**Escape Polymer Island: Designing a Learning Based Game**

Alexzondra Hurns, Hua Shu, Shea Brown

**Introduction**

With the expansion of technology, “traditional instruction” has received much criticism. Many experts are considering “traditional instruction” a downfall in the educational system and possible contribution to the loss of student interest in the classroom (Banathy, 1994; Reigeluth, 1994). In the past, there has been some investigation into the effectiveness of games used as educational tools as well as the struggles faced by game-based learning (Gros, 2007). Studies have shown that there is great educational potential in game based learning. In a 1996 study conducted by Patricia Greenfield, conclusions pointed to games developing skills in “learning through observation and hypothesis,” broadening the understanding of scientific simulations, and “increasing strategies for parallel attention.” Evidence from this study suggests that game based learning can greatly enhance students’ experience in the classroom (Gros, 2007). More evidence suggests that game-based learning (GBL) enables learners to undertake tasks and experience situations which may have been otherwise impossible in order to develop new knowledge and skills. Some serious games have been successful and are currently in use. British gas created a 3D role-playing training tool using a popular first person shooter engine. Intel created a mystery roleplaying game used to reinforce the importance of IT security to employees. “Packy & Marlon” is a game that teaches diabetes management techniques in hospitals, clinics, and summer camps. Studies have found that children and teens with diabetes who play this game at home reduce their diabetes related emergency and urgent care visits by 77 percent (Corti, 2006). The statistics from this study are a strong indication that “new knowledge and skills” were gained from use of this game.

**Problem**

The purpose of this study is to design an interactive educational game titled *Escape From Polymer Island (EPI)*. *EPI* is structured to educate high school students about polymer science. Players navigate, solve problems, and defeat enemies in order to learn more about polymers.

This project will investigate:
i. Necessary features that enhance learning without compromising entertainment
ii. Methods to implement educational objectives into the design and outcome of
gameplay
iii. Strategies to engage the player and avoid becoming “overly instructional”

After reviewing previous studies on educational game design, game based learning and classroom interaction, an initial script was made to conceptualize four learning objectives into the game play. The four learning objectives for level one of *EPI* gameplay will explain:
i. What are polymers
ii. Natural and synthetic polymers
iii. Thermoplastics and thermosets
iv. Composites

**Background**

A pilot study was done to test GBL in the classroom setting. Ninety-six underserved middle school students were chosen to learn the non-intuitive, abstract concepts found in electromagnetism. Use of the video game *Supercharged!* provided students with a visual simulation of such concepts and proved to work as the experimental group outperformed the control group. When asked to solve complex physics problems, students from the control group relied more on memory whereas students from the experimental group drew from experience. Moreover, classroom discussions were enriched when teachers led collaborative play (Squire, Barnett, and Grant, 2004).

Motivation is an important key to learning, and game-based learning increases the motivation to learn. Student’s ability to learn is deeply rooted in their level of motivation. It was hypothesized that by contextualizing the material, personalizing aspects of the game, and implementing the provision of choice in video games, motivation can be obtained. A study was done to test the effects of these strategies on students’ performance in the areas of mathematics and problem-solving on seventy-two fourth and fifth graders from the San Francisco Bay area. Results of this study led to the student’s involvement in learning, an increase in amount learned in a period, perceived competency and levels of goals, and increased student motivation (Cordova and Lepper, 1996). This study proves that GBLs are beneficial overall because of the numerous aspects that improved-- which includes the amount learned in a period.

A few studies have developed educational videos games for older students who are enrolled in more difficult curriculums. One case study designed *Immune Attack*. *Immune Attack* is a single player pc game that teaches high school students about the immune system. The game builds the educational content into the gameplay by utilization of 3d renderings of biological structures. The players explored landscapes and earned privileges to use certain weapons that helped them accomplish missions designed to meet objectives of the curriculum (Kelly, Howell and Glinert, 2007). Moreover, video games have been developed to educate college level students. *Metalloman*, a serious game designed to teach undergraduate engineering students bioscience concepts, was developed for experimental purposes. Players accomplished different missions to achieve different educational objectives. Tests conducted for *Metalloman* indicated that students understood the content better after playing the game (Marsh, Wong and Carriazo, 2005).

**Methods**

Many game design strategies were used to embed the objectives into the gameplay. An intro animation with voiceover narration was chosen to set the backstory for the game.

In the intro animation, voice over narration and visual imagery was used to portray pertinent information to the player in a succinct way. The player saw that his plane has crashed on an island, where he met Dr. Wan, a scientist who is part of a group of “good” scientists called “the Resistance.” Dr. Wan then told the player about the group’s evil counterparts and their leader Dr. Zero, who used polymers for murder and destruction. In that level of gameplay, the player had to defeat one of Dr. Zero’s scientists in exchange for Dr. Wan’s services. The animation mechanism was used to engagingly provide this structure and concisely communicate further instruction for the remainder of the level. In addition to a voice over narration and visual imagery, atmospheric music was used to captivate the player and motivate him to complete the learning objectives.

An inventory was used to store various polymer based items the player collected along the adventure. The inventory interface separated the items into three categories; weapons, health, and polymers. The weapons tab displayed what item(s) the player currently had equipped. The polymer tab featured a window on the left side that displayed a detailed visual of the selected item. In this visual display was the title of the polymer, a 3D model of each polymer structure, a concise description of the object, and a link so that the player could opt to read more about it. Finally, the health tab showed a bar of the player’s current health. The inventory is mainly the backup resource for students to read and learn about the polymers they collect. It is also the virtual library in this sense, but the information is filtered so that students choose the amount of information they want displayed.

Monomers are the smallest units of a polymer chain. Polymers are complex molecules consisting of many repeated monomers. In the game, the concept of monomers was contextualized in a way that will allow the player to see and gather it. Monomers were used as currency for trade and as raw material for polymer equipment crafting. Monomers and varied components of composite materials were released upon the defeat of enemies.

Ideally, students will be able to learn polymer concepts through the completion of in-game tasks and battling polymer enemies. In the first stage, the enemies that challenge the player were presented in various, distinct forms: silk worms, simple polymer chains, wooden monsters, thermoplastics, and thermosets. In order to defeat each form of enemy, a different approach was necessary. Each approach was to be directly dictated by the properties of the enemy combatant. Enemies were presented in a progressive manner. Opponents based on simple concepts were introduced first while those that build more advanced concepts were presented subsequently. For example, at the start of the level, the player was pitted against simple polymer chain enemies (MerMen). In order to defeat the MerMen, the player had to strike them with a solvent based attack. Later, the player was pitted against thermoplastic enemies who were not affected by solvents and had to be defeated by being subjected to high levels of heat. Game mechanics such as these introduced and ideally reinforced the designated concepts of polymer science. While retaining a high level of educational content, the game was designed to be challenging and appealing to high-school students.

As the player traveled through the jungle, he encountered a villager tradesman. Dialogue was exchanged between the two to provide necessary structure and to incorporate content regarding natural and synthetic polymers. The tradesman had weapons and clothing to trade for the natural polymers the player collected in the jungle. Some of his natural polymers included torches, slingshots, and a leather jacket, while his synthetic polymers included a spandex shirt and nylon pants. Provisions were made to ensure that the player didn’t bypass the tradesman. Moreover, the game was crafted so that certain weapons were needed to defeat certain enemies. This provision would theoretically force the player to learn more about the different polymers.

Later on, the player encountered an armory. The purpose of the armory was to allow the player the opportunity to customize his weapons in order to defeat Dr. Raven and his evil polymers. The player was able to build his weapons by combining single polymers to make composites. Provisions were put in place to assist the player in designing the best composites for battle-- such was achieved by way of graphs. The graphs showed characteristics of the individual polymers compared to characteristics of their composites. This provision of choice was a way of motivating the player while indirectly teaching him about composites. The weapons gained from the tradesman and armory, in addition to others gained elsewhere, was used to complete the mission.

**Results**

One important product of this project is the finalization of a detailed script. The script contains a blueprint of the entire first level of EPI gameplay. It includes features to enhance learning while simultaneously being entertaining, methods to implement educational objectives into the design and outcome of gameplay, and strategies to engage the player without becoming too instructional.

Also, a demo was created to effectively convey the direction in which the game was going. The demo includes an intro animation and a sample of gameplay. The intro animation was completed with a narrative and visual imagery to meet the first learning objective, learning the definition of polymers.

**Discussion**

In the 10 weeks allocated to design level one of *Escape from Polymer Island*, our group was faced with several obstacles. The initial script envisioned an open world 3D adventure game that only asked the player to collect various polymer materials. While it was engaging, a single player 3D adventure game would be too time consuming to develop and test and not as readily accessible as a 2D platformer. The script was then revised into a single player 2D adventure pc game. Much time was put into conceptualizing the script and designing the gameplay to incorporate the educational objectives. Therefore, level one of the game was not completed.

The key issues we faced in the design process were unfamiliarity with the Unity game design engine, no starting knowledge of the Javascript language, compatibility issues with RageSpline and RageTools, and working with a small team for a short period of time. The designated programmer had to read and participate in several tutorial sessions to get a grasp of the Unity engine. When the time arose to create and code the new game, we found that much of the physics, input controllers, and other features were coded in javascript. Members of our group had no experience of javascript and were unable to secure the direct assistance of anyone skilled in it. This made altering and creating necessary scripts very difficult. A large deal of time was spent troubleshooting a particular issue in which the *main character* ignored the physical barrier of the terrain, causing *him* to fall through the ground whenever gravity was applied. Other primary hindrances were connected to the use of the RageTools and RageSpline plugins. Although RageTools delivered on its claim to enable the importation of 3rd-party-generated vector shapes, it also resulted in major issues when Unity animation was attempted. The manner in which Unity handled these plugin imported objects made animation extremely taxing on the system, bringing the software to a near standstill. The limited number of team members and range of skills was also a restricting factor.

**Future Work**

Studies have suggested potential for game based learning to be an effective tool in enhancing formal education. However, more research must be done to strengthen such claims (Ricardo Rosas, Miguel Nussbaum, and Patricio Cumsille, 2003). The creation of *Escape from Polymer Island* can contribute to the field of learning based games by providing a model that can be utilized for both researching purposes and classroom enhancement. In moving forward with EPI, we suggest expanding the size of the development team and changing the design methods. With the high amount of dialogue and instruction material, it would be ideal to have several voice actors on hand for verbal recordings. Multiple game programmers with experience in both javascripting and Unity would tremendously improve the success of the process. Originally, it was anticipated that using the RageSpline and RageTools plugins would simplify the design process. However, these plugins led to many issues that would have otherwise been avoided. We would not recommend the continued use of the plugins but instead making the game “2.5D”. A game that is “2.5D” is one that uses 3D models but is constrained to a 2D space where the character can move only left-to-right and jump/fall.

Upon completion of level one, a study assessing its results will need to be conducted. The study should include gauging how effective the specialized features were in enhancing learning while retaining an element of fun. Also, the study should evaluate the methods used to achieve the educational objectives. The analysis of such a study could then be used to determine if a learning based game such as EPI is a viable supplement to the current traditional model of education. If so, EPI may be used as a template for the design of future learning based games. In this case, the completion of the subsequent levels and game design should follow so that a full game can be embedded into a hybrid curriculum. Each level should present different learning objectives and engaging ways of motivating the player to learn them through the gameplay. The levels should progressively become more difficult to win, but fit the player’s needs by basing differing levels of complexity on the player’s understanding of the content. Further research of the potential of game-based learning could be lead to a solution to improving the aging “traditional” education system.

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