Using the Virtual World of Second Life to Create Educational Games for Real World Middle School Science Classrooms

Tessa L. Cooper
College of Engineering
Ohio University
United States
tessa.l.cooper.1@ohio.edu

Stephen P. Carroll
College of Engineering
Ohio University
United States
stephen.p.carroll.1@ohio.edu

Dr. Chang Liu
College of Engineering
Ohio University
United States
liuc@ohio.edu

Dr. Teresa Franklin
College of Education
Ohio University
United States
franklit@ohio.edu

Dr. David Chelberg
College of Engineering
Ohio University
United States
chelberg@ohio.edu

Abstract: Educational video games are an effective medium for teaching in modern middle school classrooms. The Science and Technology Enrichment for Appalachian Middle-schoolers (STEAM) project at Ohio University has developed multiple computer games in Second Life to provide a more enjoyable learning experience. This paper is a report on development issues, effectiveness, and future suggestions for using Second Life in the classroom. Three games are discussed in detail to address development time issues, game components, costs and general game development in Second Life. After introducing these games, an analysis is given on the impact these educational games had on 7th and 8th grade middle school students. Next, a section is provided which contains suggestions for continued implementation of Second Life educational games in middle school classrooms. Finally, a conclusion section is devoted to discussing the effective use of Second Life educational games in modern classrooms.

Introduction

One of the challenges facing middle-school teachers is adapting lesson plans from the past into effective solutions that appeal to current students. The PEW Internet & American project in 2008 showed that 97% of all American children aged 12-17 years old play some form of digital games. Therefore, integrating video games into the classroom may be an effective means of improving teaching of science (Smearcheck, Franklin, Evans & Peng 2008). The Science and Technology Education for Appalachian Middle Schools (STEAM) project at Ohio

University was funded by the National Science Foundation (NSF) GK-12 program to improve graduate student and middle-schoolers education. The project was founded at Ohio University in 2006 and is scheduled to last until June of 2009. STEAM centers around the graduate students of Ohio University working with Appalachian middle-school science teachers to create educational games targeted at specific hard-to-teach concepts. The teachers are considered the content-experts while the graduate students are the technology-experts. The graduate students gain valuable experience in working with modern technologies. STEAM has created numerous games in Adobe's Flash, STEAM's in-house game engine STEAMiE, and Linden Lab's Second Life. The graduate students from Ohio University have a background of engineering allowing them to quickly ascertain and surmount the challenges that arise in creating computer games. In addition to gaining technology expertise, the graduate students gain valuable information about teaching in a middle-school science classroom by spending 10 hours a week in the classroom. In return, it is STEAM's goal to instill a burning desire to learn and improved interest in science among middle-school children. To accomplish the above tasks, STEAM has chosen Second Life as one of its key development platforms.

Second Life was chosen by STEAM as a development platform for its ease of use, inexpensive development costs and existing development framework. According to previous research done by STEAM, Second Life is an effective medium for creating education games that are deployed in middle-school classrooms (Bilyeu, Liu, Franklin & Chelberg 2008). Second Life was launched on June 23, 2003 by Linden Labs. Second Life is a Massively Multiplayer Online Role Playing Game (MMORPG) which brings many people together to join in a virtual world. Each user creates a character, known as an avatar, to represent their digital persona in the virtual world and can interact with other users through this avatar. Since 2003, it has continued to grow and expand with its user driven creations and entertainment. Second Life is a free to download and use game. It integrates its own scripting language called the Linden Scripting Language (LSL) and its own 3D modeler. These tools provide necessary working environments to create high quality, educational games. Features such as LSL have earned Second Life the nickname of "the world's biggest programming environment" (Purbrick & Lentczner 2007). The native tools of Second Life are easy to learn and use allowing for fast development time of one to three months before a game is ready to use in the classroom.

As was discussed previously, most American teenagers play video games daily for relaxation. Incorporating the fun aspects of video game interaction with educational content provides an effective medium for teaching. Second Life, with its free development costs, allows for minimum investment by schools. The average household income in Athens County is $29,614 (Economic Research Service 2008). This results in many underfunded middle schools which benefit greatly from the inexpensive use of Second Life in the classrooms. The only materials needed for Second Life is a computer that meets the minimum requirements and an adequate Internet connection (Linden Labs 2008). As most modern schools now have a computer lab with Internet access Second Life can be cheaply employed and replace costly materials that are currently lacking in Appalachian educational environments. For example, STEAM has created the game Fruit Fly Genetics in Second Life to simulate a science lab where students get to learn about heredity and Punett squares. Although it would be possible to faithfully recreate the experiment in real life, it would be prohibitively expensive and unfeasible to implement. Second Life provides an inexpensive and easy way to have an interactive science lab. The Second Life games Fruit Fly Genetics, Gallery Walk, and Weather Challenge are discussed in more detail in the Games section.

STEAM has been tracking each game in Second Life for multiple years. This has allowed certain trends in education to become apparent. To record this information STEAM has adopted a research protocol that tracks individual student's progress over the regular teaching cycle. Before a lesson plan is used in a class, a pretest is given to test each student's subject abilities without officially learning the material in class. Then the game is played and the middle-school students are retested. After each testing round the tests are graded and statistics are recorded to determine the initial impact of the game. Next, the material is taught in the typical class setting. Within the next two weeks every student plays the game again and is tested once more to further ascertain the effectiveness of the games when combined with traditional teaching methods. As the data is gathered it is analyzed for improvements that can be made to future educational games created by the STEAM project. The section Data / Analysis analyzes the impact of the games Gallery Walk, Fruit Fly Genetics, and Weather Challenge.

Since STEAM's founding in 2006, developments in Second Life have been used to improve education in Appalachian middle-schools. The data gathered by the STEAM project have shown that 3D interactive games when used in the classroom greatly improve retention rates, scientific interests, and critical thinking skills. Researchers have shown that modern students prefer interaction over methods such as rote memorization, drill and practice exercises and lectures (Trindade, Fiolhais & Almedia 2002). Second Life, by definition, provides a collaborative work environment where students can socialize about the experiment they are performing while advancing through the game. It therefore meets the requirements of providing an interactive, educational experience to middle-school students. In the virtual world the students are given an avatar (or character) that has been prepared for their use by

the STEAM members. The students can walk around, drive vehicles, fly, chat and interact in many engaging ways while exploring a fully 3D virtual world and learning about scientific processes. The virtual world allows students to feel immersed in learning experiences that are not normally afforded to them while remaining in a controlled computer lab environment under the supervision of their teacher and the graduate fellow. Second Life can be used to help adapt traditional teaching techniques to modern student interest.

Related Work

The Interactive Science Lab is a combination of three Second Life games created by the STEAM project. It includes Fruit Fly Genetics, the Sugar and Water Solubility Experiment and the Redi Experiment. Each game was created to address specific science concepts as dictated by the middle-school science teachers that STEAM works with. These three games are intended for use with the 8th grade and address issues pertaining to the scientific method. By taking advantage of Second Life's development environment the three games are able to share the same virtual space and were quickly developed. Each of these games were created by a single graduate student at Ohio University; Bruce Bilyeu. While only the Fruit Fly Genetics experiment is discussed in detail in this paper, the other two games are open to the public and may be played at anytime on the STEAM Island on the Teen Grid of Second Life. For more information about these and other Second Life games, please refer to the software release page at http://vital.cs.ohiou.edu/SLsoftwarereleases.html.

Ohio University started working in Second Life in the spring of 2006. The Virtual Immersive Technologies and Arts for Learning (VITAL) Laboratory is the main entity at Ohio University developing in Second Life. The VITAL Lab is headed by Dr. Chang Liu from the Electrical Engineering and Computer Science department of the Russ College of Engineering and Technology at Ohio University. The VITAL Lab currently has two developed islands in Second Life on the main grid and has 5 undeveloped islands that are planned additions to the virtual campus. The islands have been planned and created by students of Ohio University who work with faculty from the Russ College of Engineering and Technology, the College of Education, the College of Fine Arts, Ohio University Without Boundaries and other professionals from around the globe. Exhibits, such as In The Sweet Bye & Bye (Jones 2007), have brought new real-world experiences into the virtual world of Second Life. Further information on the VITAL Lab and its projects can be found at its official web page http://vital.cs.ohiou.edu/.

The University of Texas conducted research in using Second Life as a curriculum aid in a college level English class. They created a pilot program that was implemented during the two-semester course. The goal of the program was to explore the usefulness of Second Life as an instructional tool in a college classroom setting. Students received training on how to use Second Life and it's built in capabilities as before beginning the activities. The first semester project consisted of a building activity and focused on "the integration of visual and verbal rhetoric" (Mayrath, Sanchez, Traphagan, Heikes, & Trivedi 2007). The activity involved learning about and building based on different types of architecture. Based on evaluation of the first semester project, the second semester project was adjusted from a robot building activity that included programming to a role playing assignment. The students were instructed to research a role model from some point in history and design an avatar that looked like the role model. They were then arranged into small groups within Second Life and instructed to take on the persona of their role model and carry out a discussion using Second Life's chat feature. The aim was to discuss leadership from the perspective of their role model. Through this experience a "best practices" guideline was created for designing Second Life instructional activities.

Games

Second Life provides a very unique set of tools that make it an ideal platform for educational game development. The built in scripting language is very easy to learn and use, even for non-experienced programmers. The syntax closely mirrors that of other major programming languages and many features are tailored specifically for use in a virtual world. This low learning curve allows for complex scripts to be written quickly. Thus significantly reducing the development time required compared to other technologies which require a greater amount of programming expertise to use effectively. Another useful built-in tool to Second Life is its 3D modeler. Three dimensional objects can be built inside Second Life without the need for expensive and complex modeling software. The built-in modeling capabilities provided are also intended for users with little to no experience in 3D modeling and is therefore easy to use. This too increases the ease of development while reducing the time taken to

create an educational module. The approximate development time for most of the Second Life learning modules created through the STEAM project is one to three months. This is the time taken from the initial development stages through testing.

One important component of many of the Second Life games created through the STEAM project is something known as a heads-up display, or HUD. A HUD is a two dimensional object created in Second Life that attaches to a particular place on the computer screen. It remains stationary on the screen as the avatar moves through the virtual world. It can be thought of similar to a speedometer in a car. A speedometer is something the driver of a car can view and is always in the same position relative to the driver, but drivers of other cars cannot view it. Thus is a HUD to an avatar. The HUD can be used to give each avatar an individualized experience through a game while an entire class is playing the same game at once. It can track important information for a player such as score, time, status, portion of game completed, etc. It can also be used to give directions, information, and even ask questions which the player must answer. A HUD, or certain portions of a HUD, can be positioned on and off screen as needed so as not to interfere with game play.

Virtual Gallery Walk

The Virtual Gallery Walk is a very unique type of learning module which has been created inside Second Life through the STEAM project. The purpose of the Virtual Gallery Walk is to simulate a traditional gallery walk used in classrooms. In this traditional gallery walk, a teacher would assign a research topic and each student would create a poster on a subtopic of the topic. The teacher would then hang all posters around the classroom and students could use the posters to learn about each subtopic researched by other students. The Virtual Gallery Walk is the reincarnation of this idea in a more modern and easier way. Students create their posters digitally using Microsoft Word, PowerPoint or some equivalent. The posters can then be uploaded into Second Life by the developer and displayed as virtual posters.

The Virtual Gallery Walk has several advantages over a traditional gallery walk. By using the virtual method, no materials aside from research materials are needed; the posters are created entirely using a computer. This can save the money that would have been needed for supplies. It also saves the "mess" that occurs with classroom projects such as these. No setup or cleanup is required. Another advantage is that no classroom space is required. Since the gallery walk exists entirely inside Second Life, space will not have to be created inside the classroom for these posters to hang. Also, no space will have to be made for students to develop their posters within the classroom. This is essential for small or crowded classrooms in which the space to complete a gallery walk simply doesn't exist. The use of the virtual method also can be done with greater ease. The students simply need to log in to Second Life and they will have access to the entire virtual gallery walk. Problems such as crowding around posters are avoided, and all posters can be displayed in an easy to reach layout. Students have the option to zoom up on a specific poster as well, allowing all posters can be easily read.

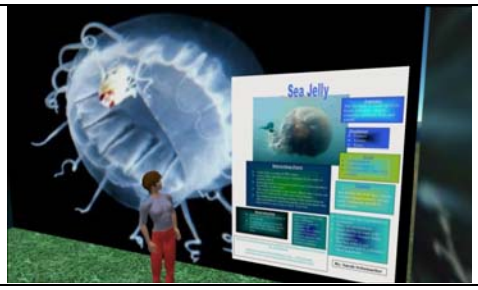

Figure 1. Virtual Gallery Walk
Sea Jelly Poster created by a middle-school student

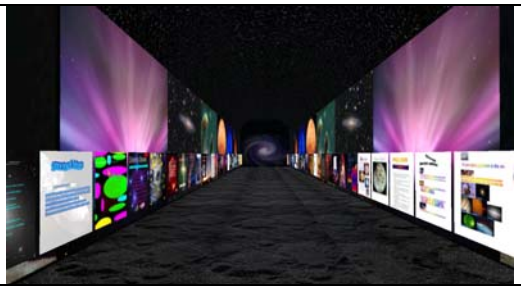

Figure 2.Virtual Gallery Walk
Entire gallery walk implemented in virtual space

From the development perspective, a virtual gallery walk is a relatively easy module to create. The development time can be as little as ten hours. Once the posters have been developed by the students, uploading them into Second Life is trivial. After they have been uploaded, the developer needs only to create a space to display the uploaded images. This gives the developer some freedom to be creative and also allows each gallery walk to be tailored to the specific research topic it addresses. For instance, in a gallery walk created to showcase research on different biomes, each biome was recreated in Second Life and the corresponding posters displayed inside that

biome. This allowed the students to experience each biome as they view the posters which discuss it in a unique way that can not be created in the real life classroom (Schendel, Liu, Chelberg & Franklin 2008).

When deployed in the classroom, the entire class logs on to Second Life and explores the gallery walk. Each student is then able to walk around and explore the gallery walk independently. Students are given a worksheet to accompany the activity in which the answers to the questions are all located in the posters displayed in the gallery walk. It is a very interesting experience to the students to see their classmates seated in the computer lab in real life and also see them walking around the virtual world of Second Life. Students are able to practice many skills, including research, documenting sources, report writing and computer skills, all in addition to the science concept they are learning. The experience proves to be very engaging and enjoyable to the students who delight in seeing each others' work in the virtual environment.

Fruit Fly Genetics

Fruit Fly Genetics is a virtual "experiment" that is conducted inside a virtual "laboratory". The module is used to reinforce the concepts of genetics. A desirable experiment for teachers to do in the classroom while teaching the concept is to actually breed fruit flies and allow students to see for themselves how traits are passed from parents to offspring. Unfortunately this can often be an unrealistic experiment to do in the classroom due to cost and trouble associated with performing the experiment. The Fruit Fly Genetics game creates a virtual laboratory in which each student can virtually conduct this experiment. The laboratory is equipped with enough desks for an entire classroom.

To begin the game, each student chooses a desk and virtually "sits" their avatar at the desk. During the course of the experiment, the avatar is held stationary at the desk and the camera view is held to the working area of the desk. A HUD is used to guide the student through the game. To begin, a user clicks a start button on the HUD and all supplies needed for the experiment appear on the desk in front of them. The HUD then gives students instructions to guide them through conducting the experiment. Each individual player is able to choose the colors they would like the bodies and eyes for both the recessive and dominant traits of their fruit flies to be. These colors range from bright pink to neon blue to black and everywhere in between. While this doesn't directly mirror the real world, the students are easily able to discern reality from virtual reality in this instance and the colors add an element of fun to the game which the students enjoy. After selecting colors, the offspring fruit flies begin appearing in a jar on the desk. The student then virtually "knocks out" the fruit flies using ether and can observe how the traits from the parents passed to the offspring. Each trait of each offspring is randomly determined based on the dominant and receives genes for that trait. This allows the students to compare the findings from the experiments with their predictions based on Punett squares and draw conclusions on why they may be different. The HUD provides the student with a bar graph for each trait showing how many flies had the dominant and recessive trait to help the student visualize the data.

Figure 3. Fruit Fly Genetics
Avatar sitting at a lab desk

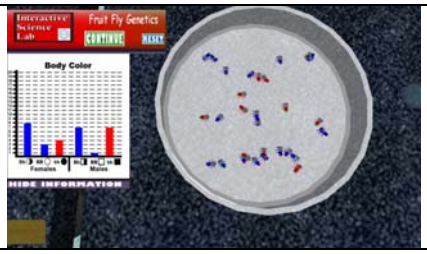

Figure 4. Fruit Fly Genetics
Counting dominant and recessive trait combinations

A worksheet also accompanies this game. Students first make predictions about the fruit flies based on Punett squares and then compare those with the actual results. Doing this experiment in Second Life allows the students to have the experience of doing the experiment without any set up, clean up or materials during a single period. It also makes it available to classrooms in which it would not be feasible to conduct the real life version. Allowing the students to choose the color of the fruit flies also helps the game to be an equalizer between male and female students.

Weather Challenge

Weather Challenge is a game focused on meteorology which teaches cloud type identification and how fronts, precipitation, pressure and temperature all affect the weather. This game is also guided by a HUD. The game consists of 5 different types of clouds which are hidden in the "sky" in Second Life. Student must find raindrops hidden in the clouds and click on them to go through a series of activities to complete the game. The student begins by flying around the sky looking for clouds. Flying is a built in feature of Second Life; all avatars are able to freely fly about the sky. Once a cloud is found, the student searches for a raindrop hidden in the cloud and clicks on it. The raindrops move about the cloud randomly and therefore are not always in the same location. Also, the raindrop moves every time it's clicked on, so if two students are racing for the same raindrop, only the first one will get it, the second will have to find it again. This helps to create a sense of competition in the game, which often encourages students to put more effort into the game.

Once the raindrop has been clicked on, the student must be able to correctly identify the cloud type the raindrop was found in. If they are able to do this, they move on to the next stage. In this stage, they are given a funny scenario about something they don't want to do, and a type of storm that will get them out of it. The funny stories do not provide any content to the game, but serve to make it more entertaining to the student, which in turn engages him or her more in the game. After being given the storm, they must then know the type of front, pressure, precipitation and temperature needed to create that specific storm. The storm also corresponds with the type of cloud it was found in. If the student is able to set all the variables correctly, then they complete that cloud type. If they answer the question incorrectly they must go find the raindrop again and start over. Once they have completed all five cloud types, they have completed the game.

Points are awarded for each correct answer and final scores are recorded in a high score board which records the top ten scores of all time and the top ten scores for that day. Getting their name on the high score board proves to be a large motivator for the students. Students are willing to replay the game many times to attempt to have their name on the high score board. More points are given for a correct answer on the first try while fewer points are given for each subsequent attempt at a correct answer. This helps to discourage random guessing. Points are also awarded based on how quickly a student finishes the game; they receive more points based on how quickly they finish. This aims to keep the students on task while playing and discourage activities not directly pertaining to the game.

Figure 5. Weather Challenge
Cloud Identification

Figure 6. Weather Challenge
Creating Weather Patterns

This game provides students with the ability to search the sky and find clouds in a world that closely resembles the real world, something that simply is not possible in a real life setting. The clouds hidden in the sky are realistic looking and mimic the altitudes each cloud type would naturally occur at in the real world. The ability to explore and learn independently is also provided by this game. Students find themselves very immersed and engaged when playing.

Impressions

Student responses to Second Life have been very positive. In most classes, only a handful of students had heard of or used Second Life before, but the majority had no idea what it was. Their first experience with Second Life was an introduction session where the students were given time to explore and learn to maneuver while completing a list of activities designed to help the students become accustomed to the virtual world. Most students were very intrigued and interested in Second Life right from the start. The ability to walk around a world similar to

the real world and see their classmates doing the same thing was very neat to them. An immediate appeal was the ability to customize their avatars or character. Second Life builds in the ability to edit and modify the appearance of an avatar in great detail. This activity is a favorite for the students. While some create avatars that look similar to themselves, others create avatars with wild skin and hair colors, crazy outfits, and unusual body shapes. Between the customized avatars and the richness of the virtual world, Second Life provides a very immersive and engaging experience for the students.

Playing the educational games in Second Life is always very exciting for the students. When the graduate students are in the classroom they will often be asked by the students if they can go to lab and play a Second Life game that day or when are they going to the lab next to play Second Life games. When in the lab, it is very exciting to see the amount of enthusiasm the students display and the amount of motivation they have while playing the games. Often students ask if and how they can play the games at home. Nurturing interest in science is a main priority of this program, and the amount of interest students show in playing these games is a large step in that direction.

Although the teachers were generally positive about the idea of using Second Life in their classrooms, they were slightly harder to win-over. In part this could be attributed to the fact that educators may have misconceptions about Second Life, especially what it is capable of and what it is not (University of Iowa 2008). Teachers sometimes were also not familiar with the technology and therefore were uneasy using it in the classroom. This may have been the single largest issue to overcome. During several professional development sessions with the teachers and STEAM fellows, many activities were done in Second Life to help acquaint the teachers with the virtual world. This helped to show the potential Second Life had as an effective curriculum aid. After becoming more comfortable with the technology, many teachers were enthusiastic about using Second Life in their classrooms. One major concern that had to be addressed was security. It was worrisome to teachers that students from other schools might log on at the same time their students were on. To address this, Ohio University purchased an island on the teen grid that was completely private. With the purchase came a set of avatars and only those avatars were allowed to access the island used for the STEAM project. This insured that no outsiders would be able to login to this island and disrupt class time. Once these issues were resolved, the teachers were almost as excited about introducing Second Life to their students as the students were about using it.

Preliminary Conclusions

Although Second Life provides a great platform for educational game development, it does have a few drawbacks. One is that a sufficiently fast internet connection is needed. Without enough bandwidth, Second Life becomes “laggy” or slow moving, as if the avatar is in slow motion. This can cause frustration in students focused on completing a game. To combat this in schools where there was not enough bandwidth to support Second Life, the students were paired up with two students to one computer and played the games as a pair. This worked very well and in almost all cases Second Life was useable when the students were paired together. To encourage participation from both students, they were encouraged to have one person operate the avatar by using the keyboard and have the other person control the mouse. Although allowing each student their own computer might be preferable, pairing the students was a decent way to combat the problem and still allowed Second Life to be used in the classroom.

Another problem was how easily students got distracted in Second Life by things outside of the game. For instance some students would spend a large amount of time using the built-in chat capability instead of playing the game, or would walk around to other parts of the island other than the part containing the game. This problem was addressed in multiple ways. One was to implement a script that would log the chat of all avatars logged on to that island. This would allow a teacher to read the chat log and determine if any students had been off-topic during the class period. Knowing that anything they said would be read by their teacher also discouraged students from using this feature for non game related chat. It was also relatively easy to create, install and use. The issue of students walking around to places other than the game was also an issue. This was dealt with differently by different games. Fruit Fly Genetics forces the avatar to be stationary and control the camera view of the game. This makes it impossible for the student to do anything else while playing the game. At the same time though, it takes away the ability to explore which is part of the appeal of Second Life. Another method used when applicable is to enclose the game so that the students can not wander away. This was implemented in the Virtual Gallery Walk. Walls were installed encasing the gallery walk so that the students could walk around inside the gallery walk but could not wander off to other places. This method could also be used with other types of games quite easily. Invisible walls can be created that will not allow a student to walk through them but will still be transparent so that the rest of the island can be viewed. Neither of these methods are feasible in Weather Challenge. This game tends to work better

once the students have already played some of the other Second Life games and learned what acceptable behavior is and what is not in Second Life.

A very valuable lesson learned through the creation of Second Life games is that the use of a HUD is invaluable in creating a multiplayer game. The HUD allows each player to have an individualized experience while still playing with all their classmates. This helps greatly to accommodate students with special needs as well as gifted students as they can all play at the same time and in the same place while working at their own pace. A HUD even makes it possible to create different versions of a game intended for different skill levels that could still all be played at the same time. The HUD is also extremely useful for giving the instructions for play and keeping track of pertinent game information such as score, status, etc. It is even possible to give questions and assess understanding using a HUD. Without a HUD it would be very difficult to allow multiple students to play at the same time and it would be more difficult for students to play through the game without direction given.

Data / Analysis

To analyze the effectiveness of these games, a research method was created. Twenty multiple choice test questions are created by the combined efforts of the graduate student and teacher pair. Considerable time is taken to equalize the questions and ensure proper formatting during scheduled professional development sessions. These questions are then divided into two separate tests, a pretest and posttest, each containing ten questions. The tests are equalized with respect to difficulty and often parallel questions are used between the pre and posttests. The research method consists of two days of testing. The first day of testing is conducted before the science content is covered in the classroom. The students are divided into two groups, an experimental group and a control group. The experimental group takes the pretest, plays the game and then takes the posttest. The control group takes only the posttest. The data from these pre and posttests allows for ascertaining the effectiveness of the game as a stand-alone teaching tool. The control groups serves as a baseline to compare the experimental group with. The control group is allowed to play the game after taking the test for the sake of fairness and equality in the classroom. The second day of testing occurs during or directly after the content is covered in the classroom. The entire class takes the same pretest, plays the game and then takes the same posttest. The data from this second day of testing shows the effectiveness of the game as a complement to the standard curriculum. The two days of testing are at least 2 weeks apart. The gallery walk is handled slightly differently due to the different nature of the activity. For this module, a pre-research test was given before the research took place, a post-research test was given after the research took place but before the gallery walk was used, and a post-game test was given after the gallery walk was used. These tests were similar in structure, containing nine multiple choice questions and one short answer question a piece (Schendel, Liu, Chelberg & Franklin 2008).

The results from both days are complied and each student's score is recorded through both days of testing. Afterwards, a statistical analysis is run using SPSS data mining and statistical analysis software on the data collected. Data from the Gallery Walk is as follows:

Test	N	Mean Score	Standard Deviation
Pre-Research	86	3.01	1.712
Post-Research	86	5.26	1.730
Post-Game	88	4.977	1.6950

Table 1. Gallery Walk Testing Data (Schendel, Liu, Chelberg & Franklin 2008)

It is clear that the student's score rose significantly after conducting their research. The mean score for the post-game test is slightly lower than the post-research test. It was hypothesized that this was attributable to the fact the post-game test contained questions whose answers were located on specific posters within the gallery walk. The large number of posters contained in the gallery walk made it difficult for students to view all posters and therefore made these questions difficult. It is possible that these questions increased the overall difficulty of the quiz and that this is the phenomenon represented in the table above. To analyze the effectiveness of the Fruit Fly Genetics educational game module, a similar protocol was used. Before genetics material was taught during class, the students were given a pretest before playing and a posttest immediately after. The material was then taught during normal lessons. After teaching the material, each student was given a pretest, played the game, and then given a

posttest. This standard research method was used between the years of 2007 and 2009 to analyze the effectiveness of Fruit Fly Genetics among multiple middle school classrooms. The results from those days of testing were compiled and each student's score was statistically analyzed in a fashion similar to the Gallery Walk. Data from Fruit Fly Genetics is as follows:

Test	N	Mean Score	Standard Deviation
Pretest Before Teaching	48	2.7083	1.5565
Posttest Before Teaching	95	4.9052	2.1388
Pretest After Teaching	181	4.7748	~2.1200*
Posttest After Teaching	181	6.0320	~2.340*

* = calculations based on incomplete data

Table 2. Fruit Fly Genetics Testing Data

These results clearly demonstrate that Fruit Fly Genetics was an effective educational computer game that contributed drastically to the students' ability to retain the related lesson knowledge. The mean test scores improved over 25% after playing the game regardless of when the material was taught.

The same methodology described above was again used to quantify the effectiveness of Weather Challenge. The game, using the research protocol, was tested at two separate schools. The results can be noted in tables 3 and 4. Although the improvement is more notable for school 1 than school 2, an increase in scores can be noted in both cases. The two schools each saw an improvement from pretest to posttest scores for day 1 and also an improvement from pretest to posttest scores from day 2.

Test	N	Mean Score	Standard Deviation
Pretest Before Teaching	40	2.7083	1.5565
Posttest Before Teaching	40	4.9052	2.1388
Pretest After Teaching	64	4.7748	~2.1200*
Posttest After Teaching	64	6.0320	~2.340*

Table 3. Weather Challenge Testing Data from School 1

Test	N	Mean Score	Standard Deviation
Pretest Before Teaching	40	3.00	1.320
Posttest Before Teaching	40	3.48	1.552
Pretest After Teaching	88	3.24	1.702
Posttest After Teaching	88	3.84	2.186

Table 4. Weather Challenge Testing Data from School 2 (Cooper, Liu, Franklin, Chelberg 2009)

Conclusions

Creating lesson plans to both engage and effectively teach is a difficult problem for teachers in an increasingly digital society. The current generation of students has been raised entirely in this technological era and is comfortable with many of these new gadgets that may still be foreign to much of the teaching generation. It is challenging for educators to accommodate these students in a society that is rapidly changing. Second Life provides a unique opportunity for educators to take advantage of some of these new technologies in a way that is enjoyable and engaging for students, yet easy to use for teachers. The world of Second Life mirrors ours in many ways, allowing a user to relate to it and feel comfortable using it. It also provides many capabilities that are not present in the real world. Things that would not be feasible to do in real life could be modeled in Second Life to allow students to experience them virtually. For instance, it may not be possible to take a class trip to see the pyramids, but a class trip could be taken to the island of Philae in Second Life to view an accurate recreation of the pyramids. A class Second Life trip could also be taken to see a power plant, a factory, etc. The possibilities are literally endless. Second Life also provides a very useable and flexible platform to create interactive digital media intended for classroom use.

Responses to Second Life from students are very positive. Students are easily able to learn to navigate and use the digital world and seem to be able to seamlessly transition their learning from real to virtual worlds. The richness of the immersive, digital world entertains and engages students. Often students even ask to play the games on their own time, and will play many times to obtain higher scores. While teachers often take longer to warm up to the technology and feel comfortable using it in the classroom, once they do they too are very excited about the possibilities and potential offered by Second Life.

Extensive testing has been conducted to evaluate the educational gains made by the students through playing these Second Life games. Through this research method, it has been shown that the Second Life games detailed in this paper show significance in helping students to learn the material. Student evaluation has also shown that the students find the games to be enjoyable and engaging, and most believe the games aide in their learning. Second Life has proven to be a useful and worthwhile tool in teaching hard-to-teach concepts in middle school science classrooms.

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Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. 0538588. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.