Does Using Biotechnology in Hands-On Experiences Affect Student Achievement and Understanding of Chemistry Concepts

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Abstract

I am currently teaching at West Florida High School of Advanced Technology, which is a charter high school in Escambia County that is centered around career academies. Every student in the school is required to take an elective in a chosen career field. Many of my students are in a career academy that is health science related. During class, I am focused on helping my students connect the information in the textbook to real-world application. The purpose of my action research plan is to determine if using biotechnology through hands-on experiences increases student achievement and understanding of chemistry concepts.

I will be giving students a survey regarding their prior knowledge of biotechnology, along with a pre-test of knowledge. I will be using micropipettes and gel electrophoresis as two pieces of biotechnology that students currently don't have access to. I will use the micropipettes in two stages: 1) teaching students how to use the micropipettes by following a set of instructions to create a design in a well plate and 2) use the micropipettes to correctly load gel electrophoresis samples. They will then complete another survey to determine how much new knowledge they have gained in respect to biotechnology, along with a post-test to determine achievement.

Rationale

When standing in front of my classroom, some days I feel as if I need to be entertaining to keep them engaged in the daily lesson. Some of my feelings might be warranted since it has been shown that more effective learning appears to be associated with fun (Amory, Naicker, Vincent, and Adams, 1999). Activities that my students consider to be fun include almost anything they get to do that doesn't require them to have to sit and listen to me lecture content, for example wet/dry labs, group projects, and computer-based activities. All of these activities can be placed in a teaching-style category called active learning. Active learning has shown significant advantages over traditional instruction in regards to not only factual recall but also in knowledge of process skills (Taraban, Box, Myers, Pollard, and Bowen, 2007). "Educational theorists have stated that hands-on activities or experiences can lead to greater cognitive gains (Korwin and Jones, 1990), and that students actively engaged in the process of science will learn that science is not static and is based on experiments in which the meaning of the data is interpreted and the outcomes are not fixed (Taraban, et al., 2007). In the end, "the goal is to develop learners who are self-directed and self-motivated, both because the activity is interesting and because achieving the outcome is important" (Garris, Ahlers, and Driskell, 2002).

"One of the essential outcomes of science education is to enable students to develop a deeper understanding of the world around them and to be able to engage in relevant discourse about science in everyday life" (Dawson, 2007). I am interested in using biotechnology through hands-on activities, that are not currently available to students at my school, in hopes of creating awareness and curiosity about other types of biotechnology, along with increasing student achievement and understanding of chemistry. It is has been shown, that students cannot make connections with only experiences or only words, both are required and reinforce the other (Korwin and Jones, 1990). Unfortunately, teachers have to be very careful about the type of hands-on experiences used in the classroom. Many are generated for the purpose of interesting the student and most times, appear to be only loosely tied to content objectives (Bergin, 1999). To ensure that the activities associated with this research are educationally and content sound, I have created check points to ensure that the engagement of the students is not only interest based but also provides for concept understanding and application.

Action Research Intervention

I will be implementing these lessons in my chemistry classes, which is composed of juniors and seniors, to introduce the use of biotechnology through hands-on experiences. A single class period consists of a 90 minute period that meets every other day. Day 1 – students will complete an attitude/familiarity survey and pre-test to determine prior knowledge, along with learning proper technique for using micropipettes and create a design in a well plate. Day 2 – students will take notes on methods for mixture separation and characteristics of substances that can be used to separate mixtures. Day 3 – students will complete a lab activity using electrophoresis and paper chromatography to separate the components of food coloring. Day 4 – students will complete the survey again to determine any changes in attitude towards the biotechnology used in class and a post-test to determine if there is an increase in achievement and understanding of chemistry concepts.

Connections to Bench to Bedside summer institute

During the two week immersion into biotechnology at the Bench to Bedside institute, we were given the opportunity to work with many different types of biotechnology. I have chosen to have my students use the micropipettes and create designs in well plates, just like we did at the institute. I will also be using electrophoresis as a separation technique for food coloring, rather than for DNA that was conducted during the institute.

Data Collection and Analysis

I plan on using a pre/post student survey, pre/post content test, student interviews/journals, and a teacher journal as means of collecting data that will then be analyzed to determine effectiveness of this action research on changing student attitudes towards biotechnology and use of biotechnology to increase achievement and understanding of chemistry concepts. I will then quantitatively analyze the data using measures of central tendency and variability.

Literature Cited

Amory, A., Naicker, K., Vincent, J., & Adams, C. (1999). The use of computer games as an educational tool: identification of appropriate game types and game elements. *British Journal of Educational Technology,* 30, 311–321.

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Budget and Budget Justifications

Pipette tips
Food coloring – for the well plate activity and for electrophoresis activity
Well plates

Permissions

- Student/Parent consent forms for releases of pictures, data, etc.

Lesson Title: What's in a color?

Grade Span: 11th and 12th

Content Emphasis: Science – mixture separation

Targeted Benchmarks:

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School: West Florida High School of Advanced Technology

District: Escambia

Lesson Preparation

Learning Goals:

- Students will be able to correctly use micropipettes.
- Students will be able to identify and explain the use of different separation techniques (distillation, chromatography, and electrophoresis).
- Students will be able to choose and conduct the appropriate method of mixture separation based on the physical and chemical characteristics of the mixture.

Estimated Time: Series of Lessons

Four days of 90 minute blocked classes. Plan to implement at the end of September.
Day 1 – students will complete an attitude/familiarity survey and pre-test to determine prior knowledge, along with learning proper technique for using micropipettes and create a design in a well plate.
Day 2 – students will take notes on methods for mixture separation and characteristics of substances that can be used to separate mixtures.
Day 3 – students will complete a lab activity using electrophoresis and paper chromatography to separate the components of food coloring.
Day 4 – students will complete the survey again to determine any changes in attitude towards the biotechnology used in class and a post-test to determine if there is an increase in achievement and understanding of chemistry concepts.

Materials/Resources:

Micropipettes and tips , small microcentrifuge tubes, electrophoresis set-up with power sources, food coloring, well plate, 1X TBE buffer, 0.8% agarose gel, copies of student procedures, coffee filters, salt solution, glassware (graduated cylinders, beakers, large flask)

Teacher preparation:

1X TBE buffer, 0.8% agarose gel, copies of micropipette practice procedures and electrophoresis

procedures, create and copy survey and pre/post test, salt solution

Lesson Procedure and Evaluation

Introduction: Students will take an attitude/familiarity survey regarding prior knowledge of biotechnology; specifically use of micropipettes and gel electrophoresis. Students have already learned about mixtures, so I will have them brainstorm ideas as how to go about separating different types of mixtures.
Exploration: Students will use micropipettes and well plates to practice use of micropipettes with different volumes and in the process, create designs associated with our school. Once they have mastered the use of the micropipette and have listened to a lecture on the different types of mixture separation techniques, they will complete a lab activity in which they will use gel electrophoresis and paper chromatography to separate dyes (food coloring). See attached student hand-out for specific instructions. I will facilitate the inquiry process during the introductory brainstorming and by giving students examples of mixtures in which they will have to determine appropriate techniques for separation. Students will also compare and contrast the information obtained from the electrophoresis and chromatography experiments and write a summary of their conclusions.
Application: After completion of the lab activity, students will be asked to research other mixtures that can be separated by gel electrophoresis and explain why these mixtures are being studied.
Assessment: Students will take a post test to determine acquisition of content. Analysis of gel and a summary of their conclusions will also help me identify students that understand the concepts introduced during the activity.
Teacher Self-Reflection: Record your thoughts on the lesson and describe and modifications you would recommend based on the outcomes.

Agarose Gel Electrophoresis with Food Color - Student Handout

http://biotech.biology.arizona.edu/labs/Electrophoresis_fdclr_teac.html

Agarose gel electrophoresis can separate molecules based on charge, size, and shape. In this laboratory you will use gel electrophoresis to separate molecules present in different food color mixtures.

Materials and Equipment

For each team (four individuals):

Micropipetes and tips to load dye samples.
Electrophoresis units and power supplies
0.8% agarose gel (already poured)
1X TBE for electrophoresis units
Various dye mixtures in microcentrifuge tubes: Green, Blue, Red, Yellow
Timer

Preparing the agarose gel

1. Obtain a 0.8% agarose gel (already prepared)

2. Remove black casting dams, add 1X TBE to electrophoresis unit, and remove comb.

Loading the samples

1. Record on data sheet where you will load the dye samples (R,Y,G,B).

2. Load the numbered dye samples in the wells in the middle of the gel.

3. Connect electrophoresis unit to power supply (red to red, black to black). Plug in the power supply.

4. Turn on the power supply, and set voltage to ~100 V. The dyes will start resolving toward both the negative and positive poles

5. Electrophorese samples for ~10 minutes. Turn off power supply, disconnect power cords from the chamber, and remove top of electrophoresis chamber.

Analyzing the gel

1. Carefully remove casting tray with gel. Place gel in large weigh tray.

2. Draw a diagram on your gel sheet of the banding pattern of the samples.

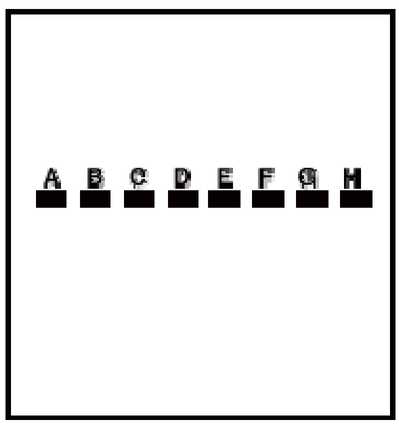
Questions

1. Which food color samples have a positive charge?

2. Which food color samples have a negative charge?

3. What colored dyes make up each of the food color samples?

BLACK



RED

Lane Number	**Sample**
A	____________________
B	____________________
C	____________________
D	____________________
E	____________________
F	____________________
G	____________________
H	____________________

To be attached later…….

- Survey
- Pre/post test
- Directions for micropipette designs
- Directions for paper chromatography of food coloring