"THE PATHOGEN" – VIRTUAL INVESTIGATION & IDENTIFICATION OF EMERGING PATHOGENS

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Abstract: (*150 words*)
The author proposes the development of an interactive computer-based game which is designed to educate students about biotechnology and emerging pathogens. The game will follow an investigation of an outbreak from the perspective of an epidemiologic investigator. The learner will be tasked with the identification of the pathogenic cause of the outbreak by utilizing biotechnologies such as micropipette techniques, restriction endonucleases, agarose gel electrophoresis, and a bioinformatics database. This game will enable learners to investigate biotechnology in a safe, familiar and engaging environment of a computer game. It will also afford learners an opportunity to view and learn about real-world applications of biotechnology as well as provide the learner with an overview of the complicated process of identifying a pathogenic agent of an outbreak. Finally, the learner will be able to see the entire process without requiring purchase of the equipment needed for this investigation.

Mission Statement

To design and develop an interactive game that will provide a safe, familiar, and engaging environment for secondary school students to investigate the entirety of the process of identifying emerging pathogens as the etiologic agents of given medical situations using virtual versions of modern biotechnology. *(45 words)*

Description of Teaching Module:

This proposal concerns the design and development of an interactive game. Given that the product of this proposal is intended to be similar to a computer game it will hereafter be referred to as "The Game". The Game is designed to take the player through the stages of investigating and identifying a bacterial or viral pathogen as the cause of the virtual epidemic. The Game, in its current formulation, will only simulate a single pathogen, but future versions will expand this number to include multiple agents so that there will be multiple storylines although the method for identifying the agents will be virtually identical.

Utility

The Game may be used to introduce a lesson on biotechnology, as a means to understanding the real world implications or virology or bacteriology, a stand-alone investigation to develop critical thinking skills, or as an assessment for a biotechnology course. Learners will develop an appreciation for the biotechnology techniques

investigated and explained in this module. Additionally, learners will appreciate the contributions of different scientists and techniques in the completion of a very complex problem. Further, learners will also understand the entirety of the process of identifying a pathogenic agent for an apparent outbreak or epidemic. Finally, the module will directly inform the learner of biotechnology and some noteworthy techniques without the expense of purchasing costly biotechnology equipment.

Even at some of the best equipped public secondary schools a significant obstacle for learners and teachers is access to funding to acquire biotechnology devices for the classroom laboratory. This module overcomes those limitations by placing multiple tools in a virtual environment in order to expose students who would not be able to see or interact with these tools ordinarily. Additionally, the virtual environment is safe. There is no risk of harm to the student or to the equipment in this module. If a learner errs, she received feedback that she committed an error and returns to the decision point until the correct decision is made. There is no need for safety equipment or a laboratory. Everything needed for this module is safely contained in the virtual lab.

Introductory Animation

The game will begin with an introductory animation. This animation will convey that there is an outbreak of unknown etiology at Grove hospital. Twelve (12) cases have been reported already, and the hospital believes that more cases are inevitable. The reported symptoms are flu-like and fairly nonspecific, but the cases rapidly deteriorate. Furthermore, two (2) of the 12 cases at Grove hospital have expired in the past 24 hours. The player assumes the role of Dr. Elisa, a county epidemiologic investigator. A panicked call comes from the mayor's office: "what do we do Dr. Elisa?" Next, text appears on the screen that communicates to the player that she must first identify the agent of the infection. Successful identification of the pathogen will quickly lead to controlling the epidemic, but the first step is of utmost importance, and needs to be done as soon as possible. There is not much time as the epidemic is continuing to spread, and the longer it takes Dr. Elisa to identify the pathogen, the higher the number of fatalities due to the unknown pathogen. The text will finally communicate that samples from one patient at Grove hospital have arrived to the lab. The samples appear on the lab bench, and the investigation begins.

Tasks in The Game

The Game will consist of five (5) major tasks. Each of the tasks must be completed correctly prior to moving on to the next task. Each task will have at least two (2) decision points in the current version, but future versions will expand the decision points and increase the interactivity of each task.

Task 1

The first task will be to correctly label the sample. When the samples arrive at the laboratory in standard containers they will be marked as "Sample 1", etc. The first prompt for the player will task the player with correctly indicating the contents of the container, and then to extract some of the sample to Eppendorf tubes for the purpose of extracting the pathogen from the sample fluid obtained from the patients at Grove

hospital. Once again, the player is prompted with a query of how to properly label the Eppendorf tubes. There are a couple of noteworthy reasons why correct labeling was selected as the first task in The Game. First, it logically occurs first. Once anyone receives anything, the first step is to classify it within the recipient's system of organization. Second, this is considered to be a fairly simple task. It seems logical to begin any activity with a task that is simple enough to demystify the activity so that even less confident students will feel empowered to continue progressing through the various tasks. Finally, in every classroom laboratory it is common to see students abandoning the simple step of proper identification of a sample in favor of maximizing the time they have to complete the actual procedure. However, it is difficult to conceive of a more important step than proper identification for any procedure. Hence, the first task is designed to not only be relatively easy, but also reinforce the importance of the rational deliberation in the laboratory.

Task 2

The second task will be to extract the DNA from the provided sample in order to correctly perform a southern blot technique. Once the player has correctly labeled the sample, she will be given positive feedback, and then queried with multiple options for how to proceed. The multiple options will be presented as a single multiple choice problem, and if an incorrect response is produced there will be feedback concerning why the selection was incorrect but also providing positive feedback for the player. Once she correctly selects that her next step is to extract the DNA from the sample, the player will see a brief animation on the techniques of extraction and then an animation of the process of extracting the DNA from the sample.

Task 3

The third task will be to identify the pathogen's DNA by utilizing a southern blot technique. Just as in the previous stage, the player will be prompted with a multiple choice question. If she selects an incorrect choice, then feedback will be provided to the player as to why the selected option is not the most appropriate step at this point in the investigation. Once the player selects the correct option of a southern blotting technique, a brief overview animation will show her what steps need to be done to complete the technique. However, this animation also contains all of the answers for the decision points in this task. Following the animation the player is prompted with a multiple choice question of which step to begin the technique. Additionally, there is a link at the bottom to the prior animation in case the student wishes to review the steps of the technique. This affords additional repetition and reinforcement of the technique. Since proper learning usually requires repetition, this method is user centered and allows the learner to assess their own level of knowledge, and if she deems it insufficient the tools are at her fingertip to rectify the situation and expand or clarify her knowledge of the technique. Once the player selects the correct first step, using endonucleases to digest the sample DNA, she then will view an animation of the endonucleases being added to the sample. The next decision point is what to do next in the southern blotting technique. Once the player correctly selects agarose gel electrophoresis, with the same feedback as mentioned previously in the task, an animation showing the loading of the sample into the gel wells will play, and then the

results of the electrophoresis will be displayed. Then the player will be prompted with whether she would like to view an animation on interpreting electrophoresis results or simply view the results of her virtual electrophoresis.

Task 4
The fourth task will be to sequence the DNA of the pathogen. A brief animation will communicate that now the DNA pieces must first be amplified, then sequenced, and finally assemble the contiguous fragments. The player will be tasked then with determining what step to begin. Once she correctly selects amplification, a brief animation of amplification will play and she will be prompted with a second question. Once sequencing is correctly identified, she will view a short animation on the sequencing of her sample pathogenic DNA. The final question for this task will then be posed. Once she again selects the correct step, assembly of the contiguous fragments, she will view an animation of the process of how those fragments are assembled. Finally, the result will be shown as a sequence of nucleotides denoted by A, T, G, or C.

Task 5
The fifth, and final, task will be to utilize a bioinformatics database in order to identify the pathogen by its DNA. A brief animation will be shown about bioinformatics and BLAST. Then the player will be tasked with entering the sequence into the correct input box on a website. There will not be an actual website or linkage, but the purpose is to emulate the BLAST interface, but in a vastly simplified version so that a learner will understand what input is needed, and what successful input will generate. Indeed, the only possible output is the correct output, but the learner does not need to know that. After she selects the option to copy and paste the sequence she obtained from the previous step into the input box for the bioinformatics database, the matched organism will be displayed and the correct identification of the pathogen will be complete.

<u>Supplies</u>
The Game will be authored in Adobe Flash CS3 Professional. The interactive experience will be similar in form to popular computer FPS (First-Peron Shooter) games and their environments. This approach will lend a significant degree of familiarity and comfort to the player. Data on computer game sales and online expenditures by adolescents lead to the expectation that secondary students will be very familiar with the virtual environment, tools, and functions featured in The Game. It is estimated that 200 million people engage in computer games throughout the world and 21% of them are secondary school and college aged students. Indeed, given the quality of the animations and the storyline there may even be exogenous interest in The Game.

Expertise of the PI:
Mr. Boswell authored each and every component of the action proposal. Starting in 2002, Mr. Boswell developed commercially viable SAT and ACT preparation products. Indeed, for two (2) years, he led a company from its inception to its sale to a major software manufacturer. During this time, he conceived, organized, and programmed the SAT and ACT preparation products. There were two (2) main products and both were

produced in Macromedia Flash MX (now called Adobe Flash Professional). Mr. Boswell is also a teacher at Cypress Bay High School in Weston, Florida. He teaches Advanced Placement Biology, Honors Chemistry, and Physics. Mr. Boswell will be assisted by Renoj Varughese, who is a student at Cypress Bay H.S. and familiar with programming languages. Together they believe that they will complete the project in about two (2) months, and then pilot test The Game at Cypress Bay H.S.

Literature Cited

"Second life". 2003. Linden Lab Inc. June 26, 2008. http://secondlife.com
"Biointeractive - Virtual Labs". 2008. Howard Hughes Medical Institute (HHMI). June 26, 2008. http://www.hhmi.org/biointeractive/vlabs

Budget & Justification

One item is required for this project: an upgraded to the most recent Adobe Flash CS3 Professional software version. The cost of this product is approximately $205.00. The PI will gladly pay the negligible difference between the maximum grant award and the cost of the upgrade product. While Adobe Fireworks and Photoshop will be used in designing the product, only the Flash upgrade is necessary as the newer version provides substantial streamlining of development and actionscript programming. Additionally, the PI already has a fully licensed copy of Adobe Fireworks and Professional, but has a substantially older and less functional version of Adobe Flash Professional.