



## *Salt Marsh Dynamics ~ a Problem-Based Learning Scenario*

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### ***Abstract***

Multi-user, persistent virtual environments have shown promise for fostering community and situated learning because they can support immersive, collaborative, extended experiences and simulations similar to those found in real world contexts. This project involved the development of a problem-based learning environment using the online virtual world of Second Life, for use in undergraduate Ecology and Environmental Science courses. Both process and content were featured to promote collaborative learning, advanced problem solving and the application of research and scientific thought as students gathered, interpreted and analyzed data to solve an ill-defined real-world problem. This scenario was used to investigate how effectively content information and scaffolding can be designed and delivered in a virtual environment. We found that while the scenario offered students an engaging environment for active learning, they relied heavily on the mini-scripts acquired through past content-driven courses rather than working to make critical observations, and to analyze and interpret their own discoveries. Without specific scaffolding, modeling of process and frequent reflection, most students did not search for information beyond what was presented to them in narrative format, nor did they observe characteristics of the scenario beyond what they recognized or expected to see based on their superficial acquaintance with real world sites.

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**Key words: problem-based learning; simulations; virtual worlds; Second Life; salt marsh ecology; system thinking**

### ***The Challenge***

Effective education helps students to *think*. The ability to think critically, reason in a variety of ways and solve ill-structured problems creatively has become an essential skill needed to succeed in today's world. Models of critical thinking provide a means for evaluating problem-solving maturity. Susan K. Wolcott (2005) describes the development of critical thinking with a series of shorthand phrases, remarking that half of the students entering college are "confused fact-finders" lacking the skills to put



facts together to solve problems. At the end of college, the majority have advanced to the next stage, “biased jumper.” They jump to a conclusion, based upon previously-held biases and then look for evidence to support it. Few master the next stages, “perpetual analyzer”, which involves the critical analysis of data and assumptions, and “pragmatic performer,” making well-founded decisions based on objective analysis. Even fewer reach the higher order thinking skills of the “strategic re-visioner”. The challenge to educators and instructional designers is to create opportunities for students to mature in their critical thinking skills.

### ***The Theoretical Perspective***

The “knowing” of concepts, definitions and facts has dominated traditional undergraduate education. However, educational theorists for years have been questioning the very definition of what it means to know something and how knowledge is actually acquired. John Dewey in his 1916 book, *Democracy and Education*, remarked that understanding is not obtained by “telling” and “being told”, but instead is the result of an active constructive process. Brown, Collins and Duguid (1989) argued that knowledge is a “tool”, understood only through its use. Knowledge is situated through experience, by “doing”, instead of rote memorization of facts and concepts in isolation. In the process of “doing”, students come to understand the world through their own models and representations obtained through personal experience and reflection (Duffy & Jonassen, 1992). They actively *construct* their knowledge rather than passively *receiving* it from others.

In recent years these situational theories have been moving from learning being a solitary endeavor to one where knowledge is acquired through shared experiences and social contexts (Lave & Wenger, 1991). With this anthropological approach, learning takes place in a participation framework where it is distributed among the participants similar to the reciprocal nature found in apprenticeship between the apprentice, the master and his or her workshop. In the process the learner adopts the identities and “habits of mind” of that practice.

Learning theory is important because what one believes about learning and acquiring knowledge will influence the type and nature of the learning environments he or she designs. A well-designed problem-



based learning environment models real life with contextual narratives that situate concepts in practice (Brown, Collins and Duguid, 1989). It asks students to articulate the data they use to solve the problem, and to develop methods to test their proposed solutions. The learning environment guides students to analyze theory in practice, develop “ways of knowing” and sharpen critical thinking skills.

The use of *problem-based learning* has been widespread in the field of medicine for many years (Williams, 1992). Characterized by small cooperative learning groups, learners are responsible for developing their own position on an issue or solution to a problem as opposed to *case-based learning* where one studies solutions others have identified. In problem-based learning, the *problem* comes first. This is in sharp contrast to the traditional strategy of teaching concepts and facts first to be later followed by a lab or “end-of-the-chapter” problems for application. In problem-based learning students must identify what they know, what they don’t know and what they need to know to solve a problem that has no one “correct” answer. Through the process of identifying the problem and recommending solutions, students are exposed to a variety of viewpoints, acquiring new perspectives and increasing their understanding of the complexity that surrounds seeking solutions to real-world problems. A seemingly simple issue becomes complex as decisions impact stakeholders in different ways, both positively and negatively. In this method, the instructors become facilitators of learning instead of presenters of knowledge, as they shift from teaching content to engaging the learner in authentic tasks through which they are most likely to acquire the desired concepts and skills (Barab & Duffy, 1990).

### ***Problem-Based Learning and Virtual Worlds***

Advances in technology have opened up new forms of instructional delivery while providing unlimited access to content. Many of the popular online multiuser games have their foundation in problem-based learning as players gain skills and resources to engage in quests and various challenges with other players (Gee, 2003). These venues allow the participant to become situated within the play space, taking on the identity of a virtual character. It is through participation that the player becomes part of the world itself in which he gains knowledge through actions and consequences. Key to virtual online



games is their persistent physical and social nature that evolves over time in much the same way as any learning community (Squire, 2006).

Unfortunately, these applications are very expensive to produce and beyond the skills of most educators and designers. However, virtual worlds such as Second Life offer educators the tools to build graphically rich, interactive problem-based learning environments, similar to those found in online gaming. Using effective design principles, one can provide clues to encourage students to intelligently proceed through a problem based on the layout of the material environment and the objects in it. Through this embodied experience, students discover that objects, artifacts and the way in which the environment is set up can store knowledge. A well-constructed environment provides subtle clues and bits of evidence that offer students the opportunity to practice skills in inductive reasoning. They become more proficient in “reading” a space. Because the virtual world supports a variety of media, meaning and “ways of knowing” can be built through multiple modalities such as image, action, and sound, impossible with the traditional “paper and pencil” case. This supports a variety of learning styles and challenges students to use observational skills related to all their senses to interpret information.

### ***Applicability to the Ecology Classroom***

A key objective in science education at the college level is to engage students in real world scientific practice (i.e. careful, subtle observation, data analysis, hypothesis generation and controlled testing, all carried out within the context of a socio-scientific community). Scientific practice begins with an appreciation for the nature of complex systems and the fact that real-world problems have complex causes and solutions. These system-level dynamics function across disciplines often involving a balance of ethical, economic, political and scientific factors and interests.

Multidisciplinary problem solving is a necessary skill, yet is seldom practiced in discipline-based courses. Science courses focus on understanding scientific knowledge and perspectives, whereas parameters relevant to other disciplines, such as political, social or economic factors may be ignored or dealt with superficially. In addition, students have many pre-assumptions, based on their experience in the world. When faced with problems to solve, they often jump quickly to a conclusion, by interpreting their



limited observations, such as what they can physically see or have heard through mass media. For example, in searching for a cause for ecosystem decline, rather than critically analyzing all possible causes, both direct and indirect, they see evidence of litter or medical waste and presume them to be causative agents. As a result, their solutions to environmental problems tend to be simplistic, usually lacking depth of knowledge, appreciation of different perspectives as well as creativity in integrating multiple causes.

To bridge the gap between theory, lab exercises and real world practice, the course may include field trips so that students may learn from nature in her own setting. Scheduling constraints make these short, intensely guided experiences. Students tour an area, learn about vegetation and animal life, discuss effects of such events as global warming and weather on the ecosystem, demonstrate simple tests and field measurements, and write up some “reflection questions” to tie together theory and field observations. The quality of these experiences tends to vary greatly from student to student, although most students find field work enjoyable and the experience leaves a more lasting impression than a classroom lecture. However, students rarely get the opportunity to solve an actual problem that involves working collaboratively with a multidisciplinary team of scientists, as well as dealing with the specific concerns of a stakeholder group of citizens. Using problem-based learning, students are guided to work as a team of investigators, finding their own strengths, as they learn from each other to investigate, and to engage in practices that are consistent with those of real world practitioners.

Using a virtual world such as Second Life for creating a problem-based scenario for the science classroom, offers rich collaborative inquiry-based explorations through which students can apply principles and content covered in class and during the field trip. Educators simulate real-world problem situations that would normally not be possible or accessible to students (Barab *et al*, 2006; Dede, 2005). By taking advantage of persistent and social affordances in virtual spaces, students develop skills in team building, creative problem solving and critical thinking with enough time to acquire the “habits of mind” that are the basis for authentic learning.



## **The *Salt Marsh Dynamics* Environment**

This project took place in an online 3-D, multi-user virtual environment known as Second Life, created by Linden Labs in June, 2003. *Residents*, by creating a virtual representation of themselves called an avatar, can explore the environment, meet others, attend special events and create and sell virtual goods and services. Known as “the main grid”, Second Life is for people over the age of 18 while the Teen Second Life is for ages 13 to 17. To enter Second Life, one downloads the free application viewer to their computer and launches the application.

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Everything in Second Life has been created by residents through three-dimensional modeling tools based around simple geometric shapes built into the software. Functionality can be added to objects within the environment by embedding special scripts within them. For example, by interacting with an object, an avatar can receive an informational note card, be directed to a web site or play streaming media. More complex elements and interactions can be created in outside programs to be imported into the environment. Unlike traditional online computer games, Second Life does not run on an underlying game engine, being instead, more of a social online *space* known for its creative potential.

Educators have been exploring the potential of Second Life as a learning space since its inception. Well over 200 colleges, universities, libraries and museums have a presence within the environment (Harrison, 2009). Educational subjects such as Chemistry, English, Language Instruction, and the Arts have been taught in-world, and entire continents are devoted to science and technology. For the first time, educators have the tools to actually build graphically rich, interactive environments similar to those of online gaming. In December of 2008, the United States Air Force launched MyBase, a Second Life island devoted to Air Education and Simulation Training.

## ***Project History***

In 2006, Seton Hall University partnered with the New Media Consortium to develop plans for the creation of virtual environmental learning spaces inspired by actual endangered ecosystems within Second Life. Professors Marian Glenn and Martha Schoene in the College of Arts and Sciences, along with the instructional design team, identified flora and fauna and developed learning activities with the



intent to pilot the effectiveness of these spaces and experiences on teaching and learning in Biology, Earth Science and Ecology courses on the Seton Hall campus. Design emphasis centered on promoting collaborative learning, advanced problem solving and the application of research and scientific thought through authentic real world contexts. In 2008 the team was awarded a New Media Consortium Virtual Learning Prize, thus starting the development of *Salt Marsh Dynamics*, on Pirate Island, virtual property owned by Seton Hall University. Professors Marian Glenn and Martha Schoene served as content experts, providing resources, writing narrative and composing assessment questions. The instructional designer served as project manager, Second Life content developer, multimedia creator, and inspirational coach.

### ***The Design***

Designing the *Salt Marsh Dynamics* learning environment was similar to building a house from the ground up. The project goals and outcomes were identified early in the process and served as a guide to determine what creative possibilities to include and what to set aside. This provided an initial structure and framework for design of the scenario, environment and user experience.

The following project goals and key learning outcomes (objectives) were identified.

#### **Project Goals**

- Provide students with a problem that is meaningful, interesting, relevant, engaging and ill-defined with no right-wrong answers.
- Deconstruction of students' pre-assumptions to allow for the reconstruction of new, more complex notions on the workings of an ecosystem.
- Focus on the process of learning (collaboration, scientific inquiry, inductive reasoning) over learning content.
- Provide opportunities for the acquisition of 21st century skills such as knowledge gathering, collaborative team building, establishing knowledge communities and creative problem solving.
- Encourage diversity of thought and multiple perspectives.
- Determine and provide appropriate scaffolding.



- Present information in a variety of formats (multimedia, print, online resources).
- Integrate into existing curriculum, supporting other learning activities such as annual field trips.
- Apply successful online multiuser virtual gaming and epistemic game theory to virtual world environment where appropriate.
- Provide continual student assessment, explore group assessment.
- Establish best practice.
- Determine project assessment early to set up possible comparative studies.
- Publish findings.

### Key Learning Outcomes

At the completion of the case-based activity in Second Life, learners would be able to ...

- Gather, analyze, manage, and evaluate data from numerous sources to include historical and provided data, environmental observations, and outside resources to substantiate and support arguments.
- Apply scientific principles and concepts to real-world contexts.
- Work collaboratively to exchange ideas, information and perspectives.
- Debate, discuss and arrive at a group consensus, identifying and evaluating possible solutions.
- Create and present a plan of action to alleviate/solve present environmental impact and restore area to its natural state, including methods to assess and modify the plans scientifically.
- Demonstrate the acquisition of “ways of thinking” found in scientific and research communities.

Problem-based instructional models based in other online virtual worlds such as *Quest Atlantis* (<http://atlantis.crlt.indiana.edu/>) from Indiana University, *River City* from Harvard University (<http://muve.gse.harvard.edu/rivercityproject/>) and *PowerUp* by IBM and the New York Hall of Science (<http://www.powerupthegame.org/>) were explored to get an overview of their organizational and educational framework, design, scaffolding and embedded learning activities. These educational learning environments served as inspiration and examples of best practice. Also examined and played were the commercial online games of *Nancy Drew Mysteries* (<http://www.herinteractive.com/>) and *Myst* (<http://www.mystworlds.com/us/>), looking at user interaction with objects and overall experience.



Knowing that the project was to be instructionally grounded as a problem-based scenario, a storyline was written to support (1) the concepts of eutrophication, water quality and system dynamics (2) build skills in hypothesis generation, scientific inquiry, water quality/data analysis, and socio-scientific reasoning (3) encourage the development of “reading” an environmental space. It was also important that the narrative be compelling enough to draw the students into the experience, motivate their interest and provide a realistic problem-based scenario of an ecological issue in our geographic area. Through character development within the story, students were expected to develop an appreciation for the complexities involved in drawing scientific conclusions, applying scientific knowledge to management decisions and public policy and balancing economic, social, and political factors with the conclusions of scientific investigations.

The storyline begins with a mysterious fish kill in the virtual marsh on Pirate Island. Local officials have called in a team of experts to perform follow up tests in the bay, ocean, inlet and marsh with volunteers needed to help in the ongoing investigation. Further details are provided as students navigate and click on in-world, non-player characters, four scientific experts and four stakeholder-citizens, each with a particular set of information and clues about the possible causes of the fish kill (see Appendix A). In creating the story plot, the developers listed all the information desired in the environment, “mapping” the information onto the eight characters, including some repetition (see Appendix B). When there was overlap, there was also some discrepancy in the results that students would be challenged to deal with. In this way the storyline formed a complex web that also served as a “watertight” information package. In creating the mystery this way the developers actually modeled how a team of experts operates in solving a mystery. The environment was embedded with artifacts (i.e. field guides, graphs, charts, scientific journals, and newspaper articles) some that directly related to the scenario and some with irrelevant information and red herrings (see Appendix C).

Once the storyline was drafted, project tasks were identified which fell into three main design categories: (1) scenario (2) natural environment itself and (3) learning experience. Specifics ranged from designing the graphics (i.e. logo and banner) to brand the project, creating characters and their



narratives (see Appendix D), building the learning environment in Second Life to finding subject content with supplementary resources. Challenging, but essential, was the interrelationship between these components, requiring the team to continually review and reassess process, components and material to further support and define the student experience. For example, once the storyline and character narratives were defined, a “blueprint” was created for the Second Life environment that included land topography, watershed boundaries, buildings and learning areas to support the narrative, hold content, and provide easy avatar movement. This environment was then changed and adapted as objects were added and revisions were made to the overall experience.

### ***Participants and Setting***

Students were added to the project in the Fall 2009 undergraduate course BIOL2341AA- Ecology taught by Dr. Marian Glenn, Professor of Biological Sciences in the College of Arts and Sciences at Seton Hall University. Dr. Glenn was a main content contributor and co-author on the project. The class met on Tuesday afternoons for 75 minutes, and on Thursdays for 4 hours. The class was comprised of 18 junior and senior Biology majors who had previously done other project-based, collaborative, inquiry based work in core courses in the major, however this project was their only ecology course and their first experience in Second Life.

This face-to-face course was held in a workshop format. Discussions and class activities covered assigned readings. There were four field trips to nearby natural areas including Horseshoe Cove Salt Marsh at Sandy Hook National Recreation Area. Class assignments included keeping a nature journal for reflection along with special individual and group projects. Assigned readings included *Life and Death of the Salt Marsh*, by John and Mildred Teal, a classic natural history text focused on salt marsh ecology. This book was also used by the instructional designer of the project as a reference for creation of the Second Life marsh environment.

BIOL2341AA course goals included:

1. Cultivate and apply the skills of a biospheric scientist: analysis, imagination, compassion.
2. Practice observing nature with a "deliberate gaze."



3. Apply quantitative analysis to ecosystem problems.
4. Apply knowledge of salt marsh ecology to management issues.
5. Evaluate multidisciplinary synthesis applied to biospheric ecology.

### ***Project Integration into the Curriculum***

Along with the discussion of *Life and Death of the Salt Marsh*, students had a guided field experience at the actual salt marsh, led by an educator from the New Jersey Marine Sciences Consortium. Students conducted water quality testing and practiced identifying local plant and marine species, as well as learning general information about estuary and salt marsh ecology. This took place in mid- September, prior to the virtual marsh learning activity. Following the field trip, students were sent an email that described a mysterious fish kill that had occurred in the virtual salt marsh at Pirate Bay (see Appendix E). It concluded with an invitation to participate in the investigation (i.e. the scenario) currently underway by the virtual professionals and scientists. Students were provided two initial contacts within the virtual environment to get started on their inquiry. They were also informed of an orientation to the Second Life environment that was to be held during a lab period. At the orientation students created their avatar and practiced basic Second Life skills needed for participation in the problem-based learning scenario.

Working in groups of four, students were given two weeks to explore the virtual salt marsh and develop their initial hypothesis and supporting arguments about the causes of the dead fish, to be presented to the class. After each group presented their findings, the instructor facilitated a general discussion. Each group then had the opportunity to revise and refine their original hypothesis. A few weeks following, groups submitted a final report which included their final hypothesis, justifications and reasoning, along with plans to restore the environment to a healthy state and prevent future fish kills. Groups presented their ideas orally with classmates having the opportunity to question each other's conclusions and offer alternatives. To wrap things up, the faculty member revealed the rationale on which the case was based, including the many bits of evidence, both relevant and irrelevant placed into the scenario for them to discover (see Appendix F). This "answer key" revealed the complexity of the cause-and effect



relationships in this ecosystem, as well as explaining the scientific consensus about the true causes of fish kills, rationalizing the mysterious observations presented in the case (see Appendix G).

### ***Assessment***

An analysis of the outcomes of the project was made from student's written and oral presentations, the instructional designer's anecdotal field notes, student focus group meetings conducted by the instructional designer, and a survey of student opinions, with the intent to evaluate the learner experience and to document the effectiveness of the virtual environment in teaching critical thinking skills. Faculty and instructional design staff reviewed student feedback and reflected on the activity, identifying processes that went well and those needing revision. Following the design-based research model approach (Reigeluth & Frick, 1999), we looked at the data collected in respect to four goals: (1) recording an account of the experience (i.e. in terms of aspects that went well or needed improvement) (2) identifying possible solutions to enhance the learning outcomes (3) devising a means to assess the effects of the changes (i.e. "next steps") and (4) making recommendations to others considering creating similar environments.

### ***Results***

The input and observations are grouped into three categories: (1) the design (2) the student experience and (3) evidence of learning. There is some overlap and interdependency however these divisions helped to organize the findings.

***The Design*** refers to the actual layout of the ***Salt Marsh Dynamics*** learning environment within Second Life and the functional artifacts contained within. The focus here is whether educators, with limited resources and experience can build authentic problem-based scenarios within this venue. The results of this project showed that it is indeed possible to create this type of learning environment, with some scripting and building, on a modest budget.



The largest expense in *Salt Marsh Dynamics* is the rental or purchase of space within Second Life. Since Seton Hall was renting a full “sim” (256X256 meters) prior to *Salt Marsh Dynamics*, and space was available, this was not an issue. However, for others considering such as project, *Salt Marsh Dynamics* was built on a Quarter Sim, (128 x 128, 3750 prims) renting for US\$1500/yr (February, 2010) from New Media Consortium Virtual Worlds. For those on very limited funding, free land rentals do exist from other educational institutions and much smaller parcels are available from the NMC starting at \$100/yr. The \$5000 grant from the New Media Consortium Virtual Learning Prize was spent on scripting for the clue giver boxes which were designed to help students identify important evidence in the case. Total purchases of objects for Salt Marsh Dynamics totaled US\$400 with many objects being obtained for free or little cost. Some editing was done to customize objects for the environment with only a few made from scratch (i.e. heron nesting structure).

All objects worked as expected and students were able to view .pdfs and web site material, however they struggled with the clue giver and guided question boxes with over half finding them difficult to use even though directions were provided. These objects were meant to help students focus on important clues and evidence provided either in the environment, character narratives, or artifacts. The clue giver, indicated by the letter “i” for information, worked on individual avatar proximity and provided a different clue in the chat window each time the avatar approached the object (Figure 1).



Figure 1 - Clue Giver



It was possible if a group of students explored the area together, they would each get a different clue that they could share with other team members.

The guided question boxes provided a set of multiple choice questions that the student answered through chat. These were designed to help students see the relationships between the artifacts and scientific theory.



**Figure 2 – Guided Question Box**

Feedback was provided to each question which included the correct answer and reason that choice was the best (Figure 2). The limitation to this box was only one avatar could interact with the guided question box at a time and once they moved away from the box, the question period ended. Also, it was difficult to send student results to the faculty member in any readable form making it difficult to see if participants were making necessary connections in the environment.

With the most recent upgrade to the Second Life viewer released this February 2010, there is now the ability to create these interactions using a third-party software tool to then import in-world to be displayed on a Second Life object (i.e. box). This would eliminate the scripting problems and limitations experienced, making them easier for student use and capture. The clue givers and guided question boxes could also be used during the Second Life Orientation so that students get used to them, understand their purpose and centrality to the experience.

The topography of the area was inspired by photographs of Horseshoe Cove salt marsh, Sandy Hook, New Jersey, taken by Professor Martha Schoene, another co-author of the project. The layout and design of the virtual environment was built by the instructional designer. Although time-consuming to plan and build, the virtual environment looked surprisingly similar to its real counterpart.



**Figure 3 – Salt Marsh Dynamics Layout**

Students overwhelmingly felt they could make a cognitive connection between the two and enjoyed that aspect of the experience as expressed in these student survey responses:

“I enjoyed the entire sense that we could explore the salt marsh from the computer.”

“I enjoyed that the virtual marsh was a reflection of our actual visit to Sandy Hook”. The information parallel reaffirmed what we learned, both areas allowing for a more effective uptake on the information”.

“I enjoyed being able to investigate a real marsh without having to go and get messy in a real marsh.”

As expected, students still experienced a delay in objects appearing within the environment known as “rezzing in”, associated with using Second Life. They complained about the poor graphic resolution on their university laptops which influenced their ability to visually view the environment and interact with it. When asked what would be one thing they would change in the virtual environments, responses included “better graphics”. This issue has always provided a barrier to using virtual worlds in the classroom. In the latest *NMC Two Minute Survey on What’s Happening in Virtual Worlds* (February,



2010) results indicated university infrastructure needed to support the application still an issue. Virtual world environments perform best on a hard-wired internet connection however the processing power and graphic card capability of the computer is also a contributing factor.

When looking at the ***Student Experience***, the ability to navigate the environment and interact within was definitely a contributing factor to satisfaction. Some students felt the orientation was not enough to pick up the Second Life skills they needed stating that “navigating my avatar” was one of the aspects of the activity they found the most difficult. Since the majority of the students indicated they explored the environment individually, they were not able to help each other with basic Second Life functions throughout the semester. Perhaps adding a scavenger hunt to the orientation within the virtual marsh would help students practice navigational skills and provide a more focused, structured introduction to the activity itself. Exercises could also be built that would encourage students to meet in-world together to perform specific tasks and then share outcomes or methods with each other.

From results on the survey, the majority of students seemed to feel their group worked well together and they enjoyed this process with an added social benefit:

“Believe it or not, it encouraged many of us who had never met before to actually get to know one another. So not only is it great looking, it also promotes social interactions in a sense.”

“The environment, getting to learn about it and interacting with students in an out of class environment was definitely interesting.”

However, the groups also struggled in knowing exactly what they were supposed to do once they interviewed their two characters, if they could find them. It was difficult for them to “decide where to go and what to do”. Confused, the majority of students needed the scaffolding provided in the face-2-face sessions to organize themselves, “I felt as though the majority of learning as done when we worked together as a class talking though things”. This difficulty with the lack of structure is typical of that experienced by students in other problem based scenarios as reported by Williams (1992). Roger Shank (1996) proposed that we learn from our past experiences by forming scripts that we take into the next situation. These scripts are composed of a number of micro scripts that can be quite unconscious. One



could say in our project that some of the students here were lazy learners however an argument could be made that it was not entirely their fault. They were using micro scripts formed from more linear educational experiences. Regardless, students felt they needed more background on the scenario and what they needed to do:

“Improving the introduction to the assignment would help (i.e. explaining that some things aren’t what they seem, showing where things are, explaining the kinks and then general feel before letting users become entrenched and confused.”

This could be easily accomplished by adding an anchoring introductory movie which would set the scene, explain the challenge and provide suggestions as to “next steps”. Anchoring movies invite students to engage in the problem and provide a “macro context” (CTGV, 1993). They help learners to see the problem as one worth solving while providing important background context and direction. Anchors equalize the preparation of the students for the project and help them set goals within the context of the problem, analogous to seeing the “whole task” rather than only pieces (Barab & Duffy, 2000).

The ultimate success of the project is assessed by *evidence of learning*. Did the students achieve the learning outcomes identified for the project even though they may have struggled through the process? The initial and final group presentations offered the best opportunity for confirmation. It was during this time that teams presented their hypothesis and supporting arguments along with making recommendations to restore the marsh to a healthy state. Students had the opportunity to compare the differences in their conclusions and receive input from others regarding their hypothesis. This resulted in a rich, scientific discourse, ending with the students experiencing their “ah-ha” moment as the complex set of causes of the mysterious happenings was revealed by the faculty member. During the focus group session, students commented that during that time, everything fell into place for them.

With that said, it was clear during the presentations that students did not distinguish well between relevant and irrelevant data nor were they sure how to organize information or evaluate its applicability to their hypothesis. Students also did not pick up clues placed in the environment as well as originally



envisioned. Most did not understand the significance of important environmental clues and failed to pick up on small details. For example, few noticed the abundance of jelly fish or that the microbiologist was unfamiliar with the marsh habitat, necessitating the need for his observations to be confirmed. Others fell for the “red herrings” embedded in the case such as twenty-year-old storm data, and reports of horses on the beach. Student comments on the survey revealed they felt they should have been told to “filter information which was provided and that it was all not true” and to “search the area more for clues”.

This presents an interesting challenge to the developers. Students relied heavily on the mini-scripts that they had picked up through past content-driven courses. They implicitly thought that if the information was provided, it must be important and relevant. Instead of looking critically at the environment, they noticed the things they expected to find, and failed to appreciate the significance of unexpected observations. The guided questions and clue givers scattered throughout the environment were designed to help them focus on important information to the case however students failed to use or evaluate that information to support their hypothesis, relying instead on the scripts “told” to them by the character narratives. They were more attuned to the “lecture” method than the “discovery” method, to being told by a so-called “resident expert,” than to investigating for themselves.

In redesigning the experience, this would be a perfect opportunity to teach inductive reasoning, the value of assembling small bits of data to form a hypothesis, which is an important step in creating a scientific theory. Inductive logic looks at the relationship between a set of facts to explain an observation or experience, stating some degree of probability for the conclusion. For ***Salt Marsh Dynamics***, students would gather as much information as they could (i.e. gather widely), and only then put it together to form a hypothesis. This would provide students with a reasoning process to use to solve the problem. Inductive reasoning could either be covered in class by the faculty member or inserted in-world through a virtual agent (i.e. Bot Buddy). In the form of a Scientist, the Bot could serve as a “guide on the side” to help students think through an effective method to solve the problem. Uses of virtual agents are based on the cognitive apprenticeship framework which emphasizes learning at the elbow of an expert who is present to coach and model the cognitive activity (Collins, Brown and



Newman, 1989). The new Second Life Viewer 2 opens additional options for creating the agent in third-party software and importing in-world perhaps in the form of small video clips.

Also needed are better opportunities to capture what students are thinking as they work through the scenario to gauge their progress, provide “just in time” teaching if needed and identify areas for future development in the environment. This could be done with an online field journal or workbook and a series of reflective assignments. Also helpful would have been a grading rubric for group presentations. This would serve to connect the project objectives, reasoning process and case scenario, helping students see the salt marsh virtual activity more holistically.

### ***Conclusions:***

***Salt Marsh Dynamics*** demonstrates a real-world, problem-based scenario in a virtual world (Second Life). The scenario is both engaging and instructional. With a little money, elementary scripting and building experience, and a sprinkling of creativity, the virtual environment can look similar enough to an actual location visited on a field trip to expand the experience and create a learning community within a classroom. However, building an information-studded virtual environment makes various activities possible but does not guarantee that students will pursue them (CTGV, 1993). In addition to the venue, scaffolding has to be provided to identify and model the processes needed to help students develop team building and creative problem solving skills. Real world instructors may provide such scaffolding, but another approach is to build it into the virtual scenario.

Students need to be guided to develop new expectations for learning that involve deeper critical thinking about information, information sources, and greater reliance on testing inductively-generated hypotheses from evidence they collect. They need to be guided to seek out data beyond what is presented or what they can physically see. The detail-oriented ability to “read an environment” is impeded by students’ micro-scripted learning styles, and revising these presumptions requires guidance from the instructors and/or scaffolding within the scenario. ***Salt Marsh Dynamics*** would better facilitate new learning styles with more scaffolding to integrate data collection and theory-generation, facilitate



creative collaboration, and guide effective reflection. Opportunities to practice skill development need to be carefully embedded with the expectation that the learner does not currently have them.

The students in the fall 2009 pilot noticeably wanted to be “told” about the nature and design of the instruction. However one might argue that this clearly shows a need for more problem-based learning in the classroom. Real world problems are complex requiring a higher level of critical thinking. Not all information from sources is valid or appropriate. Students become accustomed to more linear content-driven courses which provide little experience in real-world problem-solving. To develop into confident problem-solvers key proficiencies include: observation and data-gathering, creative yet skeptical inquiry, openness to teamwork and collaborative solutions.

***Salt Marsh Dynamics*** proved to be an excellent tool in both supporting situated learning and assessing student expertise in solving real-world problems in undergraduate science. In the next iteration we plan to overlay our well developed content layer with an improved process layer to help students look more critically at a problem using inductive reasoning. We intend to also provide better anchoring devices to enable students to see the “big picture”, capture student thinking for “just in time” instruction and develop a grading rubric for student presentations.

In closing, Salt Marsh Dynamics demonstrates the value of Second Life as a setting for a virtual world scenario that simulates real world problem-solving. It is hoped that others will look beyond the science model presented here to consider designing scenarios in other contexts. A discipline is “practiced” not in isolation but in relation to other contributing agendas (i.e. social, political, and economic) which is more in line with how content is experienced in the real world, supporting the situated learning theory presented in the paper. Technology has made it possible for us to bring this real-world into the classroom through virtual worlds, however, students are also likely to bring their real-world presumptions into the virtual world, so technology alone does not ensure development of new, more critically-attuned learning styles. Learning environments need to be carefully constructed to allow for the deconstruction of students’ pre-assumptions to allow for the reconstruction of new, more complex notions on how things work.



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Appendix A

Story Characters

Character	Occupation, Location and Focus
 <p><b>Maddie Ball</b> <i>Environmental Scientist</i></p>	<p>Found inside at the Environmental Center. Works for the Second Life Environmental Council on ecological restoration project in Pirate Bay. Cool lady!</p> <p>Focus: Eutrophication, native and invasive marsh plant species, formation of the marsh, how nutrients are generated, importance of balance, rainwater effects</p>
 <p><b>Sunny Cheeky</b> <i>Citizen Activist</i></p>	<p>Found outside the Environmental Center. President of local <i>Save the Bay</i> chapter.</p> <p>Focus: Litter on the beach, thermal pollution, raw sewage in the bay</p>
 <p><b>Jamie Meltzer</b> <i>Grandpa</i></p>	<p>Found down by the beach, old-time resident fisherman.</p> <p>Focus: Historical perspective, weather changes, sea nettles, trash on the beach</p>
 <p><b>TLTC Indigo</b> <i>Park Interpreter</i></p>	<p>Found in the Visitor Center. Young, enthusiastic, has a border collie. Somewhat new to the job.</p> <p>Focus: Provides historical information regarding storm damage at Pirate Bay, draws student attention to nearby sheep and geese, discusses salt concentration on the growth of native grasses.</p>
 <p><b>Dawn Vale</b> <i>Reporter</i></p>	<p>Located by the dead fish in the marsh. Local college student and part time reporter for the paper. Always looking for a good story.</p> <p>Focus: New condo development on Pirate Island, past newsworthy events on Pirate Island, horses on the beach leaving behind fecal material</p>



 <p><b>Ashleigh Hartmann</b> <b>Hydrologist</b></p>	<p>Found by the Water Quality Testing building. Hired by the condominium developer to work on marsh restoration.</p> <p>Focus: Water Quality testing as a method to determine the ecological status of the marsh, role of detoxification and tides, historical on marsh formation and size</p>
 <p><b>Holly Meltzer</b> <b>Microbiologist</b></p>	<p>Located in the Research Center. Called in by the Second Life Marine Sciences Consortium to investigate the fish kill before the reporters get the story. Determines if the beach needs to be closed down. Reports findings to the Second Life Environmental Commission.</p> <p>Focus: Coli form testing, algae species and chlorophyll testing</p>
 <p><b>Jenny Steeplechase</b> <b>Fish Biologist</b></p>	<p>Found by the seining area outside the Visitor Center. Works for the Department of Fish and Wildlife.</p> <p>Focus: Marsh macro species , food web, water quality and ph</p>



## Appendix B

# Character Worksheet



### **Environmental Scientist:**

*Avatar Name:*

*Maddie Ball*

*Voice Narrator: Marian Glenn*

*Location: Environmental Center*

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### **Overall Learning Goals for Environmental Scientist Script:**

- Concept of Eutrophication
- Marsh plant species
- Formation of Marsh from a biological perspective.
- Provide marsh water quality data

### **Specific Objectives for this Character:**

After interacting with this character and supporting artifacts, students will be able to:

- Describe how native grasses lead to formation of the marsh.
- Explain the role of nutrient loading and invasive plants.
- Describe how nutrients in the marsh are generated by the plants and animals.
- Describe the signs, causes and effects of eutrophication.
- Explain the relationship between storm water runoff and eutrophication
- Evaluate test strip results in relationship to eutrophication.

### **Information students are finding from Environmental Scientist:**

- Native and invasive marsh plant species
- How native grasses help establish the foundation of the marsh
- How nutrients are generated in the marsh and the importance of balance in maintaining a healthy marsh environment
- Rainwater effects the levels of nutrients

### **Avatar Appearance:**

- Woman
- Green eyes
- Sunglasses
- Casual shirt
- Work boots or topsiders



**Crazy Talk Text:**

#2

Do you folks know what we mean by eutrophic? It's from the Greek for "well-nourished," but beware, too much nutrition is not healthy for the ecosystem. Normally the river water that feeds the marsh doesn't contain much in the way of minerals. Most of the nutrients in the marsh are generated by the plants and animals that live in the marsh. The river water supplies fresh water, but not much in the way of nutrients. For plants, to grow, they need nitrogen and phosphorous, to make their proteins and nucleic acids (DNA and RNA). Nitrogen is supplied by nitrates and ammonia, and phosphorous is supplied by phosphates. This is what's in the fertilizer that you can buy for your lawn.

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We measure nitrates and phosphates in the bay and in the marsh to keep track of these nutrients. We notice that after heavy rain we get a spike of higher concentration of nitrates and phosphates in the marsh, so we think the river water might be bringing them down into the marsh.

Those nutrients increase the growth of phytoplankton, the microscopic algae that live in the water. The algae on the top shade the ones underneath which then die and begin to rot. The process of decay in the marsh is aerobic it uses oxygen dissolved in the water. So the end result is depletion of the oxygen in the water, which can suffocate the aquatic animals.

So, those nutrients that wash into the marsh end up being too much of a good thing. Eutrophication is not good for the ecology of the marsh. It gets over-fed, and the rotting algae deplete the oxygen from the water, which puts a big stress on the animals.

---

**Cluegiver:**

- Most of the nutrients in the marsh are generated by the plants and animals that live there.
- The river water supplies fresh water, but not much in the way of nutrients.
- Nutrients increase the growth of phytoplankton, the microscopic algae that live in the water.
- The process of decay in the marsh is aerobic it uses oxygen dissolved in the water.

**Learning Artifacts:**

The following materials need to be made ...

- Field Journal of Plants (photos from Martha Schoene)
- Article: *Impacts of Harmful Algae on Eelgrass Beds in Barnegat Bay*  
<http://www.heiditrotta.com/vm/Science%20and%20Technical%20News.pdf>
- Pamphlet : *The Effects of Nitrogen on Our Waters*  
[http://www.heiditrotta.com/vm/pamphlet\\_nitrogen.pdf](http://www.heiditrotta.com/vm/pamphlet_nitrogen.pdf)
- Photo Viewers: Real photos of marsh plants (Martha Schoene)



- Testing Strips Box  
 Strips from 3 different location (ocean, bay, marsh)  
 Strip: Salinity, nitrates, phosphates, dissolved o2, temp



Strip Results:  
 Ocean ... normal (medium) for all

**Marsh**  
 High phosphates  
 High nitrates  
 Low dissolved o2  
 Low Salinity

Temp ... (red herring, just confuses the issue) .... 19 C ... 67 F

**Guided Question:**

1. Detritus is a Latin word meaning ground. It refers to rotting organic material. What is its ecological role in the marsh?

- a. It provides nutrients for filter-feeding animals
  - b. It forms the slimy mud above the sand, for plants to anchor their roots.
  - c. It gives the marsh its distinctive aroma
  - d. All the above
- \*d

2. What do you think explains the neat divisions of the marsh grasses, with *Spartina alterniflora* growing in the lower areas and *Spartina patens* only in the upper areas?

- a. *S. alterniflora* has a higher tolerance for salt.
  - b. *S. patens* can be flooded without damage
  - c. *S. alterniflora* is taller.
  - d. *S. alterniflora* tolerates anaerobic conditions underwater better than *S. patens*.
- \*a

3. What nutrients are often responsible for eutrophication in an aquatic environment?

- a. Nitrates
  - b. Phosphates
  - c. Toxic Runoff
  - d. Insecticides
  - e. All the above
  - f. A and B
- \*f



4. What is the relationship between rainfall and eutrophication?

- a. Rainwater washes away the extra nutrients and reduces eutrophication
- b. Rainwater washes nutrients from the watershed into the rivers which carry the extra nutrients to the marsh
- c. Sediments carried by the rivers can increase the turbidity in the marsh leading to death of the algae
- d. All the above

\*d

5. When you measure the phosphate, nitrates and dissolved oxygen content in the water, which pattern would lead you to the conclusion that eutrophication has occurred?

- a. High nitrate, high phosphate, low oxygen
- b. High nitrate, high phosphates, high oxygen
- c. Low nitrate, low phosphates, low oxygen
- d. High nitrate, low phosphates, high oxygen

\*a

6. Looking at the sites overall, what conclusion do you draw about the concentration of nitrates in the marsh.

- a. Higher than normal
- b. Normal
- c. Lower than normal
- d. I can't draw a conclusion

\*a

7. Looking at the sites overall, what conclusion do you draw about the concentration of dissolved O<sub>2</sub>

- a. Higher than normal
- b. Normal
- c. Lower than normal
- d. I can't draw a conclusion

\*c



Appendix C

Maddie Ball: Objects, Artifacts and Location



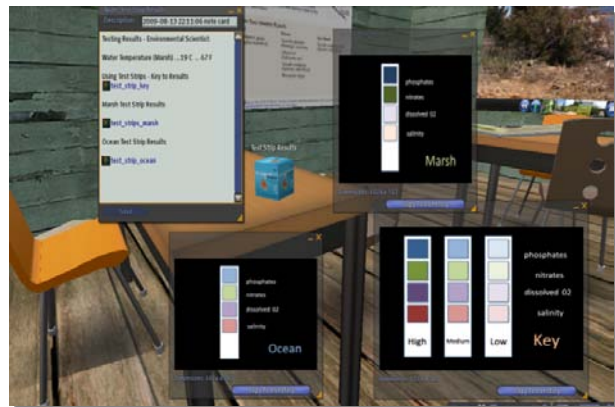
**Environmental Center – Home of Maddie Ball**



**Inside Environmental Center**



**Online Computer**



**Testing Strips**



**Field Journal**



## Appendix D

### Example of Character Narrative



<< [Click to View Movie](#) >>>

*Maddie Ball  
Environmental Scientist  
Second Life Environmental Council*

*Hi Folks, I have to ask you not to muck around in the marsh grass. This grass is not at all like a lawn in your yard. This is "working grass," it's the foundation of the marsh. Without the humble grasses, there would be no marsh, not even mudflats, just open water or sandy shoals. The grasses trap sediment, and as they grow, and their old blades die and decay, their detritus, the decaying dead parts of the plants, make the mud and peat that anchors the marsh. It's also what you smell, that pungent salt marsh aroma.*

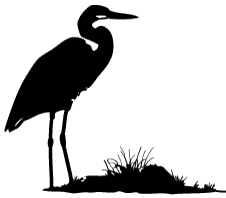
*I am working on an ecological restoration project here in the marsh. There are invasive plants like this reed grass, *Phragmites australis* that can crowd out the native plants. It's just begun to invade this part of the marsh. Notice the two native grasses growing around the edge of the marsh. These are the foundation of the salt marsh ecology. Besides stabilizing the sediment they also provide a habitat for all the animals.*

*The taller grass, called *Spartina alterniflora*, or in English, salt marsh cord grass, grows as far as the high tide line. Above that line, you find the salt hay- *Spartina patens*. It is a shorter and finer grass. It was traditionally harvested as bedding for horses and cows, and also used to stuff mattresses for people. When *Phragmites* invades, it changes the ecology of the marsh, and the usual habitats disappear. In ecological restoration, we remove the mighty phrag and encourage the growth of the humble spartinas.*



## Appendix E

### Email Letter



This morning employees and residents of Pirate Bay were astounded to find the shores of the Salt Marsh littered with dead fish. Officials estimate that between 150,000 and 200,000 fish died mysteriously during the night. Water Quality testing showed no evidence of toxins or low oxygen content in the Marsh water. Local officials have called in a team of experts to perform follow up tests in the bay, ocean, inlet and marsh. There is a need for volunteers to help in the ongoing investigation. You have been assigned to assist the (Hydrologist and the Park Interpreter) in order to determine the cause of the fish kill and to propose a solution for this event. Please join us at Pirate Bay on the Seton Hall Island (aka Pirate Island), in the virtual world of Second Life, as soon as possible. . Make sure to first attend a special **Second Life Orientation** where you will create your Second Life account and get your “feet wet” in this virtual world environment to be held: **Thursday, October 1, 2009 at 2:30 pm** in the Foreign Language Lab, second floor, Fahy. Step-by-step directions are attached along with a map of the area.

Once you arrive on Pirate Island, you will want to head southeast to find the Visitor’s Center at Pirate Bay. Obtain important directions from the board outside the Center labeled “Begin Here”.

Yours,  
The Mayor of Pirate Island



Appendix F

Course Schedule

Date	Topic
9/1	Introduction
9/3	Salt Marsh ecology, Discuss Chapter 1 – Life and Death of the Salt Marsh
9/8	Salt marsh discussion, Chapter 2 – Life and Death of the Salt Marsh
9/10	Salt Marsh Discussion, Chapter 3 – Life and Death of the Salt Marsh
9/17	Sandy Hook field Trip
Lab	
9/22	Salt Marsh Discussion, Chapter 4 - How marshes die
9/24	Salt Marsh Discussion, Chapter 5 and 6: Each group reports on marsh of particular area
Lab	Second Life Orientation, CTC Classroom
9/29	Salt Marsh Discussion, Chapter 7 and 8: Plants
10/1	Salt Marsh Discussion, Chapter 9-11: Animals, Season, Productivity
10/8	Reports on management issues in particular marshes
Lab	Group Presentations on Initial Hypothesis in <b><i>Salt Marsh Dynamics</i></b>
11/10	Final Student <b><i>Salt Marsh Dynamics</i></b> Presentations
11/12	Student Focus Group on <b><i>Salt Marsh Dynamics</i></b>
11/17	<b><i>Salt Marsh Dynamics</i></b> survey released to students
12/8	Final Class Date



## Appendix G

### Case-Study Description

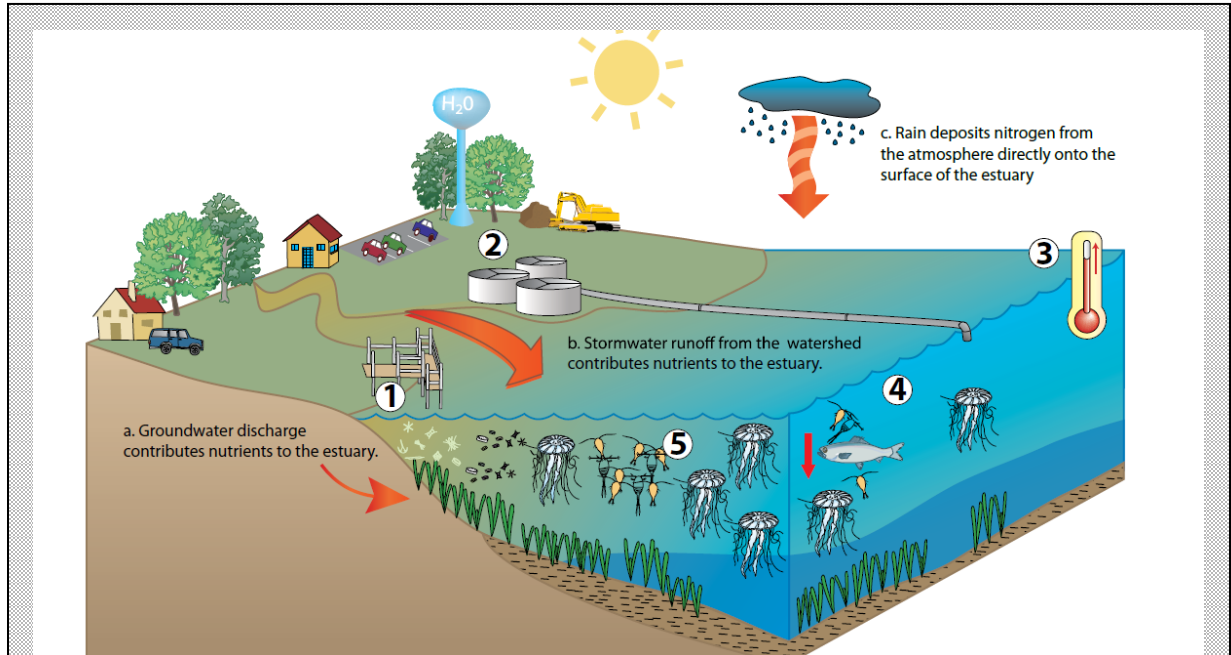


Image Credit:

[http://www.bbep.org/downloads/BBNEP%20newsletter%20SummerFall09\\_web.pdf](http://www.bbep.org/downloads/BBNEP%20newsletter%20SummerFall09_web.pdf)

#### The Hidden Secret of the Marsh

This environmental science problem-based scenario is based on the topic of non-point source pollution (NPS). Unlike pollution easily traced to a particular source, non-point source pollution comes from many diffuse sources. For example, melting snow or rainfall washes material from the land into lakes, rivers, wetlands, and coastal waters causing pollution that affects the communities of plants and animals in these areas.

In the case of the *Salt Marsh Dynamics*, a storm event has occurred in watershed. The storm water has washed lawn fertilizers and animal waste into the rivers that flow into the salt marsh. In addition, the excess water has caused the sewage treatment plants along the river to overflow, releasing sewage into the salt marsh. This nutrient rich run-off has caused eutrophication (over-feeding) in the marsh observable by:

- An increase in concentration of nitrates and phosphates, and a large fecal coli form count.
- Excess growth of algae (phytoplankton) and influx of jellyfish into the area.
- Anoxia (low dissolved oxygen) causing death of sensitive fish species such as the common Atlantic silverside.