

A Comparative Study of Teaching Strategies in Biotechnology Education

With the Inclusion of Game Simulation

Renaë Allen

Union County High School

Abstract

The purpose of this action research investigation is to determine the impact of gaming techniques on curriculum comprehension using biotechnology concepts. A computer game implementing a laboratory simulation will be used to enhance student understanding of biotechnology content, equipment, and procedures. Mission Biotech software developed through a grant with the University of Florida and the National Science Foundation will be evaluated. Two classroom content areas will be compared using a biotechnology curriculum; chemistry students and health occupation students. Both classes will receive identical content and laboratory instruction. The primary curriculum variable will be the use of game simulation with the chemistry students. The fact that two different content area classes will be compared could be considered a secondary variable. One would assume that students registered in an optional health science program would naturally have a high interest level for biomedical science content. Pre- and post-tests over concepts will be given. An attitudinal survey will also be given as a tool for data analysis.

Rationale

Science and technology provide for the development of tools that advance civilizations. The number of students with a desire to pursue higher-level science education and degrees is currently falling while the demand is rising. Even those students who begin a science or engineering degree in college often switch majors after the first year because they are unable to “tolerate it”. According to Mayo (2007), almost all (98%) of those who leave the engineering major cite “poor teaching by faculty” as a major concern. It seems that traditional teaching methods are “boring” the new generation of college students out of science.

Today’s college students have grown up in an era of computer and video entertainment. Research indicates that video-game playing enhances the release of dopamine in the brain. Dopamine has been found to enhance memory, therefore, video games may “prime” the brain for learning new material.

One advantage games and simulations appear to have over traditional teaching methods is that student or pupil involvement tends to be very high and may have a basis in more than one academic discipline which can help participants integrate concepts, thus enabling comprehension of the bigger picture (Ellington, 1981). Games have been played for thousands of years, but the application of game-playing to educational curriculum is a relatively new area of application. The first similar application was used by military instructors to simulate war strategies. The business-world began to adopt game and simulation techniques by the 1950’s.

In terms of improving content knowledge, Leutner (1993) discovered that students can learn how to play a game without instruction or support. However, “they only acquire a minimum of verbal knowledge about domain-specific concepts, facts, rules, and principles”. If the student obtains advice from an instructor while learning the content of the game, verbal knowledge of concepts, facts, rules and principles is maximized.

The purpose of my action research is to investigate the effectiveness of using the game simulation called “Mission Biotech” as part of a biotechnology curriculum. The game simulation will be the primary variable in this curriculum investigation.

Action Research Intervention

I will implement a lesson plan that includes interactive lecture, hands-on laboratory activities and collaborative group activities covering concepts such as DNA extraction, PCR analysis, and biotechnology careers. Specific learning goals will include:

1. Gain understanding of the basic concepts relevant to the field of biotechnology.
2. Become familiar with the basic tools used by biotechnologists and review lab safety guidelines.
3. Learn to use a pipettor effectively.
4. Gain understanding of the role DNA plays in diagnosing genetic disorders and diseases.
5. Participate in a DNA extraction activity.
6. Gain understanding of the structure and types of viruses.
7. Make 3-D models of viruses.

8. Learn the meaning of PCR (Polymerase Chain Reaction) and how it can be used to diagnose viruses.
9. Students will apply computer gaming strategies to reinforce biotechnology concepts learned using the software program, "Mission Biotech".
10. Students will explore a variety of biotechnology careers.

This lesson plan will be taught to two different student groups. Group one will consist of students enrolled in the Union County High School Health Academy curriculum while group two will consist of students enrolled in a chemistry curriculum. The chemistry group (group 2) will receive supplemental instruction through game simulation. If the size of the lecture facility allows, both groups will receive lecture content and perform written assignments and laboratory activities together in order to reduce variability of content presentation. Content knowledge before and after the lesson will be assessed using pre- and post-testing. In addition to content knowledge evaluation, attitude surveys will be given to all students.

Connections to Bench to Bedside Summer Institute

Several presentations and laboratory experiences within the "Bench to Bedside" Biomedical Sciences program at the University of Florida, led me to develop this action research proposal. The first presentation of Dr. Troy Sadler was of immediate interest to me as he introduced the concept of using a game simulation of a biotechnology lab. Because I teach in a small, rural county, laboratory supplies and equipment are very limited. Simulation would allow my students to manipulate equipment and processes they would otherwise be unable to experience. The various lecturers who discussed specific diseases and disorders provided me with greater background knowledge on some of the latest discoveries and treatments. Our visit to the Center of Excellence in Regenerative Health Biotechnology in Alachua was also of particular interest to me because the facility and equipment replicated the facility and equipment in the game simulation. I thought it would be a great experience for my chemistry students to be able to visit this facility and do a simple lab activity just to "feel" the biotech lab environment. I will work to arrange such a visit. I was also thankful for the opportunity to hear Dr. Barry Byrne discuss his specific genetic research as a follow-up to the movie "Extraordinary Measures".

Data Collection and Analysis

Data collection will begin with a pre-test of multiple choice content questions relating to biotechnology. I would expect low scores due to the fact that these students would not have been exposed to a biotechnology curriculum in the past. Scores in both groups will be averaged and the standard deviation will be calculated. A post-test will be given at the end of the biotechnology unit

lesson. Once again, the average score and standard deviation will be calculated for both groups. Finally, the correlation of content achievement based on pre- and post-testing will be compared using the Pearson Product Moment Method Coefficient of Correlation.

Literature Cited

- Ellington, Henry, et al. (1981). *Games and Simulations in Science Education*. Nichols Publishing Company, New York, New York.
- Mayo, Merrilea. (2007, July). *Games for Science and Engineering Education*. Communications of the ACM. 50(7). ACM. New York, NY.
- Leutner, Detlev. (1993). Guided discovery learning with computer based simulation games: Effects of adaptive and non-adaptive instructional support. *Journal of Learning and Instruction*. Great Britain. 3(2), 113-132.

Permissions

Local IRB consent.

Administrator: Dr. Chris Wood, RN: Amanda Griffis, Teacher: Jamie Dekle
 Permission from the school district office for software installation on school computers.
 Informed consent will be mandatory for all student participants.

Budget

25 copies in paperback of "The Cure" by Geeta Anand	25 @ \$10.87	\$271.75
5 containers of fresh strawberries	5 @ \$3.00	\$15.00
3 pkg of wooden popsicle sticks	3 @ \$3.00	\$9.00
1 bottle of dish detergent	1 @ \$2.00	\$2.00
2 boxes of Ziplock bags	2 @ \$3.00	\$6.00
6 bags of miniature marshmallows	6 @ \$2.00	\$12.00
10 boxes of toothpicks	10 @ \$1.00	<u>\$10.00</u>
Total		<u>\$325.75</u>

Theme: Biotechnology

Lesson Title: Biotechnology-Applications in Chemistry and Health Sciences

Grade Span: 9-12

Content Emphasis: Health Sciences and Chemistry

Targeted Benchmarks:

SC.912.L.16.7 Benchmark Description: Describe how [viruses](#) and [bacteria](#) transfer [genetic](#) material between [cells](#) and the role of this process in [biotechnology](#).

SC.912.L.16.10 Benchmark Description: Evaluate the impact of [biotechnology](#) on the individual, society and the [environment](#), including medical and ethical issues.

SC.912.N.3.5 Benchmark Description: Describe the function of [models](#) in science.

Author: Renae Allen

School: Union County High School, Lake Butler, Florida

District: Union

Lesson Preparation

Learning Goals:

1. Students will gain an understanding of the basic concepts and applications relevant to the field of biotechnology.
2. Students will become familiar with the basic tools used by biotechnologists and review lab safety guidelines.
3. Students will learn to use a pipettor effectively.
4. Students will gain understanding of the role DNA plays in diagnosing genetic disorders and diseases.
5. Students will participate in a DNA extraction activity.
6. Students will gain understanding of the structure and types of viruses.
7. Students will make 3-D models of viruses.
8. Students will learn the meaning of PCR (Polymerase Chain Reaction) and how it can be used to diagnose viruses.
9. Students will apply computer gaming strategies to reinforce biotechnology concepts learned using the software program, "Mission Biotech".
10. Students will explore a variety of biotechnology careers.
11. Students will become familiar with the physical set-up of an actual biotechnology lab by visiting a biotech lab facility as a class field trip.

12. Students will learn the details of an actual biotechnology research success story as a result of reading the book “The Cure: How a Father Raised \$100 Million – And Bucked the Medical Establishment – In A Quest to Save His Children”. The book will be a companion reading lesson with the Biotechnology Unit.

Estimated Time

This unit will be taught as a series of lessons over a period of four weeks. Each week will focus on a particular topic/theme which will include the use of a computer game incorporating biotechnology laboratory simulation.

Week 1 – Introduction to Biotechnology

Week 2 – DNA

Week 3 - Viruses

Week 4 – Biotechnology Careers

*Following the completion of this biotechnology unit, students will have the opportunity to visit a biotechnology lab as a class field trip.

Materials/Resources

Mission Biotech Program and Teacher Guide, 2010 University of Florida

The Molecular Basis of Heredity: Structures and Functions of Nucleic Acids, by Raye L. Alford, PhD. Baylor College of Medicine. BioEd Online Teaching Resource Materials 2010

(Fresh strawberries, wooden sticks, cheesecloth, ziplock bags, and detergent are needed for a DNA extraction activity)

Virus Shape and Structure and How Do Drugs Work. RCSB PDB website, www.pdb.org, 2008.

Website of the Protein Data Bank managed by Rutgers, The State University of New Jersey and the University of California, San Diego.

(Marshmallows and toothpicks are needed for virus model activity)

Student internet access for general research regarding biotechnology careers.

University of Florida, Center for Precollegiate Education and Training, for DNA Biotechnology Kit and Biotech Monopoly Game access.

The Cure: How a Father Raised \$100 Million – And Bucked the Medical Establishment – In A Quest to Save His Children by Geeta Anand. Harper Paperbacks, 2009. Need 25 copies.

Teacher Preparation

Biomedical Explorations: Bench to Bedside 2010, University of Florida, Center for Precollegiate Education and Training, Teacher Training Program

Supplies for hands-on activities, borrowed or acquired through the Center for Precollegiate Education and Training, University of Florida

Review *Action Research – A Guide for the Teacher Researcher*, Geoffrey E. Mills. 4th Ed. Pearson Education, Inc. 2011

Acquire school district cooperation for use of the Union County High School computer testing lab facility and permission of the district technology specialist to use Mission Biotech software. Access to the school site technology administrator to download software on all computer lab machines.

Lesson Procedure and Evaluation

Introduction

The students at Union County High School in Lake Butler, Florida reside within a very rural community. I expect them to have little to no background knowledge in biotechnology related concepts. Their only experience will be limited cellular biology knowledge acquired in the biology class they have probably taken within the past two years. I will use a biotechnology pretest in order to assess the scope of their background knowledge and determine areas of greatest academic weakness. Whole class discussions will give students the opportunity to ask questions and clear up misconceptions.

Exploration

During this unit, students will learn several areas of study included in the field of biotechnology. They will learn to identify the basic tools found in a biotech lab and review safety procedures. A hands-on activity will include the use of a pipettor. Students will also be introduced to a computer game called "Mission Biotech" and will be asked to complete a series of levels over the period of four weeks in the school computer lab.

Students will also review the basic cell model and the role of DNA in the cell. The chemistry of DNA will also be reviewed. This material should activate background knowledge from previous biology classes. Students will learn the importance of being able to extract DNA from cells for diagnostic purposes. A basic DNA extraction procedure using strawberries will be used as a hands-on activity. Students will learn about RNA and DNA viruses. The basic structure of a virus will be taught and students will make 3-D models of virus structures using marshmallows, toothpicks, and foldables. The meaning of PCR and PCR analysis will be taught; traditional and Real-Time PCR will be reviewed. During the DNA and Virus content of this unit, four days will be spent in the school computer lab in order to use the Mission Biotech computer game for concept reinforcement.

Qualifications, job descriptions, responsibilities and salaries for a variety of biotechnology careers will be explored. Students will participate in producing career posters as a group activity. Each group will be given time to play the Biotech version of Monopoly in class.

Application

Students will have the opportunity to apply what they learn in class to character progression in the Mission Biotech computer game. Lab equipment and safety procedures learned in this unit will be applied to all lab use activities for the remainder of the school year. Students will also apply knowledge gained in the biotechnology unit for success on the end of unit posttest.

Assessment

Quiz – Biotechnology Tools (identify tools and use)

Quiz – DNA (role in cellular function and basic chemistry)

Participation – Hands-on Activities; Using a Pipettor, Strawberry DNA Extraction, Making 3-D Virus Models

Group Project Assessment – Poster and Presentation of a Biotechnology Career

Mission Biotech Assessments – Level Completion Quizzes, checklists, virtual lab notebooks

Pre and Post-Tests with content covering entire biotechnology unit

All content will specifically correlate to targeted benchmarks .

Implementation Dates (September 19-October 15, 2010)