Action Research Proposal

Biotechnology Explorations: Bench to Bedside

Name: Jessica Mahoney

Position: High School Science Instructor, Trenton High School, Gilchrist County

Title: Application of Interactive Biotechnology Lessons in a Rural School to Assess Student Achievement and Attitudes

Date Submitted: September 7th, 2010
Abstract:
This action research project will explore the outcomes of the introduction of interactive biotechnology lessons into the rural high school, focused on 9th and 10th grade Biology I students. The focus of this intervention is to introduce concepts and hands on application of topics that have previously been considered non-core concepts to a population that is generally disinterested in science. My action research will measure not only if student achievement on complex concepts improves with direct hands on activities, but also if the general attitude towards science will be changed as well.

Rationale:
I have observed a general disinterest in science amongst high school students in the rural communities. I hypothesis this attitude is related to two preconceived notions: the first is general misconception that “science is boring.” This general feeling of boredom could be related to Altiparmak and Nakibogluetezer’s idea that to the student “classroom learning is inadequate:

Many students have heard the term biotechnology or recombinant DNA, but most of them probably could not explain the difference between the concepts. Students also have trouble in visualizing the structure of DNA, replication, central dogma, protein synthesis, and the techniques of DNA cloning. Instruction-based lecture with no other pedagogical applications yields unsatisfactory results. Students lack a motive to learn the subject as they find classroom learning inadequate.
(Altiparmak & Nakibogluetezer, 2009)

The authors go on to explain that as modern teachers we must view students as “active participants of the learning process” which is the ultimate goal in my classroom; a goal that I will be measuring through my biotechnology based action research. Ebenezer and Zoller (1993) observed while studying 10th grade students that their “enjoyment” of science directly related their comprehension of the subject material. I propose that an active learning driven instructional unit will enhance student comprehension and therefore their enjoyment of the material. This idea is supported by Stohr-Hunt’s 1996 study on hands-on experience and science achievement:

...it was concluded that significant differences existed across the hands-on frequency variable with respect to science achievement. Specifically, students who engaged in hands-on activities every day or once a week scored significantly higher on a standardized test of science achievement than students who engaged in hands-on activities once a month, less than once a month, or never (page 101).

The second general observation I have made about the attitudes of rural students regarding science is they are generally uneducated about the broad spectrum of biotechnology related careers available. By applying a synergistic biotechnology unit I believe that students will not only be able to understand difficult science concepts, as measured by various assessments, after participating in innovative and interactive hands on practices, they will also be exposed to the vast career possibilities at all education levels available in the world of biotechnology and applied sciences. The purpose of this study is to investigate the efficacy of interactive biotechnology application in the classroom on the attitudes related to science and
careers in the biotechnology field, and achievement on various assessments in rural high school students.

**Action Research Intervention:**

My research will be performed with Biology I students, who are primarily freshmen and sophomores, in a rural and socio-economically disadvantaged region. This intervention will occur after the central dogma and genetics units. The intervention will consist of a 2 week long unit with multiple teamwork projects. The focus of the project will be on molecular genetics and will being with a genetic screening activity while exploring enzyme function through restriction digest analysis. Each team will then perform a BLAST Analysis search on the National Center for Biotechnology Information website to find out which disorder they screened via the restriction digest. Finally students will create a model of the protein causing the disorder the found using the BLAST tool, with the assistance of the RCSB Protein Data Bank. Students will also perform biotechnology career research throughout this unit and report via their class blogs. Please see the attached lesson plan and budget break down for further details.

Funding is provided by CPET’s Biotechnology Explorations: Bench to Bedside Program and additional funding sources through the GCSD. I have already obtained the media releases required for this action research project through my district and with my students.

**Bench to Bedside Connection:**

This action research project will not only introduce rural students to advanced biotechnology practices, it will link them to a world of research that is creating medial therapies and protocols from the roots of classic bench top science and developing new technology inspired by disorders in at the bedside. By introducing this unit after the study of Medellin genetics my students will see the connections between classical biology and new biotechnology advancements. One of my goals embedded within this action research project is to teach my students about the vast career opportunities available within the biotechnology field and I hope that after exposure to the exciting new technology that is driving biotechnology explorations from the bench to the bedside, some of them will be motivated to join the medical research industry.

**Data Collection and Analysis:**

The types of data collection I will use are both quantitative and qualitative. The quantitative methods will include, but are not limited to: traditional pre and post tests and/or quizzes; rubric graded student projects and concept map construction; as well as surveying using a Likert scale. My qualitative assessments will include, but are not limited to: online “blogging” journal entries and video journaling. I will perform statistical analysis as are appropriate upon the completion of my quantitative data collection. To assess the qualitative responses I will look for general trends with a focus on students who report a change in attitude in regards to science and biotechnology careers.
Works Cited:


### Theme: Using Biotechnology for Genetic Analysis

<table>
<thead>
<tr>
<th>Lesson Title</th>
<th>Man, that Family is Wack!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade Span</td>
<td>9-11th (mixed section)</td>
</tr>
<tr>
<td>Content Emphasis</td>
<td>Biology I</td>
</tr>
<tr>
<td>Targeted Benchmark(s)</td>
<td>SC.912.L.16.10<em>DNA Biotechnology and Impact on Human Society, Medical and Ethical Issues, SC.912.L.16.2</em>Discuss Inheritance Patterns with Dominant, Recessive, Codominance, Sex-Linked, Polygenic and Multiple Alleles, HE.912.C.1.4*Analyze Heredity &amp; Family History</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Jessica Mahoney</td>
</tr>
<tr>
<td>School</td>
<td>Trenton High School</td>
</tr>
<tr>
<td>District</td>
<td>Gilchrist</td>
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</tbody>
</table>

### Lesson Preparation

**Learning goals:** What will students be able to do as the result of this lesson?

Upon competition of this unit lesson students will be able to analyze an enzyme digest of a gene segment to construct a family pedigree tracking a single gene disorder, use the BLAST tool to determine the cause of the disorder and then reference the PDB to construct a model of the protein related to the genetic disorder. Students will also be able to see the practical application of biotechnology and find information about careers in the biotechnology fields.

**Estimated time:** Please indicate whether this is a stand-alone lesson or a series of lessons.

This project will consist of multiple lessons and activities that will span approximately 2 weeks of class time.
### Materials/Resources: Please list any materials or resources related to this lesson.

- Carolina Scientific: Nature’s Dice- A Genetic Screening Simulation Kit (Item # 211018): $279*
- Classroom Set of Micropipettes and tips: On loan from the program
- 96 well plates for pipetting practice-THS storage room
- Styrofoam balls, modeling foam and clay for protein modeling-THS storage room

*Additional funding will be provided by the THS Science Department

### Teacher Preparation: What do you need to do to prepare for this lesson?

In addition to purchasing the Carolina Scientific kits: Nature’s Dice-A Genetic Screening Simulation Kit for the restriction enzyme digest I need to look up the nucleotide sequences for my students to complete the BLAST search and have materials available for them to construct protein models, based on the information on the PDB.

### Lesson Procedure and Evaluation

**Introduction:** Describe how you will make connections to prior knowledge and experiences and how you will uncover misconceptions.

In this lesson I plan to connect student’s previous knowledge of basic Medellin genetics and human pedigrees with the application of genetic screening and the tracking of genetic disorders throughout family histories.

Through the student analysis of the DNA fragments I will be able to determine how well they understand both the concepts of restriction enzyme sites on the DNA in addition to the process of human genetics and heredity.
**Exploration:** Describe in detail the activity or investigation the students will be engaged in and how you will facilitate the inquiry process to lead to student-developed conclusions.

Upon completing of the “Nature’s Dice” Genetic Screening kit (see product description at the end of this document) students will be provided with a nucleotide sequence to perform a BLAST search on. They will have to determine from the information in the data base which disorder their sequence is related too. Students will be provided with a “normal” nucleotide sequence so they can connect the concept of mutations driving genetic disorders. Students will also model the protein related to their disorder, which will enforce how point mutations can cause misfolding of proteins and thus change/inhibit the protein’s function.

**Application:** Describe how students will be able to apply what they have learned to other situations.

Students will be better able to visualize how DNA is translated and transcribed after seeing how the restriction enzymes cleave the DNA into fragments. This lesson will also give students an hands on opportunity to experience working with biotechnology and possibly inspire them to pursue careers in medical research and biotechnology.

**Assessment:** Describe how student knowledge is being assessed at the appropriate cognitive level for the targeted benchmarks.

The students will be assessed at each step of the unit, including a complete lab report for the restriction enzyme digest, a BLAST report (rubric graded), and a protein model (rubric graded). Students will report on their progress via their blogs (rubric graded) and the entire unit will be traditionally assessed with a pre/post test.
Teacher Self-Reflection: Record your thoughts on the lesson and describe any modifications you would recommend based on the outcomes.

This will be completed at the end of the unit.

From the Carolina Scientific Website: Students receive a 24-member family tree and DNA samples presumably taken from each family member. They determine the genotype of each of the relatives by cutting the DNA samples with a restriction enzyme and separating the fragments by gel electrophoresis. The genotypes revealed by the class are used to determine the pattern of inheritance of the “gene” being analyzed and to predict each person’s phenotype. In this simulation, the teacher and students choose a fictitious phenotype to link to the gene, although the principles and issues raised would apply to real situations.
Application of Interactive Biotechnology Lessons in a Rural School to Assess Student Achievement and Attitudes

Jessica Mahoney
Trenton High School
Objectives:

- to explore the outcomes of the introduction of interactive biotechnology lessons into the rural high school, focused on 9th and 10th grade Biology I students
- Via: the use of concepts and hands on application of topics that have previously been considered non-core concepts to a population that is generally disinterested in science
Student Population

- My research will be performed with Biology I students, who are primarily freshmen and sophomores, in a rural and socio-economically disadvantaged region.
  - Two sections of Biology I will be divided into the control group and test group.
  - The control group will not receive hands on instruction with biotechnology tools, only paper models and webquests.
  - The test group will receive hands on instruction, performing various genetic “experiments”
Measurement

- My action research will measure not only if student achievement on complex concepts improves with direct hands on activities, but also if the general attitude towards science will be changed as well.
- Via:
  - Pre/Post attitude surveys
  - Pre/Post testing
  - Rubric graded assessments
  - Analysis of Blogged responses
Time Line

- February: Pre Survey, Start Blogs, Finish background material (Biochemistry, Central Dogma and Genetics units)
- March: Complete projects
  - Restriction Digest Analysis
  - BLAST search
  - Protein Modeling
  - Biotechnology Careers
- April: Post Surveys and Analysis
  - Write and Submit Final Action Research Report
Action Research Final Report

Biotechnology Explorations: Bench to Bedside

Name: Jessica Mahoney

Position: High School Science Instructor, Trenton High School, Gilchrist County

Title: Application of Interactive Biotechnology Lessons in a Rural School to Assess Student Achievement and Attitudes

Date Submitted: April 29, 2011
Abstract:
This action research project explored the outcomes of the introduction of interactive biotechnology lessons into the rural high school, focused on 9th and 10th grade Biology I students. The focus of this intervention was to introduce concepts and hands on application of topics that have previously been considered non-core concepts to a population that is generally disinterested in science. My action research demonstrated that student achievement increased by 99%. I also attempted to measure a change in attitudes towards science and biotechnology, and while the results show a general trend towards more positive attitudes, the overall change in response was not significant.

Rationale:
I have observed a general disinterest in science amongst high school students in the rural communities. I hypothesize this attitude is related to two preconceived notions: the first is general misconception that “science is boring.” This general feeling of boredom could be related to Altiparmak and Nakiboglu-Tutezer’s idea that to the student “classroom learning is inadequate:

Many students have heard the term biotechnology or recombinant DNA, but most of them probably could not explain the difference between the concepts. Students also have trouble in visualizing the structure of DNA, replication, central dogma, protein synthesis, and the techniques of DNA cloning. Instruction-based lecture with no other pedagogical applications yields unsatisfactory results. Students lack a motive to learn the subject as they find classroom learning inadequate.

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The authors go on to explain that as modern teachers we must view students as “active participants of the learning process” which is the ultimate goal in my classroom; a goal that I will be measuring through my biotechnology based action research. Ebenezer and Zoller (1993) observed while studying 10th grade students that their “enjoyment” of science directly related their comprehension of the subject material. I propose that an active learning driven instructional unit will enhance student comprehension and therefore their enjoyment of the material. This idea is supported by Stohr-Hunt’s 1996 study on hands-on experience and science achievement:

…it was concluded that significant differences existed across the hands-on frequency variable with respect to science achievement. Specifically, students who engaged in hands-on activities every day or once a week scored significantly higher on a standardized test of science achievement than students who engaged in hands-on activities once a month, less than once a month, or never (page 101).

The second general observation I have made about the attitudes of rural students regarding science is they are generally uneducated about the broad spectrum of biotechnology related careers available. By applying a synergistic biotechnology unit I believe that students will not only be able to understand difficult science concepts, as measured by various assessments, after participating in innovative and interactive hands on practices, they will also be exposed to the vast career possibilities at all education levels available in the world of biotechnology and applied sciences. The purpose of this study was to investigate the efficacy of interactive biotechnology application in the classroom on the attitudes related to science and
careers in the biotechnology field, and achievement on various assessments in rural high school students.

**Action Research Intervention:**

My research was performed with Biology I students, who are primarily freshmen and sophomores, in a rural and socio-economically disadvantaged region. This intervention occurred after the central dogma and genetics units. The intervention consisted of a 2 week-long unit (that was unfortunately interrupted by FCAT testing) focusing on team labs, activities and computer quests. The focus of the project was on molecular genetics highlighted by a genetic screening activity while exploring enzyme function through restriction digest analysis. Each team then performed a BLAST Analysis search on the National Center for Biotechnology Information website to find out which disorder they screened via the restriction digest. Finally, students created 3D models of a hypothetical protein (using the Amino Acid Starter Kit, on loan from Walter Schroder Library at the Milwaukee School of Engineering) to help explain the connection between protein function, protein folding and certain genetic disorders.

The learning goals for this unit were as follows:

- *Students will make the connection between classic Medellin Genetics and modern biotechnology driven gene therapy and genetic engineering.*

- *Students will be exposed to “real life” science via performing biotechnology related lab procedures using research tools such as pipettors and gel electrophoresis.*

- *Student attitudes will become more positive towards science education and career possibilities after being exposed to current biotechnology methods and research.*

The implementation of my action research unit was carried out as followed:

**Day One:**
Pre-Test and Pre Survey Data Collection
Blogger Entry: What would your dream science class be like?

**Day Two:**
Lesson: What is Biotechnology and how does it Affect our World?
Mini Biotechnology Lab: Micropipetting
**Homework:** Reading Notes: Human Genetics: pgs 241-248

**Day Three:**
Biotechnology Lab: Nature’s Dice
Mini Lesson: Gel Electrophoresis
Day Four:
Lesson: Human Genetics
Nature’s Dice Results and Wrap Up

Day Five:
Lesson: DNA Restriction Enzymes
Classwork: Modeling Restriction Enzymes

Day Six:
Mini Review Lesson: Amino Acids and Biochemistry
Modeling Lab: Protein Folding- Primary and Tertiary Structures

Day Seven:
Computer Lab: Using BLAST to Identify Genetic Disorders

Days Eight and Nine:
Science in Hollywood Screening: Identifying Biotechnology References in My Sister’s Keeper- Good or Bad Science?

Day Ten:
Post Test and Post Survey Data Collection

Funding is provided by CPET’s Biotechnology Explorations: Bench to Bedside Program and additional funding sources through the GCSD, in addition to materials on loan from the Milwaukee School of Engineering. I obtained the media releases required for this action research project through my district and with my students.

Bench to Bedside Connection:
This action research project not only introduced rural students to advanced biotechnology practices, it linked them to a world of research that is creating medial therapies and protocols from the roots of classic bench top science and developing new technology inspired by disorders at the bedside. By introducing this unit after the study of Medellin genetics my students were better able to make the connections between classical biology and new biotechnology advancements. One of my goals embedded within this action research project was to teach my students about the vast career opportunities available within the biotechnology field and I hope that after exposure to the exciting new technology that is driving biotechnology explorations from the bench to the bedside, some of them will be motivated to join the medical research industry.
Data Collection and Analysis:
The types of data collection I used are both quantitative and qualitative. The quantitative methods included: traditional pre and post-tests and surveying using a Likert scale. My qualitative assessments included free response surveys and online “blogging” journal entries. The collected data, both quantitative and qualitative are displayed and discussed below.

Of the 47 students who took the pre-test the most common score (mode) was a 9/20 or 45%. The average pretest score was also 9/20 or 45%. A pre-survey was given with the following eight statements:

1. I like science
2. I think science can be fun
3. I would like to take more science classes in high school.
4. I like working with technology/biotechnology
5. I think scientific knowledge is important
6. I think I would like to be involved with science technology
7. I think a career in science or biotechnology is a possible choice for me in the future
8. I think science and biotechnology helps create solutions for the worlds' problems

The response choices for the survey, which were based on a Likert scale, were as follows:

*Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), Strongly Disagree (SD)*

The responses from the 40 students who participated in the pre survey are displayed in the table below:

<table>
<thead>
<tr>
<th>Pre Survey: Question Number</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>10% (4)</td>
<td>35% (14)</td>
<td>45% (18)</td>
<td>2.5% (1)</td>
<td>7.5% (3)</td>
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<tr>
<td>2</td>
<td>15% (6)</td>
<td>67.5% (27)</td>
<td>15% (6)</td>
<td>0% (0)</td>
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</tr>
<tr>
<td>3</td>
<td>2.5% (1)</td>
<td>37.5% (15)</td>
<td>30% (12)</td>
<td>17.5% (7)</td>
<td>12.5% (5)</td>
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<tr>
<td>4</td>
<td>2.5% (1)</td>
<td>32.5% (13)</td>
<td>52.5% (21)</td>
<td>7.5% (3)</td>
<td>5% (2)</td>
</tr>
<tr>
<td>5</td>
<td>30% (12)</td>
<td>55% (22)</td>
<td>15% (6)</td>
<td>0% (0)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>6</td>
<td>2.5% (1)</td>
<td>25% (10)</td>
<td>42.5% (17)</td>
<td>27.5% (11)</td>
<td>2.5% (1)</td>
</tr>
</tbody>
</table>
The pre-survey also included a free response collection item with the following prompt:

*Do you and/or your friends think science is interesting and/or fun? Why or why not? What are your thoughts about science and biotechnology? Likes, dislikes, concerns about the future? Be honest!*

While the student responses were varied they showed a few general trends, which can be identified from the collection of student responses displayed below:

1. *I like science but it is pretty boring*

2. *Absolutely! Science, when taught in a creative manner, can be very exciting!*

3. *No, I do not view science as a fun field, although my friends may.*

4. *I am just trying to pass high school, but I do find it [science] interesting and helpful towards then world.*

5. *I think science is interesting because we get to learn how things work. I think science is fun but sometimes science can be dangerous when we try to explore the unknown. But I love experimenting with things and breaking them down to their smallest components to see what they are made up of.*

6. *Science isn’t that great. Biotechnology can be fun because [you] get to work with technology.*

7. *Honestly, science is ten times better than a math or English class but I’m still not that into it. But it can be fun sometimes*

8. *Yes, I think science can be both interesting and fun. Science teaches you many things about the characteristics of life.*

Two distinct patterns are identifiable in the student responses; students either already have a love of (or at least an interest in) science, or they are adverse to science because it is “boring” or view science courses as a class simply necessary for graduation. A general confusion about the relationship between science and technology is also discernable.

After the completion of the biotechnology intervention unit a post assessment test and post survey were given. 99% of students showed an increase in scores on post assessment test,
when compared to their pre-scores. Of the 48 students that took the post-test the most common score (mode) was a 16/20 or 80%. The average score was 15.5/20 or 77%.

The post survey given was identical to the pre-survey, with the exception of the free response. The responses from the 48 students that took the post survey are displayed below:

<table>
<thead>
<tr>
<th>Post Survey: Question Number</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.4% (5)</td>
<td>41.6% (20)</td>
<td>33.3% (16)</td>
<td>8.3% (4)</td>
<td>6.3% (3)</td>
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<tr>
<td>2</td>
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<td>0% (0)</td>
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<td>25% (12)</td>
<td>47.9% (23)</td>
<td>16.3% (8)</td>
<td>2.1% (1)</td>
</tr>
<tr>
<td>4</td>
<td>10.4% (5)</td>
<td>35.4% (17)</td>
<td>45.8% (22)</td>
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<td>5</td>
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<td>27.1% (13)</td>
<td>4.2% (2)</td>
</tr>
<tr>
<td>7</td>
<td>8.3% (4)</td>
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<td>20.8% (10)</td>
</tr>
<tr>
<td>8</td>
<td>41.7% (20)</td>
<td>50.0% (24)</td>
<td>6.3% (3)</td>
<td>0% (0)</td>
<td>2.1% (1)</td>
</tr>
</tbody>
</table>

The free response prompt for the post survey was as follows:

*Has this biotechnology unit of study changed your ideas about science? Why or why not? Tell me what you liked and disliked about the biotechnology unit. What would you have changed if you could?*

A sample of student responses are displayed below:

1. Yes, because I used to think of science was only learning about the world around you and not using technology to improve everyday life. I like learning about how scientists used biotechnology to improve everyday life.

2. I liked it a lot. [The unit] really got me connected to real things like mutation and genetic disorders; about how humans can manipulate things like disorders, round up ready plants, chromosomes and everything. I really liked it.

3. No, science has always been one of my favorite subjects. So it's only improved that. I liked how we were able to work with actual biotechnology equipment! Especially since, when you think about it, this is something that REAL scientist do just about everyday!!! I wouldn't have changed anything! Well, I would've loved using the pipettor more!
4. It has changed my ideas about science. I used to think that biotechnology only included things that were electrical and scientific but now I understand that it was very different than that.

5. Biotechnology has changed my ideas about science by showing me that science is more than just words in a textbook that you take notes on. One thing I liked about [the] biotechnology [unit] is that there [are] a lot of hands on activities. I wouldn’t change anything about [the] biotechnology [unit] if I could.

6. Science doesn’t interest me. I know it helps the world in some ways, but I’m just not interested.

7. Yes, it has changed my ideas about science because I used to hate science in every way possible but when we got to the biotechnology unit, I actually liked it. It's fun. I liked [learning about] the gene therapy and the round-up ready crops. I wouldn’t change anything.

8. Not really, it just informed me more on procedures and steps in using biotechnology.

9. Not particularly, it was fun, however I don't feel my opinion has changed.

10. Not really. I really liked the labs but the [lessons] not so much.

11. It has showed me that science can get really involved and in depth. I liked that we learned about all the different and new technologies in science.

12. [Science] is not fun. It’s boring [to me]. I don’t know how you can change [that].

13. I actually liked this unit because I liked tracking DNA sequences and learning more about Amino Acids and Proteins.

The free responses from the post-survey did show a more positive trend that the pre-survey free responses. A much better understanding of the relationship between classic science and biotechnology tie-ins were clearly demonstrated in most of the responses. A significant number of responses (such as numbers 6, 8, 9, 10 and 12) still describe a student that is disinterested in science education and application, in spite of the biotechnology intervention.

I also compared the pre versus post survey Likert scale responses. The data is displayed on the chart below. An overall trend of more strongly agree (SA) and agree (A) responses are notable, with a resulting decrease in neutral (N) and disagree (D) responses. Interestingly, the strongly disagree (SD) responses remained unchanged in the pre and post surveys. Unfortunately, the changes between the pre and post surveys are not significant.
I would have liked to see a stronger correlation of positive response increases, however I am not completely surprised, based on the entries provided for the blogger assignment, in which students described their “perfect science class.” Again, a strong division was evident, with one group of students who love science and another group, slightly smaller than their “positive” cohort, that dislikes science and their perfect class included “watching movies” and “going outside to look at rocks and stuff.”

**Reflection on the Action Research Project:**

I learned a great deal in performing this action research project, spanning form how my students learn to the level of patience it takes to teach a slightly clumsy seventeen year old boy the difference between the first and second stop of a pipettors. The most interesting thing I learned from this project was number of students who did not change their minds away from their preconceived notions about science, how it is taught and possible career paths. I also learned that it is worth trying out a “fancy project” with a group of students that would traditionally be considered remedial.

**Dissemination:**

I shared the findings of this action research project with my colleagues both at my school and at the district level. I also shared this research unit with the teachers who will be starting the biotechnology program at my school for the 2011-2012 school year.
Works Cited:

