

***Using DNA Barcoding as a Pedagogical Tool to Teach Genetics
to Undergraduates at Queensborough Community College***

Nidhi Gadura, Queensborough Community College, USA

The North American Conference on Education 2014
Official Conference Proceedings

Abstract

Over the past five years, the author has noticed that students who take the Biotechnology (lecture/lab) first, do better in the Molecular Genetics course than those who do not. This is especially true for the part that explains the central dogma of biology, DNA, Restriction Enzymes, PCR amplification, Gel electrophoresis and DNA sequencing. The author strongly believes that this is because those students who have not conducted hands on experiments cannot fully understand these complex concepts from a textbook alone. To provide her students with a better learning experience, the author changed her pedagogical strategy. She incorporated a DNA Barcoding lab, developed by Cold Spring Harbor (CSHL), in the Genetics course as an honors component. Her Biotechnology students will serve as mentors to Genetics students while being closely supervised. A detailed curriculum and assessment strategy was developed for the DNA Barcoding. Grades for students will be compared before and after the implementation of this project, along with pre and post surveys taken by the students. Student gains made will be discussed.

Keywords: Undergraduate Research, Genetics, Pedagogy.

iafor

The International Academic Forum
www.iafor.org

Hypothesis

We hypothesize that if Genetics students are exposed to a hands on lab with a hypothesis driven experiment, they will have a better understanding of molecular biology concepts and techniques related to DNA i.e. Gel electrophoresis, Restriction Enzyme digests, PCR, DNA sequencing etc. than those not exposed. This will be reflected in their grades for that particular exam during the semester as well as their attitude towards Molecular Genetics. This will be demonstrated by the post surveys given to the students. We will also compare grades from previous semesters.

Specific Aims of this study:

Specific Aim 1: Genetics students better understand the concepts of molecular biology after hands on DNA Barcoding experiment.

Specific Aim 2: Biotechnology students involved in supervising the Genetics students will reinforce their techniques and skills that they learned in class.

Anticipated student learning outcomes:

Learning outcome # 1	Learning outcome #2	Learning outcome # 3
<ul style="list-style-type: none">• <i>Students should be able to learn molecular genetics concepts by performing an experiment that requires them to use all the techniques taught in lecture.</i>	<ul style="list-style-type: none">• <i>Students can gather information collected from their experiment and critically analyze and assess their data.</i>	<ul style="list-style-type: none">• <i>By the end of the semester, students will effectively prepare and communicate a well reasoned presentation that compares data and critically supports/refutes different points of view.</i>

Background

Throughout higher education, there is a general agreement that strengthening the teaching-research approach will benefit students, faculty and institutions (Osborn 2009).

Research indicates that students will learn better if they can relate their learning to actual research (Seymour 2004). During the Spring semester of 2013 Queensborough Community College (QCC) has decided to institutionalize and fund undergraduate research as a high-impact pedagogical activity (Kuh, 2008). The PI is a member of Faculty Initiative Group on campus who is responsible for integrating research in curriculum. DNA Barcoding Lab developed by Cold Spring Harbor Laboratory (CSHL) is an excellent tool that can be used to incorporate a high caliber research experience for students.

We know very little about the diversity of plant, animal and microbe life on our planet. Thousands of species go extinct each year without ever having been identified. DNA barcoding is a state of the art technique that can unambiguously identify an unknown species by amplifying, sequencing and analyzing a portion of the genetic material. The genetic source doesn't even have to be a whole organism; samples can be obtained from ancient decomposing material

underground, fossils and even undigested tissue from the stomach or waste. This revolutionary technique has identified new species, detected food fraud in the fish industry, analyzed the food sources of elusive animals, and assessed the quality of drinking water.

DNA Barcoding relies on a short, highly variable region of the genome to identify species. For plants, a region of the chloroplast gene *rbcL* (RuBisCo) is used where as for animals, a region of mitochondrial gene *COI* (cytochrome c oxidase subunit I) is used (Source: DNA Barcoding 101 CSHL manual).

Research Question

Do students exposed to hands on lab experiments understand molecular concepts more than when only provided with a lecture from a textbook? Since our Genetics course at QCC is only a lecture, the regular class does not experience any wet labs. This project will provide a unique wet lab experience to the students who are learning molecular techniques (Genomic DNA extraction, Gel electrophoresis, PCR, DNA sequencing and analysis) solely from textbook and lectures. Students will need to spend club hours outside the regular class time to gain the experience that will enhance their understanding on molecular genetics.

Students who opt to take Genetics for honors credit will sign an honors contract for the DNA Barcoding project in collaboration with Cold Spring Harbor Lab.

Project Description

Students worked in groups of three to do the following:

1. Develop a hypothesis driven project on the Biodiversity in and around campus or anywhere in New York City.
2. Collect a sample of tissue from a plant or an animal and log it correctly using CSHL protocol.
3. Students performed the following experiments:
 - Genomic DNA Extraction
 - Gel Electrophoresis
 - PCR amplification specific to a Mitochondrial or Chloroplast Gene sections
 - DNA sequenced
 - Align sequences using NCBI BLAST
 - Analyze the gene sequence and make phylogenetic trees using DNA Subway software developed by CSHL – DNA Learning Center
4. Students work in groups of 3 to share their projects in detail and discuss their results in a Power Point presentation conducted at the end of the semester either at the QCC Honors conference in the spring or at STEM Research Club event in the fall.

Timeline for completion of the project during the semester:

<i>Timeline</i>	<i>Benchmark</i>
<i>Week 1</i>	<i>Students agree to the honors contract and sign honors contract</i>
<i>Week 2</i>	<i>Faculty shares the project details on Blackboard</i>
<i>Week 3</i>	<i>Students research background information and post that on Blackboard</i>
<i>Week 4</i>	<i>Scientist from CSHL visits QCC and gives students details about the project</i>
<i>Week 5</i>	<i>Students start the first wet lab phase of the project DNA Extraction</i>
<i>Week 6</i>	<i>Students start the second wet lab phase of the project PCR, Gel electrophoresis</i>
<i>Week 6</i>	<i>Instructor mails DNA samples out for sequencing and get the results</i>
<i>Week 7</i>	<i>Students submit their abstracts for Honors Conference or other relevant local conferences</i>
<i>Week 8</i>	<i>Students analyze DNA sequencing results using NCBI database</i>
<i>Week 9</i>	<i>Students upload their results in CSHL database</i>
<i>Week 10</i>	<i>Students make phylogenetic trees of the sample/species analyzed</i>
<i>Week 11</i>	<i>Students make Power Point and show to the instructor</i>
<i>Week 14</i>	<i>If accepted, students present their work at Queensborough Honors conference</i>

Methodology

For Wet Lab: Students need all molecular biology instruments required to complete their project. All equipment is readily available in the QCC Biotechnology Lab. The lab is well equipped with all molecular biology instrumentation required to accomplish the project. Also available in this lab are computers with internet access to complete the bioinformatics part of the project.

For Analysis of Student Knowledge Gain: PI compared the grades for Exam IV in the course that covers all the topics learnt by completing this project. These grades were compared two ways: One Genetics students who signed up for this barcoding projects vs. those who didn't. Second, overall grades for these students vs. previous semester students who were never exposed to this experience.

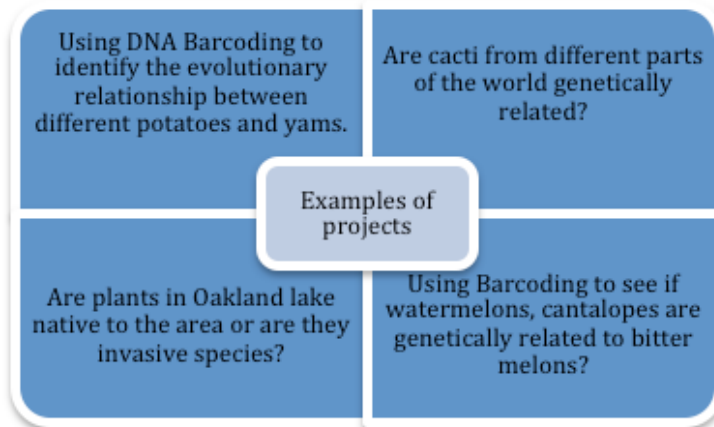
Online Pre and Post SURE surveys were developed by CSHL. They have already agreed to allow our students to use those surveys which will demonstrate student gains made at the end of the project; not just in skills, but attitude towards science in general. These surveys have been well tested and implemented by CSHL for thousands of students who are involved in this project all over New York City. This undergraduate research project will be repeated in the class in the future when and the number of students involved is significantly larger, the survey data will be collected on a long-term study to understand the impact of undergraduate research in curriculum.

Currently, the investigator created a Reflection Activity survey for the students at the end of the semester and the results are shown below.

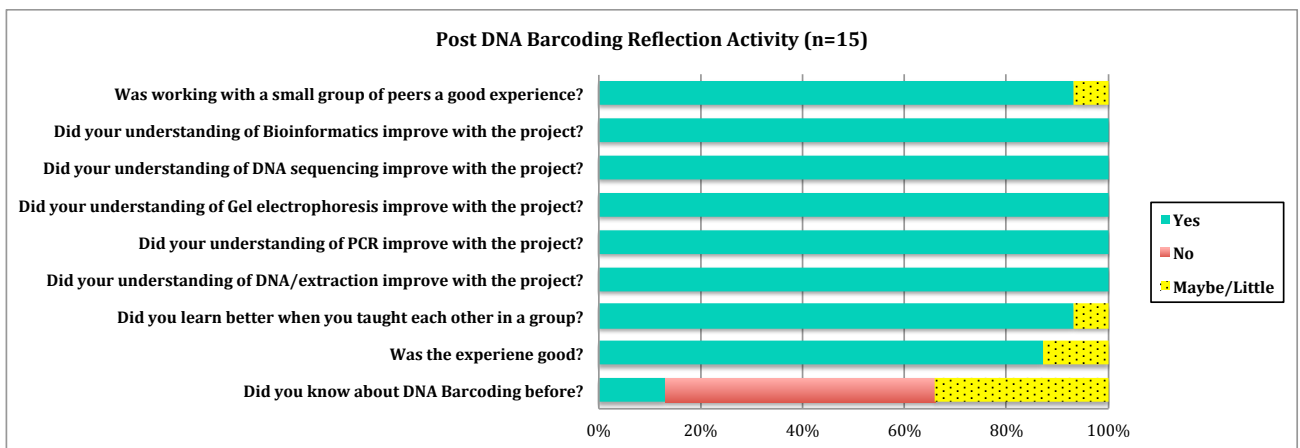
Results:

1. Types of experiments done by students varied significantly. Since it was a hypothesis driven project, students were at the liberty to form a group

consensus and to come up with their own, projects. Here are a few of the examples of projects students came up with:



2. Results from the DNA Barcoding Reflection Activity survey given to students at the end of the semester.



3. Data from the lecture exam that covers the topics done by the students as part of this experiment.

Before: (n = 44)

STATUS – degree to which students have met the specific learning outcome	Excellent (15 points)	Good (12 points)	Minimally Acceptable (9 points)	Poor (5 point)	Insufficient evidence (0 points)
No. of students	7 (44%)	4 (25%)	3 (19%)	1 (6%)	1 (6%)

After: (n = 16)

STATUS – degree to which students have met the specific learning outcome	Excellent (15 points)	Good (12 points)	Minimally Acceptable (9 points)	Poor (5 point)	Insufficient evidence (0 points)
No. of students	12 (22%)	9 (20%)	15 (40%)	5 (11%)	3 (7%)

RATIONALE - The assessment question is a critical thinking, multi-step, three part question a) b) and c). Each part is weighed equally 5 points each. If everything is answered perfectly a student can earn 15 points or Excellent. If one point is lost in each section the rating is still good at 12 points. However if student earns 3 points in each section then minimally acceptable at 9 points however anything less than that is poor understanding of the concepts and therefore not acceptable.

Student Quotes:

- *“Best lab experience I had at QCC!”*
- *“It was really nice to work in a group, even though we didn’t agree sometimes but it was nice to work together on a final presentation.”*
- *“Most fun I had working on a project!”*
- *“We didn’t want our project to end.”*
- *“I had never given public speech before, I was inspired by my daughter to make a presentation, I practiced with her.”*

Analysis of results

Only a hand full of students knew something about the DNA Barcoding while most of them had never heard about the project. The reflection data collected from the students indicate that they enjoyed the experience and most of them felt that they learned a lot in a group setting when they taught each other. As was hypothesized by this project, the experience of the project increased their understanding of DNA extraction, PCR, Gel electrophoresis and DNA sequencing. These concepts are otherwise really hard to understand in lecture alone.

The author learned that a lot of students have a hard time mastering this multi step, critical thinking problem because it requires student to have knowledge of 7 different techniques learnt in class and use it to complete one problem. Those students who have done these techniques hands on in a lab have a better understanding of the concepts compared to students who learn these concepts in lecture alone. Even though the numbers are small at this point, the data clearly indicates that undergraduate research in curriculum can have a high impact on only the grades on the exam but overall deeper understanding of the material. It also builds critical social skills of working in small groups and professional skills of making Power point presentations and delivering them in front of audience.

Bibliography

1. Osborn, J. M. and K. K. Karukstis. (2009) The benefits of undergraduate research, scholarship, and creative activity; Boyd M, Wesemann J, editors. Washington, DC: *Council on Undergraduate Research*.
2. Seymour, E., Hunter, A.-B., Laursen, S., and DeAntoni, T. (2004), "Establishing the benefits of research experiences for undergraduates: first findings from a three-year study." *Science Education*, 8, pp. 493–594.
3. Kuh, G.D., (2008) "High-Impact Educational Practices: What are they? Who has access to them? And why they matter?" *Association of American Colleges and Universities*, Washington DC, 2008.