, the user can choose a specific head, shirt, shorts, legs, and shoes. The composite parts chosen by the user are added to a CompositeAvatarBuilder object, which keeps track of each part as a separate MovingSprite, but allows for their movement and appearance properties to be modified all together.

Instances of Animation objects can be created by the developer by extending the AnimationBuilder class and specifying the various parameters of the animation objects. Before each animation is played, it is created as a new instance by the AnimationBuilder class, and can differ based on the selected avatar and opponent, and any current game state, such as the level or the number of points.
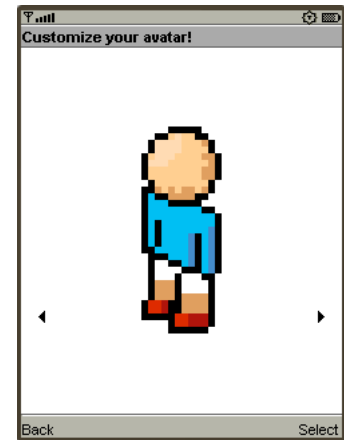

FIGURE 5: COMPOSITE AVATAR SELECTION SCREEN

Question Processing

The question processing that was part of the previous version of the game has been simplified and updated to accommodate the desired customizations by the teacher. Questions and customizations are exported by CaFE Teach as XML files, which are read by the QuestionManager class of the game and stored in QuestionAnswer objects, which are for questions with a written response by the user, and MultipleChoiceQuestionAnswer objects, which are for questions with multiple answer choices. A MultipleChoiceQuestionAnswer object can hold data for various multiple choice question types, including questions that have an image as part of the question, questions that have images as answers, and regular text multiple choice questions. The QuestionManager class now processes the various XML tags and text that specify the customizations chosen by the teacher, as explained in The Role of the Teacher section. QuestionManager can also still process XML files that were created before CaFE Teach was updated for this thesis, allowing for backward compatibility, which assumes default values for unspecified customizations.

Game Stages

The API also includes classes related to stages of the game, including MainMenu, InstructionalQuestionStage, and GameQuestionStage. MainMenu provides a standard main menu that can be shown at the beginning of the game, and when the user returns back to the main menu while playing the game. The developer needs to extend the MainMenu class to allow for any desired avatar and opponent selection and to create the stages of the game and specify their flow. The two types of stages of the game are InstructionalQuestionStage and GameQuestionStage, which are explained in the section The Role of the Developer.

Testing and Evaluation

The framework was tested at the Western Pennsylvania School for the Deaf, where seven students in the eighth grade were able to play two games created within the framework: an updated soccer game, and a mage fantasy game, which was created by Wennie Tabib. Both games were very simple, offering

avatar customization, and consisting of one Instructional Question Stage, meaning that only questions created by the teacher were asked. The Instructional Question Stage had one animation for a correct answer and one animation for an incorrect answer. The main design difference between the two games was that the soccer game also allowed the opponent to be customized. The games used questions created by the teacher and some questioned added by myself, all of which were related to verbs, including subject-verb agreement and verb tenses.

FIGURE 7. SOCCER GAME WITH CUSTOMIZED AVATAR AND OPPONENT

FIGURE 6. SCREEN SHOTS FROM THE MAGE FANTASY GAME

Testing Design

Testing was divided into two phases. For the first phase, students took a pre-test and were given a chance to play the game in class on mobile phones provided by TechBridgeWorld. They then took the phones home with them over their spring break. For this phase, the students were divided into two groups. The students in one group were able to choose their avatars for the games, while the students in the other group were assigned avatars for the games. For the spring break testing, the soccer game had a bug, which made it so that the user could try to select an avatar and an opponent at the beginning of the game, but the avatar and opponent in the actual animations were both one specific character, no matter what the student had selected. This bug, however, does not seem to have made a significant difference in the results. After Spring Break, another test was given, followed by the second phase of testing, in which all students were able to choose their avatars for the games. This phase consisted of four days of in-class testing, and a post-test.

Testing Goals

One purpose of the testing was to examine what effect the avatar customization had on the motivation of the students to play the game. In order to discover how motivating a game is, and how much the user wants to play it, the actual usage needs to be examined. This is much more effective than asking subjective questions to the users about how much they liked the game (10). Because of this, the games

were made to track usage data, including how long each game was played and how many answers overall were given to the questions. By collecting this data, and by giving only half the students avatar customization over spring break, we were hoping to be able to determine the effect, if any, that avatar customization had on the desire of the students to play the game, especially in their free time.

Another purpose of the testing was to determine the effect the game and the avatar customization had on the students' achievement. The pre-, mid-, and post-tests, which were written by the teacher, were given to help us determine this. Each test had 15 questions related to verbs. In the pre-test, each question had two answer choices. In the mid- and post-tests, each question had three answer choices. The mid- and post-tests were very similar to each other and covered the same material, while the pre-test was different and seemed to be slightly easier than the mid- and post-tests. The results of these tests can be compared across the two groups for the spring break phase.

The final purpose was to gain general feedback from the students and the teacher about the games. After the testing, the students were given a feedback questionnaire, wherein they were asked how much they enjoyed the games, how much they liked the avatar customization, what they liked and did not like about the games, and if they had any suggestions for us. A copy of the questionnaire is included in the appendix. In addition to the feedback from the students, the teacher also answered feedback questions.

Testing Results

Statistical analysis of game usage data and impact on student achievement was largely inconclusive, due, in part, to the small number of participants. In the end, only seven students used the game. One other student, who had class at a later time than the other seven students, was not shown how to use the game, did not use the game over spring break, and was not able to use the game after spring break. Despite the small sample size, however, it is still worthwhile to examine the results of the testing.

Effect of Avatar Customization on Motivation

The purpose of giving the students the games over spring break was to examine how much the students used the games in their free time. However, over spring break, only three of the students used the games. A summary of the usage by the three students over spring break is below:

TABLE 1. GAME USAGE OVER SPRING BREAK

Phone ID	Avatar Selection	Soccer Game		Mage Game	
		Time in Game	Answers Given	Time in Game	Answers Given
3	No	0 s	0	5 min 53 s	0
5	No	8 h 40 min 3 s	226	0 s	0
8	Yes	34 s	2	1 min 11 s	4

It should be noted that the time in game does include time in which the game was not being used. With

phone 5, during one use of the game over spring break, the game was on for 7 hours and 29 minutes, during which time 43 questions were answered. On the other hand, one use of the game on phone 5 lasted 32 minutes, but 160 questions were answered.

Because of the low usage overall, no statistically significant correlation between avatar customization and game usage can be determined. The only apparent conclusion to be gathered is that, for these students, avatar customization by itself did not increase the students' motivation enough to make them want to play the games in their free time over spring break. This does not mean, however, that the avatar customization, and, by extension, other customizations in general, do not increase the users' motivation to play the games.

Effect on Proficiency

Because each phase of testing was proceeded and followed by a proficiency test, we can try to ascertain some sense of the effect of the games and their avatar customization on proficiency. From the first phase, we can try to determine not only how using the game, but also how avatar customization, affected. The following graph shows the improvement in score between the pre-test and the mid-test for each student, based on how many answers the students gave in the games during Phase 1. The students are divided into those who had avatar customization and those who did not:

TABLE 2. PHASE 1 PROFICIENCY IMPROVEMENT
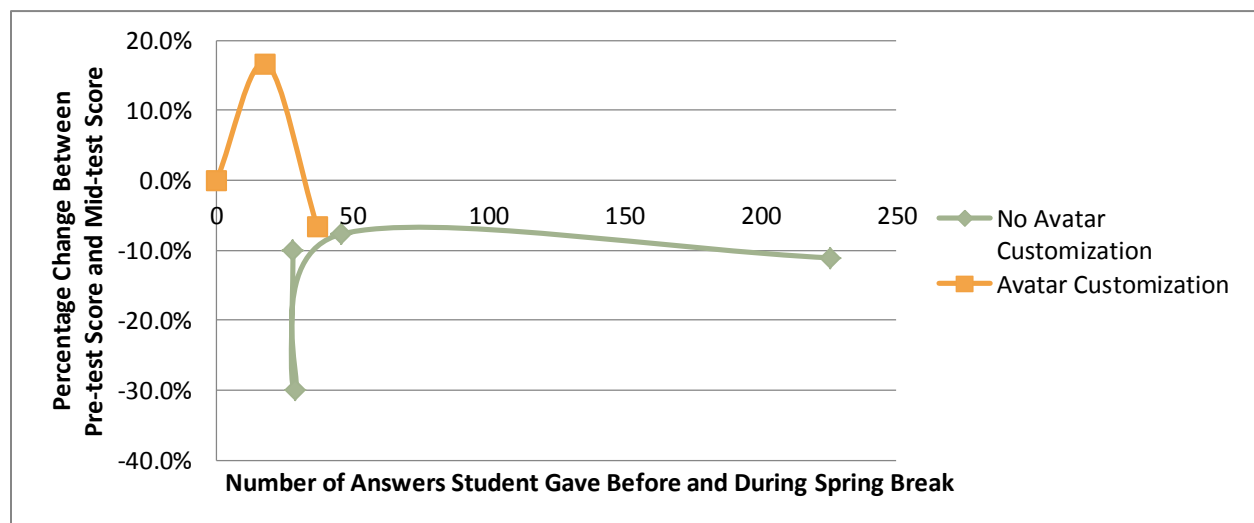
The number of answers given in the graph is likely to not be completely accurate. It includes answers given when the games were introduced to the students in class. The games at that time had a bug in which a certain question was not being read from the question file correctly, causing the game to crash. When it did this, the game was not able to record usage data for that session of use. Because of this, the students most likely gave more answers than were recorded. This bug was fixed before the students took the games home for spring break, so the usage data over spring break should be accurate.

From this graph, it is noticeable that those who did not have avatar customization saw their test score decrease between the pre-test and the mid-test. Those who did have avatar customization saw their

test scores stay the same, increase, or decrease no worse than the other group's scores decreased. The mid-test seemed to be more difficult than the pre-test, which would explain why most scores decreased. The data suggest that having avatar customization, and by extension any customization, improves proficiency, but because of the small sample size, that conclusion cannot be statistically proven.

From the second phase of testing, we can similarly look at improvements in test scores between the mid-test and the post-test for the six students who were in class to take the post-test:

TABLE 3. PHASE 2 PROFICIENCY IMPROVEMENT
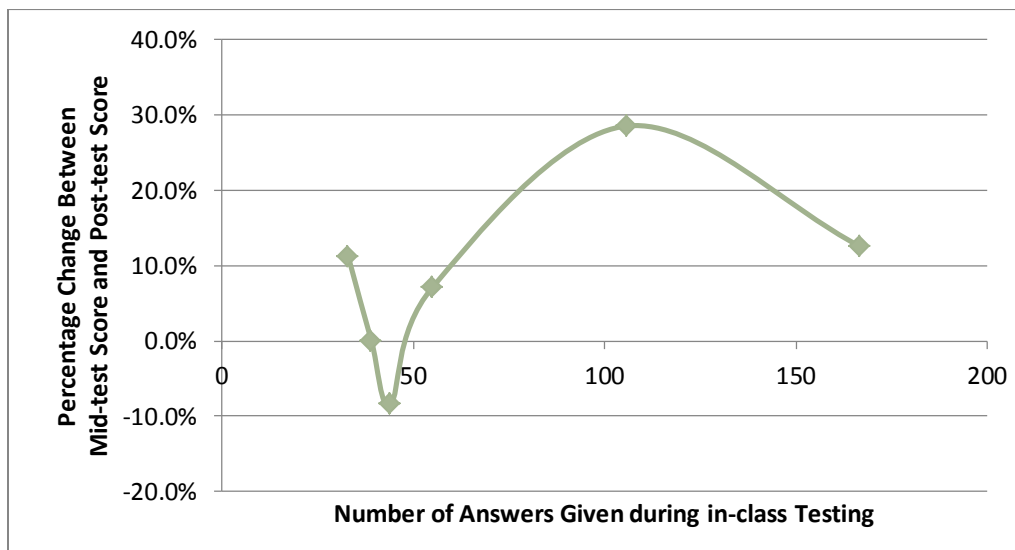
Overall, proficiency scores improved during the second phase. During the second phase, in addition to practicing by using the phone games, the students also received related lessons in English class. Because of this, the increase in proficiency would be due at least partially to those lessons, but the practice the students received by playing the phone games also seems to have helped. Overall, the more answers a student gave while playing the game, the more their proficiency score improved. Once again, because of the small sample size, this cannot be proven statistically.

Subjective Feedback

Even though statistical results were largely inconclusive because of the small sample size, we did receive subjective feedback from the students, the teacher, and the developer of the fantasy mage game, Wennie Tabib.

Student Feedback

Six of the students completed a feedback questionnaire when the testing was over. The questionnaire consisted of five questions requiring an answer on a scale of 1 to 10, and five open-ended questions. Here are the results for the first five questions:

TABLE 4. RESPONSES TO QUESTIONNAIRE

Question	Average Response
How much did you enjoy the soccer game?	7
How much did you enjoy the mage game?	9.2
How much did you enjoy being able to select your avatar at the beginning of the game?	9.2
How much did being able to select your avatar make you more interested and excited to play the game?	9.2
How much did playing the games help you practice and learn English grammar?	9.2

In addition to these responses, which affirmed the usefulness of the game in general and the avatar selection, the answers to the more open-ended questions also provided useful insight. Three of the students commented that either there was not enough user control or that there should be more user control. They were specifically referring to the fact that you cannot control the avatar in the animation, which, as the framework is now, cannot be done in real-time while the animation is being played. Such a level of control every time a question is answered may not only be distracting from the question content, but separates the answer to the question from its result. Even then, however, it might useful to implement such control in at least some form in the future. In any case, the fact that the students mentioned this not only shows the importance of control and customization in these games, but also the need to create games that more fully take advantage of the other customization and control capabilities of the CaFE Play API.

Teacher Feedback

In creating the questions for the second phase of testing, the teacher at the Western Pennsylvania School for the Deaf used the updated CaFE Teach, the online content authoring tool. After testing was completed, she answered some feedback questions. Here are some aspects of CaFE Teach that she liked:

- Straightforward and simple interface
- Ability to specify difficulty level of the questions
- All the teacher customization settings
- Easy to use buttons

She did have some suggestions for improvement, including changing the terminology for question types. She suggested changing the term "Writing Questions," since she normally thinks of writing as compositional writing or creative writing. A more appropriate term might be "Fill-in-the-blank Questions." She also found the term "pre-defined answer categories" for multiple choice questions to be confusing. She suggested using a term such as "closed-set answers."

In addition to finding CaFE Teach to be a very good tool, she liked using CaFE Phone in the classroom. She also "love[d] the avatar idea." For her students, using CaFE Phone for the first five minutes of class helped them focus on English, and she wrote that the students really liked the tool. They felt that the tool helped them learn verb grammar, which was normally hard for them to learn.

The teacher also had some general ideas to improve the games. For example, the students could earn a jewel for certain accomplishments, and then use jewels to buy clothes or other items for the avatar. An experienced developer using the CaFE Play API could implement a game with such a feature. She also suggested offering downloadable updates to the game, such as adding holiday items that could be bought for the avatars during the holiday season.

Developer Feedback

Wennie Tabib, who created the fantasy mage game using the CaFE Play API, also provided some feedback. She found that the API was able to do everything she wanted to do in her game, and she liked the modularity of the API. She did find, however, that the documentation of the API was sparse, and she did encounter a bug in the API while using it. These problems were due to the fact that the API was not entirely complete, had only some documentation, and was largely untested. She also suggested having more examples that use different capabilities of the API, in order to give developers a better idea how to use it.

Conclusion

The limited customization and control offered to the students in testing does seem to have shown a positive influence on students' motivation and learning, or, at the very least, the students enjoyed the new capabilities. They liked being able to customize their avatars, and found the game useful for practicing English. The teacher in the testing not only liked using the CaFE Phone tool in class, but found the CaFE Teach tool useful for creating and customizing the question content. Wennie Tabib, who developed the fantasy mage game, found the CaFE Play API capable of doing what she wanted her game to do.

As indicated by the results and feedback on customization, new games that more fully take advantage of the customization and control capabilities of the framework should better motivate students and help them learn. New game themes should also be developed, giving students more options. Some ideas for new game themes given by students at the Western Pennsylvania School for the Deaf include skateboarding, basketball, shooting, racing, platform games, war, and kickball. With new game themes, especially ones that allow more customization and control, the CaFE Phone tool should be tested again, hopefully with more participants and over a longer period of time, in order to determine the effectiveness of the tool and the framework, and the effectiveness of customization and control in general.

Works Cited

1. *How Do Profoundly Deaf Children Learn to Read?* **Goldin-Meadow, Susan and Mayberry, Rachel I.** 4, Learning Disabilities Research & Practice, Vol. 16, pp. 222-229. http://idiom.ucsd.edu/~rmayberry/pubs/GoldinMeadow-Mayberry.pdf.

2. **U.S. Committee for Refugees and Immigrants.** Refugee Resettlement. [Online] [Cited: March 15, 2011.] http://www.refugees.org/our-work/refugee-resettlement/.

3. **Burt, Miriam.** Issues in Improving Immigrant Workers' English Language Skills. *Center for Adult English Language Acquisition.* [Online] December 2003. [Cited: March 15, 2011.] http://www.cal.org/caela/esl_resources/digests/workplaceissues.html.

4. **Sprint.** *Sprint Relay Store.* [Online] [Cited: March 15, 2011.] http://www.sprintrelaystore.com/.

5. **AT&T.** Text Accessibility Plans for iPhone®. *Wireless from AT&T.* [Online] [Cited: March 15, 2011.] http://www.wireless.att.com/learn/articles-resources/disability-resources/text-accessibility-plan-for-iphone.jsp.

6. **SafeLink Wireless.** Lifeline/SafeLink Fact Sheet. [Online] [Cited: March 15, 2011.] https://www.safelinkwireless.com/EnrollmentPublic/benefits.aspx.

7. Mobile and Immersive Learning for Literacy in Emerging Economies (MILLEE). *Human Development Lab @ Carnegie Mellon University.* [Online] [Cited: May 4, 2011.] http://www.cs.cmu.edu/~mattkam/lab/millee.html.

8. *The Implementation of Framework for Edutainment: Educational Games customization tool.* **Embi, Zarina Che.** 2008, ITSim 2008 International Symposium on Information Technology, Vol. 1, pp. 1-5.

9. *Games, Motivation, and Learning: A Research and Practice Model.* **Garris, R., Ahlers, R. and Driskell, J. E.** 4, 2002, Simulation and Gaming, Vol. 33, pp. 441-467.

10. **Schell, Jesse.** *Phone Interview.* November 18, 2010.