Simulations for Learning: An Inquiry-Based Approach to Biology

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Introduction

BioBLAST® is a multimedia curriculum supplement for high school biology classes. In the *BioBLAST* scenario, students use simulations based on USA National Aeronautics and Space Administration (NASA) life sciences research data to develop and test their own designs for a biological life-support system that could support humans in space. The primary goal of the *BioBLAST* program is to get students involved in critical analysis and problem solving processes associated with scientific inquiry. The interactive adventure/simulation framework includes computer-based tools and resources, telecommunications events, and hands-on experiments that are all presented within a graphically rich QuickTime™ Virtual Reality (QTVR) interface. [Figure 1] provides an illustration of the three-dimensional lunar base model used in the QTVR user interface to the interactive simulations. The software is designed to draw students into a futuristic, problem-solving scenario in which teams of students are sent to a simulated lunar research facility. There, students use graphical simulation tools and resources to prepare for their mission goal: to design and test a model for a plant-based life-support system that can support a crew of six for three years.

Features of Simulations

The laboratory-based Plant Production [Figure 2], Human Requirements, and Resource Recycling simulators enable students to perform investigations not possible in real time or within the facilities of a high school lab. In addition, the interactive, simulation/modeling tools give students hands-on experience with the technology tools that scientists use to collect, analyze, and display complex sets of data. The three lab-based simulations are designed to accompany each of the three research strands within the BLiSS (Bioregenerative Life Support System) problem that students will address. A fourth simulation called BaBS (**B**uild **a** **B**LiSS **S**imulator) [Figure 2] is used to pull all three topical areas together to construct an idealized model of plant-based life-support system. Students refer to the research database provided within the main simulator to generate their numeric entries regarding crop growth, human diet, energy requirements, resource recycling parameters, the number and gender of crew members, and duration of the test. All four of these simulations utilize NASA data and make it easy for students to export the database and the results of their simulation runs. Students are encouraged to further analyze their results in a spreadsheet program. Through the process of selecting and testing features to include in their simulation run, students apply, synthesize, and expand their understanding of such principles as: (1) how energy flows through living systems; (2) the role of plants in recycling air and water cycle for human use; (3) how various environmental factors affect the rate of photosynthesis; and (4) why photosynthesis and cellular respiration form a continuous cycle. As prescribed in the National Science Education Standards (NSES) [NSTA, 1996], student work with the simulations leads up to a design model that the student must explain and defend in a written report and/or verbal presentation. The final BaBS run, analysis, and report is one of the culminating activities in *BioBLAST*.

Teacher Involvement

Early on in the development of this program, high school science teachers representing a variety of cultural and socio-economic communities and geographic regions of the United States were selected to participate in the design, testing, and evaluation of this software. Two primary criteria were used to select teachers to join the extended design team: (1) access to the computer technology required to run the software; and (2) demonstration of a clear desire to use an inquiry-based approach that emphasizes problem-based learning. This study describes how early involvement of teachers in the design, development, and formative evaluation process helped identify the goals for teaching and learning that the simulations in this software most effectively address. Teachers used the initial list of goals that we designed this software to address as a planning document.

Based on teacher reports regarding the process of integrating the simulations and related materials, student use and analysis of outcomes of the *BioBLAST* simulations fulfill the NSES [NSTA, 1996] through activities that ask students to: (1) Trace energy transformation and/or apply the principles of mass/energy conservation to physical and biological systems; (2) Relate the effect of light and other factors on various aspects of plant life and growth, including photosynthesis and respiration, germination, and tropisms; (3) Predict the effect on an ecosystem due to a given or proposed environmental change; (4) Formulate an experimental design to test a given hypothesis; and, (5) Relate the effects of biotic and abiotic factors to animal life including growth, reproduction, and behavior.

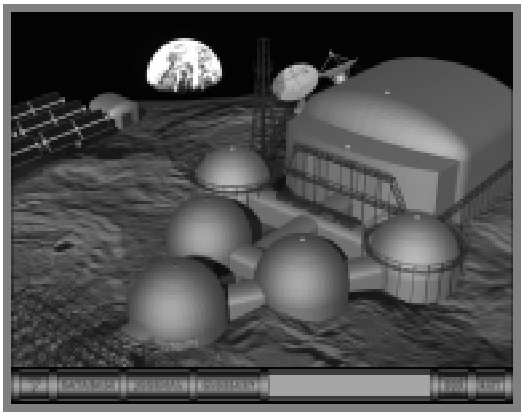

Figure 1. This screen capture shows the graphical interface for one of the *BioBLAST* simulators.

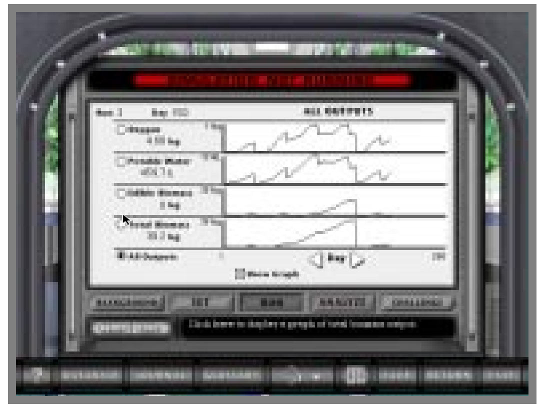

Figure 2. This screen capture illustrates the dynamic graphing available in the *BioBLAST* simulators.

Summary of Results

The formative evaluation of the *BioBLAST* software included data from pre- post-tests, student reports, teacher observations, and student work. Teachers developed unique ways to integrate this program into their curriculumin that suited their school curriculum and course offerings. BioBLAST has been incorporated into introductory, general and advanced biology, advanced technology, student research electives, and math classes. Teachers reported that they had to change their teaching style to integrate this program and found that students needed the following skill-building activities prior to beginning the computer simulations: (a) cooperative learning and team building activities; (b) introduction to the use of spreadsheets for organizing and analyzing data; (c) concept mapping to tie together concepts and connect ideas; (d) building and interpreting graphs to represent data; and (e) conversion to and use of metric units of measure. Further analysis of pre- and post-tests will show whether our selection of ninth grade as the target population for *BioBLAST* is consistent with the findings of [Friedler & McFarlane 1997] and [Burkam, Lee, & Smerdon 1997] who determined that data logging and analysis can significantly improve student graphing and interpretation skills if conducted prior to age 16. Analysis of student portfolios provide descriptive indicators of student motivation and effort and, as [Hickey 1997] suggests, will provide ways to document teacher reports of increased student motivation and effort associated with the interactive media tools and approach to teaching that encourages inquiry-based learning.

References

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