A Study of the Impact of Teaching in-depth Biotechnology Concepts and Laboratory Techniques on the Knowledge, Attitudes and Skills of High School Biology Students

Ybelise Escoto, Biology Teacher
Freedom High School
2500 W. Taft Vineland Rd
Orlando, FL 32837
Ybelise.escoto@ocps.net
Abstract: The purpose of this research is to measure the effect of the implementation of in-depth biotechnology knowledge, laboratory skills and attitude towards biotechnology. The plan is to expose a honors biology class of about 25 students to in-depth biotechnology concepts and laboratory skills. I will choose the class of students that has highest average on three formal class assessments. Data will be collected using both qualitative and quantitate techniques. The hypothesis is that by exposing students to in-depth concepts accompanied with hands on real science students will develop higher level knowledge and skills with and better attitude towards biotechnology.

Rationale: Our 9th grade biology students have minimal real life lab skills experience. The reason being is our schools have a limited amount of resources due to budget cuts or lack of a middle school science rich curriculum. Most students have not had a solid science education during their middle school years. These students tend to have a negative attitude towards science and math. The common misconception is that science is hard and boring. Some students think that science is blowing up something or killing animals to find the cure for a disease. More and more students ask for hands on labs that simulate real life scientific research. We are now in the age of technology and students are very accustomed to watching CSI or some other forensic type of TV series that uses science to explain unknown events. Due to our low science budget, we cannot order materials to supply all our classrooms with lab materials to conduct a lab for each biological concept. Klop, Severiens, Knippels, van Mil, & Ten Dam, G (2010) described active learning as a process where students engage in higher-order thinking tasks such as analysis, synthesis, and evaluation. These authors indicate that students seem to learn better when they are placed in an active role of learning to make sense of the world around them. Students are not seen as passive receivers of information, but as active interpreters of social meanings. Biotechnology lends itself to a deeper understanding of the biological concepts that we need to cover accompanied with hands on lab practice.

According to Dawson (2007) it is essential that our students develop a deep understanding of the natural world around them to engage in discourse. I believe that our students need more exposure to hands on labs that lend themselves to learning and a deeper understanding of the natural process that takes place in living organisms. We are in an era in which technology has made it easy to obtain basic knowledge without having to get our hands dirty but the beauty is to feel nature and understand it in its deepest level. Most people have misconceptions about biotechnology and genetically modified products, not understanding that our ongoing economy thrives due to the advance in biotechnology and bioengineering. Dawson (2007) pointed out that that our schools should educate students about biotechnology issues can help to ensure that young people have the knowledge and skills to enable them to contribute to public debate and make informed decisions. I strongly believe that our high students need to understand the knowledge and work required to obtain such bioengineered products such as medicine and food.

Sadler, Schwart, Sonnert & Tai’s (2008) study reported that teaching high school science in depth appeared to have more of an advantage than teaching concepts in breath. Due to the amount of concepts included in our curriculum and now the end of course exam we are stranded for time and most teachers are forced to teach in breadth than in depth. This action research plan has allowed me to self-evaluate my current teaching methods and make room for improvement (Mills, 2011).
Florida Department of Education requires that we teach our biology students concepts in biotechnology that will be tested at the end of course exam. The biotechnology standard number is SC.912.L.16.10 on page 65. The standard concentrates on the evaluation of the impact of biotechnology on the individual, society and the environment, including medical and ethical issues.

The purpose of this study is to describe the impact of teaching in-depth biotechnology concepts and laboratory techniques on the knowledge, attitudes and skills of high school biology students. The study will be based on a thematic unit focused on Diabetes I & II that includes in depth biological concepts with the biotechnology component for real life hands on laboratory experience. The diabetes theme is a great vehicle to bring in the biotechnology concepts to my student population. Most students have some understanding about the disease and know someone that lives with the disease making it a relevant theme to use for instruction. I believe my students will learn in depth knowledge of DNA, gene therapy and laboratory skills. These concepts and skills will elevate my students’ self-esteem and provide them with a greater appreciation of advances in biotechnology.

**Action Research Intervention:** The research plan objective is based on in-depth understanding of the following: DNA Extraction, Protein Synthesis, DNA Transformation, Cloning, Stem Cells and Cases in Bioethics. These concepts will be reinforced by use of hands-on labs like the following: Pipetting Lab, Insulin Lab, DNA Transformation Lab, DNA Extraction Lab, Stem Cell Lab and Cloning Virtual Lab. By conducting these series of labs the students will learn laboratory skills like the following: Pipetting Practice Lab, Lab Protocols, Centrifugation, Measurements, Aseptic Techniques and Bacterial Colony Growth.

<table>
<thead>
<tr>
<th><strong>Diabetes I &amp; II Lesson Unit</strong></th>
<th><strong>Topics</strong></th>
<th><strong>Lesson Objectives</strong></th>
<th><strong>Activities</strong></th>
</tr>
</thead>
</table>
| **DNA Structure and Function** | Students will learn to describe the structure and function of DNA in living organisms. | - Timeline & scientists contribution to the discovery of DNA  
- DNA Model Construction Activity  
- DNA Extraction Lab (Strawberry) | |
| **Cell Membrane Receptors** | Students will explain the major function of cell receptors in the regulation of sugar in the body. | - Cell membrane receptors list and diagrams  
- Diagnosing Diabetes Laboratory (B2B – Lab) | |
| **Protein Synthesis (Translation)** | Students will relate the role of codons to the sequence of amino acids that result after translation. | - Genetic code activity and bingo  
- Build an insulin protein activity | |
| **DNA Transformation** | Students will explain and obtain data from a DNA transformation lab. | - Pipetting Practice Lab (B2B)  
- DNA Transformation Lab (B2B – BioRad) | |
| **Cloning and Stem Cells** | Students will describe the cloning process and explain the process of stem cell differentiation. | - Virtual Cloning Lab (B2B)  
- Create a Stem Cell Line (Edheads)  
- Stem Cell Lab (B2B - Lab)  
- Bioethics case studies | |
The plan is to start the research unit by the middle of September 2011 till the end of January 2012. The research group will be selected from the highest scoring group obtained from a series of three teacher made formal assessments.

Connection to Bench to Bedside Summer Institute: Pipetting Lab, Dr. Lawrence’s Microarray Lab Kit, DNA Transformation Lab (Pglo Lab), Insulin Lab, Stem Cell Lab, Virtual Microarray lab, Virtual Cloning, and Virtual Stem Cell Lab.

Data Collection and Analysis: The data will be collected from a series of activities and formal assessments. The assessments will be analyzed using qualitative and quantitative techniques. Before each unit students’ prior knowledge will be assessed by use of a quick questionnaire or survey. At the end of the lesson, activity or lab students will be formally assessed with a similar form of the pre-assessment to quantify knowledge acquisition. The data will be analyzed by calculating a measure of central tendency with a range of scores. In this way, I can obtain information about the entire group (Mills, 2011). I will also display a pre and post-assessments on bar and line graphs for visual representation of the data collected for interpretation. Student attitude is a factor that will be assessed by use of pre and post-survey questions and teacher created tally sheets about the student attitude towards the lesson. The laboratory skills will be assessed by pre and post-questions on laboratory procedures and techniques learned during class. The data collected from formative and formal assessments will guide me on student interest and learning gains.

Literature Cited:


**Budget:** I plan on using the **$187.40** from the B2B Summer Institute to cover the costs of lab preparation. I will need materials such as strawberries, detergent, salt and other materials to support the research labs. The B2B program will provide the lab set-up and chemical reagents for the biological labs. The chart below reflects an estimated cost per quantity of items.

<table>
<thead>
<tr>
<th>Biotechnology Laboratory</th>
<th>Materials</th>
<th>Estimated Cost (25 Students)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA Extraction</td>
<td>Strawberries (50)</td>
<td>$15.00</td>
</tr>
<tr>
<td></td>
<td>Ziploc Bags (30)</td>
<td>$6.00</td>
</tr>
<tr>
<td></td>
<td>Hand Soap (4)</td>
<td>$8.00</td>
</tr>
<tr>
<td></td>
<td>Isopropyl Alcohol 70% (4)</td>
<td>$8.00</td>
</tr>
<tr>
<td></td>
<td>Salt (2)</td>
<td>$2.00</td>
</tr>
<tr>
<td></td>
<td>Economical Powdered Latex Exam Gloves (M, L of 100 Each)</td>
<td>$52.40</td>
</tr>
<tr>
<td>DNA Structure</td>
<td>Colored Paper (4)</td>
<td>$12.00</td>
</tr>
<tr>
<td></td>
<td>Glue (24)</td>
<td>$12.00</td>
</tr>
<tr>
<td></td>
<td>Scissors (16)</td>
<td>$12.00</td>
</tr>
<tr>
<td>DNA Transformation</td>
<td>Small Electrical Refrigerator</td>
<td>$60.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$187.40</strong></td>
</tr>
</tbody>
</table>

**Permissions:** No permission required.
Science Lesson Plan

Title: Diagnosing Diabetes

Key Questions: How do we know if we have diabetes type I or II?

Science Subject: Biotechnology

Grade and Ability Level: Grade 9 – Biology Honors

Science Concepts: The lesson will begin with a review of the concept of cell surface receptors and their function. The main lesson will be administered as a discovery lab to diagnose diabetes I and II from Science Take Out to understand the concept of insulin balance in the body.

Time Estimate: The lesson will take approximately 50 minutes.

Learning Styles: Students will be involved in pair group and hands on lab, individual analysis.

Vocabulary: The key terms to be used and defined in the lesson include – Insulin, cell membrane, receptors, hormones, blood plasma, glucose, transport protein, feedback mechanism, homeostasis and pancreas.

Lesson Summary: The lesson is designed to teach students by discovery the importance of chemical balance in the body and the two types of diabetes. Students will explain the knowledge learned based on the case study to diagnose a patient with a type of diabetes.

Learning Objectives: Students will be able to

1. Recognize the two types of diabetes

2. Use a simulated biotechnology lab to diagnose the type of diabetes (lab procedures)

3. Understand the importance of cell surface receptors in homeostasis

4. Graph and interpret the insulin data collected

These objectives relate to the Florida Next Generation Sunshine State Standard number SC.912.L.16.10 and HE.912.C.1.3.

Materials: The materials needed include:

25 Safety Goggles

13 Diagnosing Diabetes Kits (1 per pair)

25 Copies of the Diagnosing Diabetes Lab Questions Packet

Background Information: Students need a solid understanding of the role of homeostasis in maintaining internal stable conditions. Organisms need to have the ability to respond to their changing environment in order to avoid disease or death. Receptor molecules and hormones play an important role in the interactions between cells.
**Procedure and Discussion Questions:** The lesson will be presented according to the following

**Procedure:**

1. **Cell Receptor Review Activity** – Students will answer the bell work questions individually based on a cell membrane diagram. Describe the function of the cell membrane proteins. How does it relate to homeostasis? Then check for answers and conclude with discussion.

2. **Diagnosing Diabetes Lab** – Students will be given a kit per pair to follow the directions of the case study and identify the type of diabetes the patient suffers.

3. **Lab Questions Packet** – At the end of the lab diagnosis students will individually finish answering and graphing the data obtained from the lab.

**Assessment Suggestions:**

1. The assessment for all objectives will be done by observation, formative assessment and formal assessment. The teacher will assess attitude and lab procedures by use of a tally sheets. The formal assessments will be graded from the diagnosing diabetes lab.

**References:**

Diagnosis Diabetes, from Science TakeOut: [http://www.scientakeout.com](http://www.scientakeout.com)
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Rationale and Focus Statement

• Our 9th grade biology students have minimal real life lab skills experience. The reason being is our schools have a limited amount of resources due to budget cuts or lack of a solid middle school science rich curriculum. These students tend to have a negative attitude towards science and math. The common misconception is that science is hard and boring. Some students think that science is blowing up something or killing animals to find the cure for a disease.

• The purpose of this research is to teach a thematic unit focused on Diabetes I & II that includes in-depth biological concepts with the biotechnology component for real life hands on laboratory experience. These concepts and skills will elevate my students’ self-esteem and provide them with a greater appreciation of the advances in biotechnology.
# Intervention

## Diabetes I & II Lesson Unit

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|                                 |                                                                                                                                                    | - DNA Model Construction Activity [X]            |
|                                 |                                                                                                                                                    | - DNA Extraction Lab (Strawberry) [X]            |
| **Cell Membrane Receptors**     | Students will explain the major function of cell receptors in the regulation of sugar in the body.                                                | - Cell membrane receptors list and diagrams [X]  |
|                                 |                                                                                                                                                    | - Diagnosing Diabetes Laboratory (B2B – Lab)     |
| **Protein Synthesis (Translation)** | Students will relate the role of codons to the sequence of amino acids that result after translation.                                      | - Genetic code activity and bingo                |
|                                 |                                                                                                                                                    | - Build an insulin protein activity              |
| **DNA Transformation**          | Students will explain and obtain data from a DNA transformation lab.                                                                               | - Pipetting Practice Lab (B2B) [X]              |
|                                 |                                                                                                                                                    | - DNA Transformation Lab (B2B – BioRad) [X]      |
| **Cloning and Stem Cells**      | Students will describe the cloning process and explain the process of stem cell differentiation.                                                | - Virtual Cloning Lab (B2B) [X]                 |
|                                 |                                                                                                                                                    | - Create a Stem Cell Line (Edheads) [X]         |
|                                 |                                                                                                                                                    | - Stem Cell Lab (B2B - Lab) [X]                 |
|                                 |                                                                                                                                                    | - Bioethics case studies                         |
Data Collection and Analysis

Qualitative and Quantitative

The data collection has been by way of formal, informal assessment and attitude surveys.

Qualitative – Surveys (20 Students)
Prior knowledge of Biotech 10%
Knowledge of biotech after the lesson 85%
Interested in biotechnology as a career 25%
Enjoyable and valuable lessons 100%

Quantitative – Test Questions
Short answer test questions averages 90%
Literature Cited


