The EduFrag Project in Physics: Educational Gaming Applied to Freshman Physics Using First-Person Shooters

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Contents

1 Acknowledgments

I would like to thank my advisor, Professor Bradley. Without him, I would never have been introduced to the EduFrag concept, and would not have had the chance to work on this project. I would like to thank my mother, who has always believed in me and who has helped me in more ways than I can count, with more things than I can think of. Lastly, I would like to thank my fiancé, Hal, just for being himself.

Abstract

This project has generated pilot data examining the effectiveness of game-based learning as reported by students. Students from a calculus-based Newtonian physics class who chose to participate were asked to take an on-line quiz, and to test an educational version of Unreal Tournament. After testing both methods, students were surveyed about the effectiveness of each method. The two method have the same questions in the same order. This will examine whether encountering the material in the game format results in any measurable difference in subjective learning. Survey results, and student comments, indicate that students felt that the game had significant room for improvement.

2 Introduction

The idea behind this experiment is that there exist basic concepts in physics which students must internalize in order to fully grasp the subject matter. A question which arises is, "What is a good way to get students to learn these concepts?" Various study methodologies (such as using flashcards) revolve around the idea of real-time reinforcement of concepts. These methodologies revolve around the concept that real-time reinforcement/correction is better than delayed reinforcement/correction, and so the student will better remember the material when he can find out whether he was right or wrong right away, rather than having to wait until he or she has answered other questions and/or done other things. This game provides real-time reinforcement of concepts, in that, if a student provides an incorrect answer, he or she is teleported back to an initial point in the game that has the correct answers.

3 Procedure

The educational version of Unreal Tournament was given to participants with physics maps. These maps are in the form of a maze. A participant's game character starts in the initial room (hereafter known as the "study room") and from there moves to the teleporter that will teleport the character to the first room in the maze. In this room, there are four teleporters, each in the form of a wall containing a piece of physics information. One of the pieces of physics information is correct, and the other three are incorrect. If the participant moves his or her character through the teleporter that has the correct piece of information, the character will be teleported to the next room in the maze. If the participant moves his or her character through a teleporter that has an incorrect piece of information, the character will be teleported back to the

beginning of the maze. The character will move through the maze in this way until the character is able to identify each piece of correct information and walk through the appropriate teleporter for that piece of information. When the character has moved through every room in the maze this way, the character will be transported to the final room, which will have no physics information, and that will constitute finishing the game.

In addition to testing the game, the participants also took an online quiz. This quiz has 20 questions, with four choices per question. One choice is correct, and one choice is incorrect. The information presented is in the same order as it appears in the game. This quiz is also be similar to the game in that if a participant chooses the wrong answer, the participant must start the quiz over from the beginning. This is to eliminate the question of whether it is the repetition which causes effectiveness, rather than the game environment. The quiz has advantages over the game in that it is possible to take data down about how many times a participant has to start over, which question cause the greatest number of restarts, and how likely a participant is to get a question wrong which the participant previously got right, all of which are information that a teacher may find useful to know for developing future game quizzes. Answering the final question correctly will send the participant to a page which will let him or her know that the quiz is finished.

4 Question Creation

The questions were created by taking formulas from a freshman physics textbook from within the chapters covered by a freshman Newtonian physics class, as indicated by the syllabus.

5 Map-Creation Process

5.1 Background

One major part of this project has been to streamline the map-making process. The map-making process has already been vastly simplified by other contributors to the EduFrag project.

When the EduFrag project was started, the map-making process involved creating each room individually, and setting up all of the details (start points, lights, teleporters, etc.) of each room individually. Particularly, each picture has to be placed on the appropriate wall individually, and the appropriate teleporter has to be associated with each picture. This was very time-consuming.

5.2 Prior Work

This was made easier by an improvement made to the EduFrag project such that there is a precreated map. All that is required is to create images, name them appropriately, import them into the game's editor, and save them correctly. This is a marked improvement, because it means that anyone can make new maps by simply making new pictures, without having to understand how to create maps from scratch using the editor.

This improvement speeds things up considerably, but it still requires that each question be created and named individually, generally requiring a graphics program to crop the image to the correct size (256x256). For 20 rooms with four images per room, this means creating 80 images, which is, itself, time-consuming.

5.3 Current Progress

Thus, the next issue which needed to be tackled was the image-creation process. As previously stated, the images must be bitmaps which are 256 pixels wide, 256 pixels tall, and 256 colors. Images do not grow this way in the wild, so some tinkering is required to get them into this form. The images created for this project all use LaTeX for the initial formatting, because they are all equations. The question then becomes: What is the best way to take a LaTeX file and turn it into a set of 256x256 images, in 256 colors, named according to a certain scheme?

The best way that has been found so far is to use Python and Perl scripts, which were created and/or edited for this very purpose in the course of this project. The first step is to take the LaTeX file and turn it into a bmp of the appropriate size. This script is a Python script, named tex2bmp.py, and it is a modification of Richard P. Muller's program tex2gif.py. The first change to this program is that is turns the file into a bitmap instead of a gif file. It then reduces the image to 256 colors.

The previous script is called by another script, which is a Perl script named mkquests.pl, which, for each line in the LaTeX file, calls the Python script to create the image, and passes this script a name to name the images $q_i, i = 1 \ldots 80$. There are 80 of them because there are 20 quiz rooms with four images in each room. The number of questions is easily modifiable.

The next script used is rename.pl. This script takes the images output by the previous script and renames them using the naming scheme required to put the images into the map. This script renames both the false and the true images correctly, provided that the equations were written in the correct order in the LaTeX file. The limitation of this program is that the questions must be written such that they follow a pattern of one correct answer followed by three

false answers. This worked well wth the way that images were created for this project, because the images were created in sets of four, with one true equation followed by three similar false equations.

One drawback to this process is that tex2bmp.py has only been tested on Linux so far, and will not work under Windows without a variety of things which do not come standard with Windows, including Perl, Python, and the ImageMagick libraries, among others. This program can be run under CygWin, provided that all of the required programs are present.

The next step in the map-creation process is to move the images to a machine that is running Windows, because the map editor will only run under Windows. The images must be imported into the texture editor by the following process: First, the Quiz.utx file, which is already set up in the format required to put the images into the map, is opened, and all of the images created by the scripts are imported. Next, the texture file must be saved from within the texture editor, not using the general save option for the editor, and then the texture file will be ready for use with a map.

6 Web-Quiz Creation Process

The first step to creating the Web quiz was to create a registration page for it. This allows for information to be gathered about the students who attempt the quiz, such as what level of physics they have had, and to keep track of their gameplay over time to see if it improves. This information all goes into an SQL database.

The Web quiz that was used is in the form of a Web page with four pictures on it, each picture containing a piece of physics information. The pictures are in the same format as in the game, and are in the same order. Thus, the pages are set up to choose the pictures from a directory based upon the filename.

In order to keep students from learning the layout of the information rather than learning the material, the Web quiz was set up to display the pictures randomly, that is to say, while the same four pictures will occur each time a particular question is presented, the position of those four pictures on the page will be random

Another thing which was done to keep the students from using something other than the physics information to answer the questions was to disguise the URL which appears when the mouse is over an answer so that students cannot simply avoid choosing an answer which leads back to the initial page. The URL for each answer ends with $p = i, i = 0, 1, 2, 3$. Also included in the URL is a number, b, which, when taken modulo four, gives the rotation offset of the correct answer. Thus, the position of the correct answer on the page is always $4 - (b \pmod 4)$.

7 Survey

7.1 Initial Survey

After testing both the game and the Web quiz, students were asked to take a survey about their experiences with them. The survey contained the following questions and answer options:

Username for the Web quiz This was an open-ended question.

The number of times you have played the EduFrag Project in Physics video game: Never, Once, 2-5 Times, 6-10 Times, 11+ Times

The number of times you have played the EduFrag Project in Physics Web quiz: Never, Once, 2-5 Times, 6-10 Times, 11+ Times

Rate the EduFrag Project in Physics video game: This was on a scale from 1-10, where 1 was Not Enjoyable, 5 was Somewhat Enjoyable, and 10 was Very

Enjoyable

Rate the EduFrag Project in Physics Web quiz: This was on a scale from 1-10, where 1 was Not Enjoyable, 5 was Somewhat Enjoyable, and 10 was Very Enjoyable

State: The answer options for this were a dropdown list of states, as well as the District of Columbia, and an option for those not in the United States.

Grade Level: Prior to high school, High school Freshman, High school Sophomore, High school Junior, High school Senior, College Freshman, College Sophomore, College Junior, College Senior, Graduate Student, Other

Physics Level: None, Non-Calculus-Based, Calculus-Based, Advanced, Other

Is this game something you would use as a personal study aid: Yes, No

Would you use a similar game to study for other subjects: Yes, No

Additional Comments: This was an open-ended question.

7.2 Second Survey

An attempt was made to get more data from the students by asking them to take a second survey, which contained the following questions and answer options:

Username for the Web quiz: This was an open-ended question.

How much did you feel that the EduFrag Project in Physics video game helped you learn: This was on a scale from 1-10 where 1 was Not Helpful, 5 was Somewhat Helpful, and 10 was Very Helpful

How much do you feel that this type of game would help you learn physics: This was on a scale from 1-10 where 1 was Not Helpful, 5 was Somewhat Helpful, and 10 was Very Helpful

8 Test Subjects

The test subjects for this project were a group of advanced-placement physics students at Stamford High School in Stamford, Connecticut. The teacher for this class agreed to allow the students to test the game and the Web quiz during classtime, and to take the survey during classtime. The data provided by these students in the two surveys given was the only data used for this project. Nine students took the first survey, and three took the second survey.

9 Results

9.1 Survey One Numerical Results

The first question that arose about the data was whether the two samples come from the same distribution. To test this, a Kolmogorov-Smirnov test was done. The test result was 0.98. This indicates that the hypothesis that they come from the same distribution should be rejected.

Next, the means of both distributions were analyzed. The mean rating of the game was 3.22. The mean rating of the Web quiz was 3.78. This would tend to indicate that the students preferred the Web quiz to the game.

The median of both distributions was three. This indicates that for both the game and the Web quiz, roughly half of the students gave a rating above three, and roughly half gave one below three.

9.2 Survey Two Numerical Results

The mean rating for how much the students felt that the EduFrag Project in Physics helped them learn was three, and the mean rating for how much they feel that this type of game would them learn physics is 3.7.

9.3 Survey One Comments

One question on the survey asked students to provide general feedback about the game. Students left comments of varying lengths, the general thread of which was that the students would prefer that the game be more thrilling somehow.

One student suggested, "Give the game more challenge and most of all big guns." Another said, "Instead of resetting to the beginning of the game, I would rather die in the game by falling into a pit of water, or by being attacked by angry aliens." These are issues which can be resolved by using a map in the full version of the game, rather than the educational version. The full version of the game allows the freedom to use guns, to play against bots, or other players, and to have the character die in various interesting ways.

Another prevalent topic was that going back to the beginning each time a wrong answer was chosen is tedious. Particularly when in the later rooms, students would have preferred to have had some sort of checkpoint, so as not to have had to go back as far each time.

Two of the students also suggested other educational games, such as Math Blaster, or Reader Rabbit, as more effective versions of the educational-gaming concept.

10 Conclusion

There is obviously room for future work in this vein. In the future, more work should be put toward integrating the educational part of the game with more features that are exciting, and that will draw students more into playing the game, as opposed to simply being a quiz to run through.

Also, it would be good to see results from a larger sample group, and from a variety of levels of students, as opposed to the current results, which are only

from high-school students.

References

[1] http://edufrag.blogspot.com/

[2] http://edufrag.wikispaces.com/

[3] Bradley, J.-C.; Lucci, A. and Thaker, Y. *New Approaches to Games for Learning Organic Chemistry*

[4] Squire, K. *Changing The Game: What Happens When Video Games Enter the Classroom?*

[5] Squire, K. and Jenkins, H. *Harnessing The Power Of Games In Education* 2003

Figure 1: This is a picture of the first page of the Web quiz.

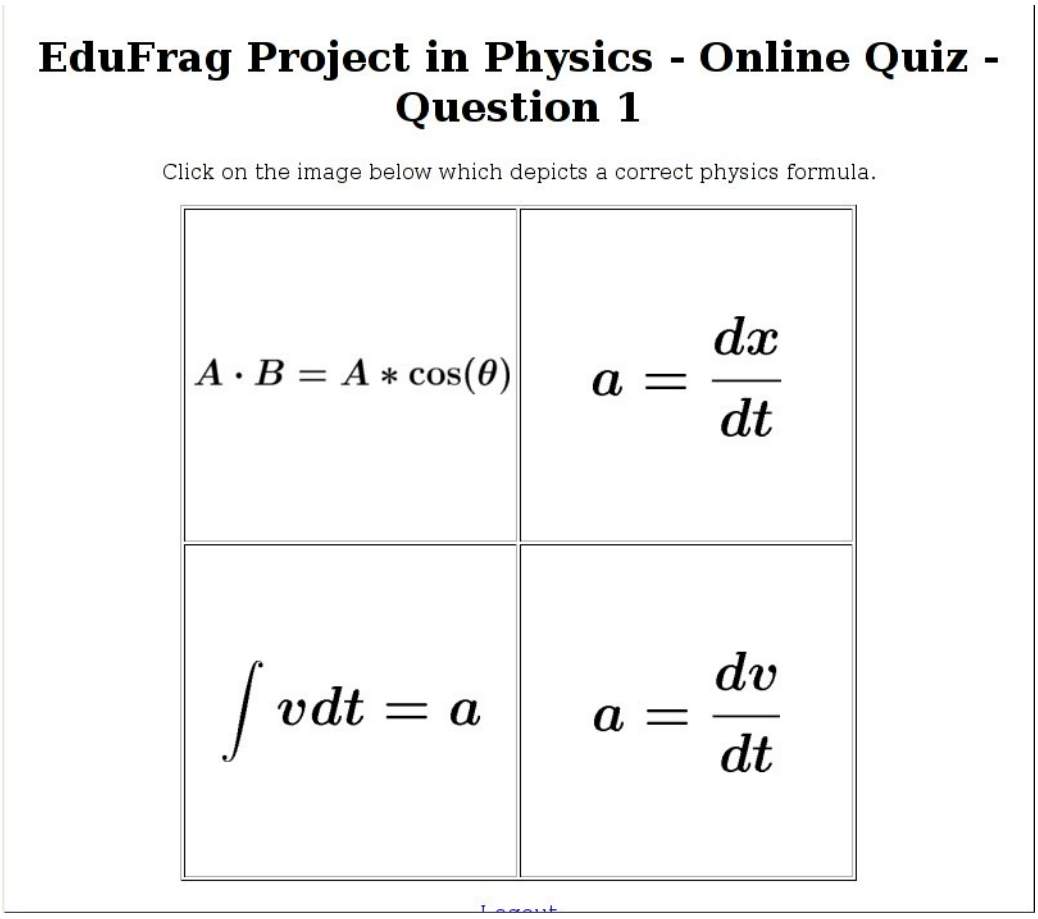
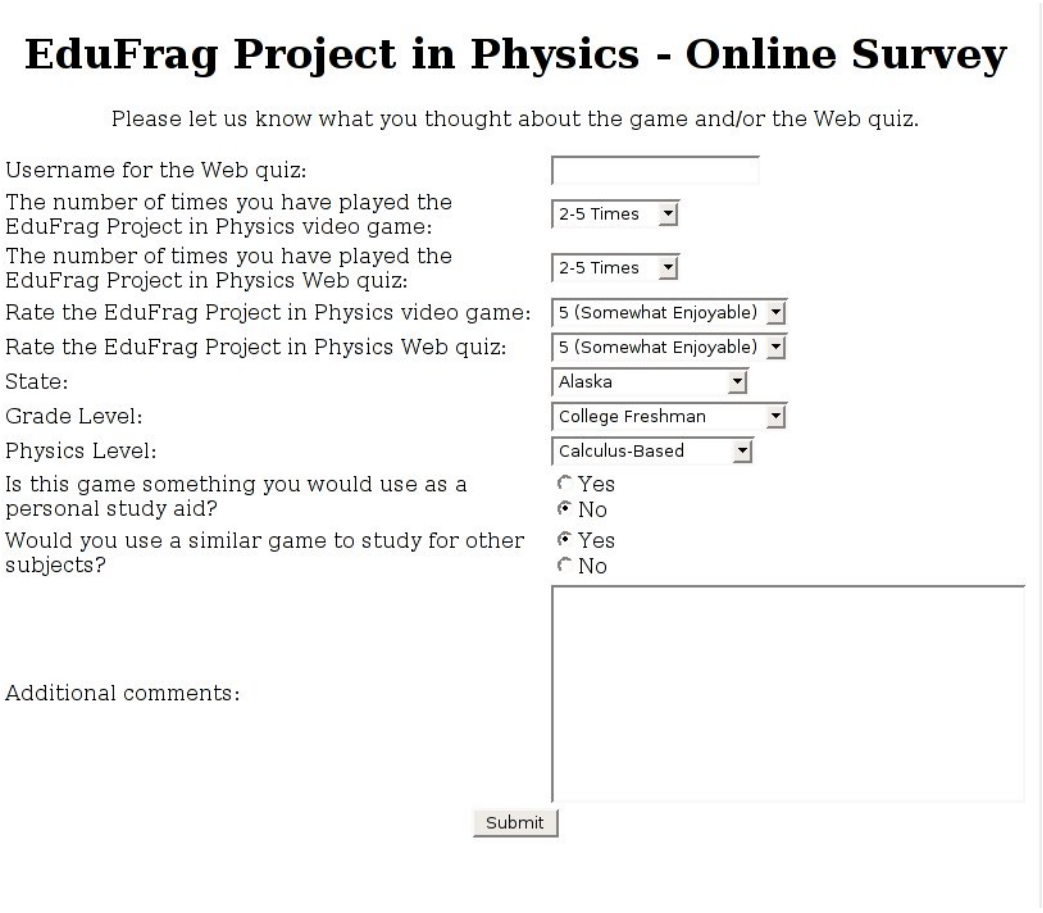


Figure 2: This is a picture of the first survey.



EduFrag Project in Physics - Online Survey

Please let us know what you thought about the game and/or the Web quiz.

Username for the Web quiz:	
The number of times you have played the EduFrag Project in Physics video game:	2-5 Times
The number of times you have played the EduFrag Project in Physics Web quiz:	2-5 Times
Rate the EduFrag Project in Physics video game:	5 (Somewhat Enjoyable)
Rate the EduFrag Project in Physics Web quiz:	5 (Somewhat Enjoyable)
State:	Alaska
Grade Level:	College Freshman
Physics Level:	Calculus-Based
Is this game something you would use as a personal study aid?	○ Yes ◉ No
Would you use a similar game to study for other subjects?	◉ Yes ○ No
Additional comments:	

Submit

Figure 3: A histogram of the survey results for the question, "Rate the EduFrag Project in Physics game"

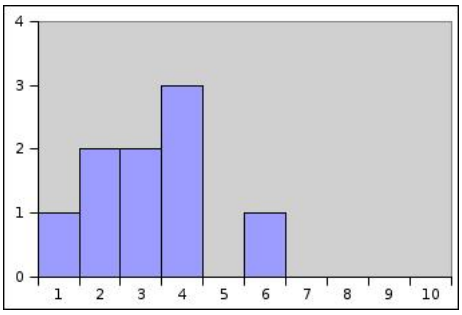


Figure 4: A histogram of the survey results for the question, "Rate the EduFrag Project in Physics Web quiz"

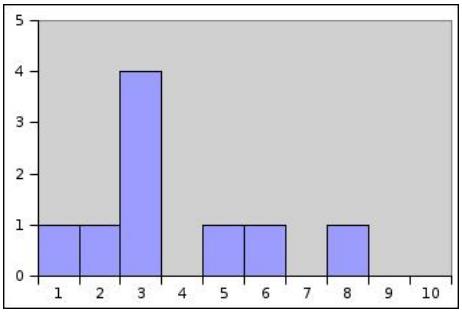


Figure 5: A histogram of the survey results for the question, "How much did you feel that the EduFrag Project in Physics video game helped you learn?"

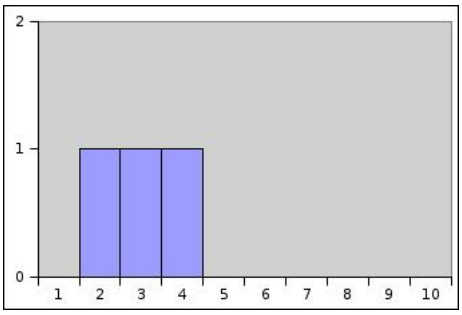


Figure 6: A histogram of the survey results for the question, "How much do you feel that this type of game would help you learn physics?"