Investigation of the Effects of an Inquiry-Based Version of AP© Lab 6b (Gel Electrophoresis) on Students' Knowledge of the Methods, Utility, and Application of Biotechnology Techniques

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Abstract (140 words)

The AP© Biology course will be changing dramatically in 2012-2013 to include inquiry-based laboratory exercises. Based on knowledge gained from the 2011 Bench to Bedside Summer Institute at the University of Florida (UF), and from materials on loan from UF CPET (Center for Precollegiate Education and Training), an inquiry-based version of AP© Biology Lab 6b will be completed by Cypress Bay High School AP Biology students in December 2011. Student laboratory groups will determine the identity of the bacterial DNA sample provided. All students will have to use restriction fragmentation followed by a gel electrophoresis of the nucleic acid fragments. Students may elect to use plasmid maps or BLAST searches to identify their bacterial pathogen. Research data will be collected through a pre-test and post-test administration design. Additionally, a rigorous laboratory assessment will be administered following Lab 6b that is identical to the assessment administered to students in AP© Biology 2010-2011 in order to provide additional quantitative data.

Rationale

Student performance in Advanced Placement (AP©) Biology at Cypress Bay High School has been nothing short of impressive in the last few years. Faced with a shrinking budget for materials and an administration willing to distribute funds away from the needs of this course, the students in AP© Biology have overcome these challenges and responded to their teacher's innovative teaching methods. The 2010 course had a 73% pass rate on the AP Biology Exam, and the 2011 course had an 89% pass rate with 52% of the class scoring a five or 84% scoring a "4" or "5".

A major focal point of the AP© Biology course at Cypress Bay High School is to develop self-sufficient students. In other words, students are encouraged to learn material on their own and then apply that knowledge in the classroom activities. This is intended to enable success in an undergraduate atmosphere where far less direction and support is provided. If former student comments are to be believed, then this strategy has been highly effective. Because of this milieu, this population of AP© Biology students is suitable to use for the purpose of investigating the efficacy of self-directed learning.

The model of self-directed learning to be employed in the proposed intervention is one popularized by the Khan Academy (Khan, 2011). This model is commonly referred to as a "flipping of the classroom". In a typical classroom, students acquire and organize information through a lecture-based methodology, where the student passively receives information and takes copious notes. The passive nature of this methodology is its most objectionable facet. Following the classroom-based lecture, students leave the classroom and review material through various means such as reviewing their notes, completing worksheets, composing concept maps, etc. By contrast, the methodology espoused by the Khan Academy begins with videos of previously recorded lectures. Students are directed to view the lecture on the night *prior* to the classroom time allocated to learning the lesson. The main advantage of the recorded lecture is that students can watch the material at a time convenient to their schedule. Another advantage is that they may pause the lecture, rewind the lecture to review points, or skip around the lecture to make connections between lesson material at different time points during the lecture. Finally, students can also review the lesson material following the classroom session in preparation for an assessment or for any other purpose that they deem worthwhile. After the students have been introduced to coursework through the video recorded lectures, they return to the classroom and complete in class what was previously termed "homework" or the lecture reinforcement material. Students may work in groups and may ask other students or the teacher facilitator for assistance and guidance in completing the reinforcement material. Finally, an in-class individually administered assessment is used to determine whether the students have acquired the required information.

The AP© Biology course at Cypress Bay High School covers all 55 chapters on the AP Exam by the end of March of the school year. This means that during each quarter, about 18 chapters are covered. This averages out to a little more than 2 chapters a week. Consequently, time is one of the most precious resources for the AP Biology teacher and student material. In fact, biotechnology is covered in a single chapter in Campbell & Reese's *Biology*, which is the standard text for AP© Biology courses. Attending the 2011 Bench to Bedside Summer Institute has enabled the author to become familiar with many ways to utilize biotechnology and activities to demonstrate this utility. Indeed, this author cannot think of any other opportunity that would enable a

secondary school teacher to be exposed to the cutting edge technologies and biomedical research discoveries as those that have been covered in the 2011 Bench To Bedside Summer Institute. Indeed, this author would be remiss in his duty to prepare students for their future were he to not share with his students what he has learned at the 2011 Bench to Bedside Summer Institute. At the Summer Institute he learned that there is literally a world of opportunities opening up in fields that utilize biotechnology of which many students would simply remain ignorant unless serendipity smiled upon them while in college. Hence, allocating more than a proportionate amount of time to the topic of biotechnology is more than justifiable; it is a requirement.

The next logical question is how best to construct a lesson to educate students about the biotechnology concepts and methods assessed by the AP Biology Exam as well as those concepts and methods that they will likely encounter in their future studies. According to Bigler (2011), hands-on learning has been effective at increasing student content knowledge with regards to biotechnology material. Additionally, Yarden (2010) found that students learning the concepts and technique of polymerase chain reaction (PCR) using animations had a statistically significant increase in knowledge as compared to those students who viewed static visualizations (images). Moreover, Hanegan (2009) found that inquiry-based laboratory exercises were the most effective means of increasing student content knowledge of biotechnology as opposed to other education methodologies. In accordance with the findings from the literature, the proposed intervention will be a hands-on laboratory that will be inquiry-based and utilize animations in preference to static presentation of images. Additionally, this intervention will feature a number of biotechnology tools and concepts woven together to accomplish an overarching goal. Although a rough framework is in place, the particular goal of this intervention has already been tested. Jensen (2010) provided a suitable framework for an inquiry based laboratory exercise with her *The Mystery of the Cyclopic Lamb*. This inquiry-based exercise is centered on determining the mechanism behind this dramatic deformity. In order to make this determination, students must develop their own experimental design to visualize the genome of a lamb embryo. Students must complete a number of laboratory techniques in their quest to successfully resolve this query. The procedures to be completed in this exercise include polymerase chain reaction (PCR), gel

electrophoresis, utilizing bacterial transformation and restriction enzymes, and *in situ* hybridization. Although the proposed intervention is similar in nature to the exercise provided by Jensen, it will cover a smaller set of biotechnology techniques, but the focus will be on developing an understanding of these techniques and their role in solving practical problems.

Finally, AP© Biology is changing in the 2012-2013 school year. One of the major changes is that the laboratory exercises in AP© Biology will shift away from a "cookbook" format to being inquiry-based. Indeed, the new laboratory manual is entitled: *AP Biology Investigative Labs:* ***An Inquiry-Based Approach*** (The College Board 2011). The new lab exercise formulations are designed to have an "… engaging, inquiry-based approach (that) will inspire students to investigate meaningful questions about the real world." (The College Board, 2011). Hence, there is no reason to wait for the new laboratory exercise formulations from The College Board. The time for action is now.

The purpose of this study is to determine the effects of an inquiry-based version of AP© Lab 6b (Gel Electrophoresis) on students' knowledge of the methods, utility, and application of biotechnology techniques.

Action Research Intervention

This intervention consists of two main parts: preparatory work and the inquiry-based exercise. On Day 1, the pre-test measure will be administered and then the students will be directed to review the virtual laboratory exercise for AP© Biology lab 6b found on http://www.phschool.com/science/biology_place/labbench/lab6/intro.html. This exercise is designed to help students understand the rationale behind the procedural steps of the traditional, "cookbook", exercise design. This site features a series of brief animations and assessments throughout the entire presentation. The students will also be presented

with *The Outbreak*, which is an interactive animation, which explores the investigation of an infectious disease outbreak of nebulous etiology. This interactive animation is used to introduce the reasoning behind using certain biotechnology procedures, and their utility in epidemiologic investigations where the etiology is unknown. Additionally, simulated plasmid maps & DNA sequences from select bacteria will be provided to each student group. On Day 3, the students will be given a brief lesson on the basics of micropipeting for about 20 minutes. Then the students will receive a brief review of the virtual laboratory exercise. Next, the students will be led on a review of the relevant animation from *The Outbreak*. Finally, they will review information about how to enter in a genomic sequence into BLAST, which will return the likely species to which this sequence belongs. These three reviews should last, in total, about 60 minutes, especially when time is allocated for student questions. The balance of the 90-minute period will then be allocated to student questions or to orally assess student content knowledge. Students will then be given a homework assignment, which is to write a brief outline of how the biotechnological techniques they have learned could be used to determine the identity of the "pathogenic bacteria" in an afflicted patient.

At the beginning of day 4, students will be given simulated "bacterial DNA", which was separated from an afflicted patient. It is the origin of this "bacterial DNA" that they will need to identify. They will also be told that they need to have their outline approved before they can begin the laboratory operation. Pending approval of their outline, students will complete 1 of the following 2 processes:

1. Complete a restriction fragmentation of the provided "bacterial DNA" with enzyme ONE, followed by a gel electrophoresis procedure to separate the restriction fragments. Compare the banding patterns to the plasmid maps that were previously provided in order to determine the identity of the "pathogenic bacterial species".
2. Complete a restriction fragmentation of the provided "bacterial DNA" with enzyme TWO, followed by gel electrophoresis procedure to separate the restriction fragments. Compare the banding patters to the given patterns, and

then use the provided genomic sequences to input into BLAST in order to determine the identity of the "pathogenic bacterial species".

Next, the students will complete a brief laboratory report on the identity of the bacterial pathogen they investigated as well as how they arrived at their determination of the bacterial pathogen. Finally, students will be assessed with a brief post-lab quiz. This post-lab quiz will be basic in nature, but designed to assess whether the students understood the reasoning behind their procedure. On day 5, the post-test measure will be administered. On day 8, the in-depth laboratory report will be due and students will also take an assessment on the underlying logic behind the selection of their procedure as well as a number of questions of high order content knowledge of biotechnology tools and applications.

Connections to Bench to Bedside Summer Institute

The equipment locker provided by the Bench to Bedside (B2B) Summer Institute that can be shipped to the classroom will enable AP© Biology students at Cypress Bay High School to actually complete AP Lab 6b. Cypress Bay High School can afford neither the micropipettes nor the gel electrophoresis apparatus required to complete this laboratory exercise.

Though independent of the proposal under consideration, students from Cypress Bay High School will visit the University of Florida HHMI Undergraduate Laboratory as well as the Center of Excellence for Regenerative Health Biotechnology (CERHB) in late January 2012. In the classroom, the protocol of Part I of the B2B Lab Project will also be used to demonstrate the utility of gel electrophoresis and pedigree analysis prior to performance of the reformulated, inquiry-based, AP Lab 6b. Finally, Cypress Bay students will also complete a bacterial transformation using heat shock based on that found in Part II, section F of the B2B Lab Project as an effective substitute for AP Lab 6a.

Data Collection and Analysis

There will be two main data collection instruments and two different methods of analysis corresponding to these data collection instruments. The first data collection instrument will be a pre-test and an identical post-test. While most of this assessment, 15 questions, will assess comprehension and understanding of the methods, part of this assessment, 10 questions, are a series of qualitative questions designed to assess student attitudes and perceptions of biotechnology techniques and methods. The section of qualitative questions will utilize a Likert scale for ease of analysis. For this instrument, basic descriptive statistics (measures of central tendency & dispersion) will be computed for each of the questions on the assessment instrument. Also a two-sample paired t-test will be conducted in order to identify statistically significant differences between the pre-test and post-test measures for each of the questions on the instrument. Should the number of participants not be sufficient to satisfy the appropriate conditions set forth in the Central Limit Theorem, then a Wilcoxon signed-rank test will be conducted.

The second data collection instrument will be the post-laboratory exercise assessment. This assessment will be administered a few days after the actual laboratory exercise to ensure that students have sufficient time to review their laboratory reports, reconcile any misconceptions, and complete a full analysis of the material covered in the lab exercise. The identical assessment was provided to AP© Biology students in the 2010-2011 school year. It consists of 25 multiple-choice questions covering the methods of the laboratory exercise as well as the application of those methods. However, during that year the class followed a traditional "cookbook" laboratory exercise design. This enables the researcher to do a simple comparison of content knowledge when the inquiry-based methodology is employed versus the traditional "cookbook" laboratory methodology. For the purposes of data analysis, the basic descriptive statistics will first be calculated for each of the two administrations. This will enable an *ad hoc* comparison of the sample values. Next, an unpaired or Student's t-test will be conducted in order to identify statistically significant differences between the treatment group (inquiry-based laboratory exercise) and the control group ("cookbook" version laboratory exercise).

Literature Cited

Bigler, A., & Hanegan, N. (2011). Student Content Knowledge Increases After Participation in a Hands-on Biotechnology Intervention. *Journal of Science Education and Technology, 20,* 246-257. doi: 10.1007/s10956-010-9250-7.

Hanegan, N., & Bigler, A. (2009). Infusing Authentic Inquiry into Biotechnology. *Journal of Science Education and Technology, 18(5),* 393-401. doi: 10.1007/s10956-009-9155-5.

Jensen, J. (2010). Using the Mystery of the Cyclopic Lamb to Teach Biotechnology. *American Biology Teacher, 72(4),* 245-251. doi: 10.1525/abt.2010.72.4.9.

Khan S. (Speaker). (2011, March 9). Let's use video to reinvent education. [Video File]. Retrieved from http://blog.ted.com/2011/03/09/lets-use-video-to-reinvent-education-salman-khan-on-ted-com/

The College Board. (2011, July 20). Advances in AP Biology. *Retrieved from* http://advancesinap.collegeboard.org/science/biology

Yarden H., & Yarden, A. (2010). Learning Using Dynamic and Static Visualizations: Students' Comprehension, Prior Knowledge and Conceptual Status of a Biotechnological Method. *Research in Science Education, 40,* 375-402. doi: 10.1007/s11165-009-9126-0.

Budget

Inova X5MT-WUVT Ultraviolet LED Flashlight: 3($40)		= $120
Copies, paper towels, & Incidentals	= $40	
USB Flash Drive - 2($20)		= $40
	TOTAL REQUESTED	= $200

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Cypress Bay High School requires that all visitors onto its campus are documented and have photo ID available. Hence, the author will meet with Assistant Principal Jeffrey Nelson to ensure that the CPET agent is able to come on to campus without any delay or disturbance. The author will also ensure that any materials arriving from CPET are appropriately transferred to limit injury or unnecessary delay. To do this, he will meet with Joan Hearst who is in charge of Shipping and Receiving for Cypress Bay High School. The author will also schedule a visit from the School Board of Broward County's Risk Management for the day following cessation of laboratory activities to

ensure that any chemicals or sensitive items are disposed of or removed from site in accordance with the regulations set forth in the School Board of Broward County's *Safety, Policies, & Procedures in Science* handbook.