A Case Study of the Differences in Content Mastery and Attitude between Single Gender Classrooms versus Hetero-Gender Classrooms in Teaching 'The Central Dogma of Biology and its Role in Gene Expression'.

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Abstract

Previous studies have suggested marked differences in test scores between single gender schools versus co-ed schools. This case study focuses on reviewing if the accepted outlook of gains made by a single gender classroom can be bridged with gains made by hetero-gender classrooms, through the use of inquiry based strategies in biotechnology. More specifically, this study is focused on looking at the specific impact to science by teaching a difficult concept to master – "the central dogma" to regular level 9th grade Biology students. Using attitude assessments, implementation of relevant biotechnology labs and pre/post testing of the lessons - two schools will be evaluated for learning gains – an all-boys catholic school and a co-ed public school. The expected outcome is that through the use of biotechnology within the molecular genetics curriculum, there will be little difference in gains made between single gender and hetero-gender classrooms.

Rationale

One of the fundamental topics in Biology is genetics. Through the study of genetics, students have the opportunity to explore careers in the fields of medicine, agriculture, forensic science and pharmacy, The importance of studying genetics in the high school classroom is marred by the complexity of the pathways involved (Rotbain et al, 2006). Over the past several years, there has been an explosion within the biotechnology field due to rapid development of new concepts and methodologies. This is has led to key studies involving students' difficulties in molecular biology (Bahar, Johnstone, & Sutcliffe, 1999).

There are also tremendous social implications to biotechnology studies from lack of public knowledge. Many scientists have vocalized this has a huge deterrent in their ability to move forward with genetic research (Kier et al. 2014). Since educating the public is key, much of this dispensation of information has been tasked to high school teachers in preparing a generation who are more open to biotechnology (Simon, 2010).

There has been conflicting results in the area of gender studies within the science classroom. Some sources have provided evidence which reflects no correlation between single gender classrooms and higher test performance (Harvey 1985). However, many other gender studies point to a different scenario where same sex classrooms learn very differently than mixed sex classrooms. Some studies have shown that single gender classrooms have allowed more student engagement and collaboration (Parker, Lesley & Rennie, Leonie 2010).

In 2011, specific courses, as outlined in their course descriptions, were given their own mandated state wide assessments called EOC Assessments. These assessments are computer based and criterion-referenced assessments that measure the Florida Standards and Next Generation Sunshine State Standards. In 2012, the average percentage of students passing the Biology EOC for the state of Florida was 50% compared to Hillsborough County which averaged 35% of students passing. In 2013, the state average of students passing the Biology EOC was 67% in comparison to Hillsborough County Public Schools which averaged 64%. This negative regression from the state averages can be seen for subsequent years. Furthermore, Leto High School consistently scored below its' district average for all years of EOC implementation (Figure 1 & Table 1).

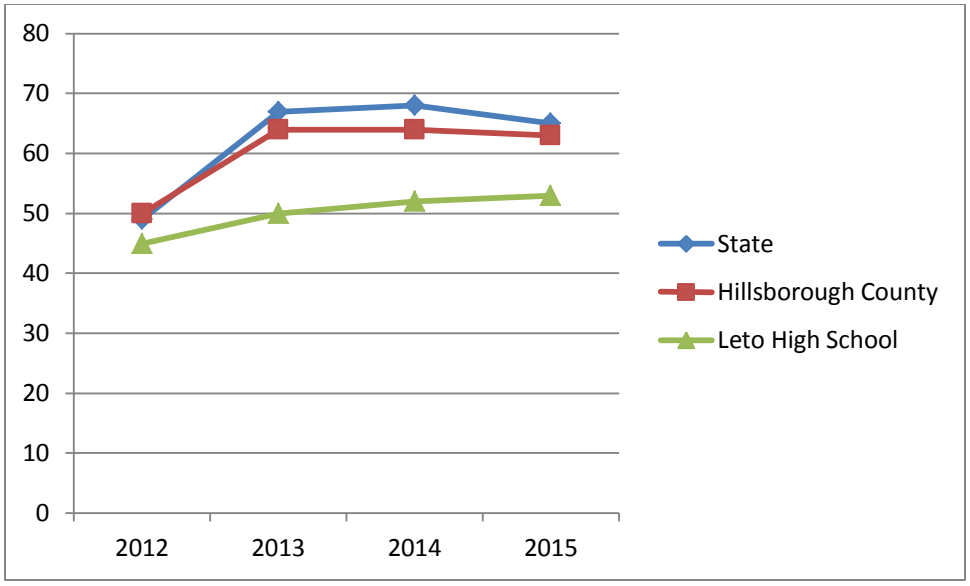

Figure 1: Graphical representation of mean scores.

	State	Hillsborough County	Leto High School
2012	49	50	45
2013	67	64	50
2014	68	64	52
2015	65	63	53

Table 1: Comparison of mean scores between State level, district level and school level.

Leto High School serves approximately 2000 students with 72% Hispanic student population and 75% on free/reduced lunch. The surrounding community is of primarily low/middle low socio-economic class. Jesuit High school is also located in Hillsborough County, but is an All Boys Private School with 25% of the population on full scholarship (qualifying based on socio economic need). Jesuit High School of Tampa is a college preparatory school of 733 students in grades 9-12, fed by 56 local schools in the Tampa Bay area. In 2014-2015, the school scored an average 1920 on the SATs and 29 on the ACTs with a Science score of 27. This is compared to an average score of 1540 on the SATs and 21 on the ACTs with a Science score of 21 by Leto High School. Obviously there is a discrepancy of ability so we will be focusing on % gains so that a better comparison between the two can be made. This study focuses on the implementation of Biotechnology in the 9th Grade Biology Curriculum, and comparing the results of Formative Testing in both a single gender and hetero=gender classroom. Our hypothesis states that through the use of innovative technologies, as with the labs in biotechnology, there will not be a strong difference in test scores between single gender and hetero-gender classrooms.

Description of teaching unit or module(s), including expected outcomes

For this unit the teaching goals that will be covered are:

- Understand how DNA is replicated.
- Be able to describe the process of transfer of information during gene expression from DNA to RNA to protein and the relationship between these sequences.

- Understand that each chromosome contains a large amount of information and that only a small part of this information is needed to code for a specific protein. Identifying information to make a specific protein requires the use of punctuation at both the DNA level and at the RNA level.
- Determine the protein coded for by a DNA or RNA molecule, and comment on how changes to the DNA / RNA molecule will affect the protein.
- Understand the role of RNAi in the Central Dogma
- Discover the impacts of DNA Fingerprinting, PCR, Gene Therapy, Mutations, Cloning, and the Human Genome Project
- Identify bioethical questions that have been raised with these new advances in science

A heavy integration of biotechnology will be implemented in a variety of case studies and labs to help the students master the concepts of DNA, and the Central Dogma, Gene Expression, Genetic Problems and advancements, and the bioethics associated with those. Limited teacher based instruction will be used to clarify and preview certain topics.

UF Equipment lockers that would be utilized for this unit in order to integrate the technology effectively would include…

Pipetting by Design, Nature's Dice, C.elegans (Experiments #1 & #2)

Expected outcomes after integration of hands-on labs are 30% or better learning gain from both groups on pre/post assessments and attitude assessments with little deviation between the single gender and hetero-gender classroom groups.

Data collection techniques and/or student assessments

Pre/Post testing, Attitude Assessments, Formative assessments, Lab Analysis Questions, and student reflections will all be collected as data and compared. Quantitative qualifiers will be used on all data so that a fully quantitative analysis of the results can be made.

B2B summer institute elements specifically included (UF connections)

In our entire UNIT we will incorporate the following B2B summer 2015 elements:

Pipetting By Design Lab : How to use a pipette
Building a Protein Model: Connection to form fits function with a change in an amino acid affecting the end size or shape of a protein affecting its function.
How to utilize the BLAST database and identify a gene
Reading With Restriction Enzymes: Teaches how an electrophoresis works with DNA Restriction Enzymes to create a Fingerprint (Upgraded from Best Practices by merging 2 really good lessons together)
Nature's Dice Lab: Actually teaches how to run a real gel electrophoresis and interpret results.
C. elegans' RNAi Gene Silencing Lab: How to silence a gene, transformation of a DNA sequence.

Previously, this lesson was taught through direct instruction and teacher made worksheets. Students were given information and then asked to learn it and memorize it. On some occasions, students would get into their groups to do a 'group reflection' but time limitations sometimes do not allow this.

The B2B UF program introduced me to many hands on activities for students to employ inquiry based strategies towards their learning. Students will be taught gene expression and silencing via the 'C.elegans lab'. A lab to reinforce gene expression has never been taught to these levels of students.

New Pedagogies – Inquiry Based Labs, Argument Driven Inquiry (ADI)

Budget justification

Examining the RNAi Mechanism Kit (RNAi and Amplification; with Prepaid Coupon) - Item # 211392 [Carolina Lab]: $310.00

Literature Cited

Bahar et al. (1999) Investigation of students' cognitive structure in elementary genetics through word association tests. Journal of Biological Education, 33, 134-141.

Harvey, T.J. (1985) Science in single-sex and mixed teaching groups. Educational Research, 27, 179-182.

Kier et al. (2014) The Development of the STEM Career Interest Survey (STEM-CIS). Research in Science Education, 44, 461-481.

Rotbain et al. (2006) Effect of Bead Illustrations Models on High School Students' Achievement in Molecular Genetics. Journal of Research in Science Teaching, 43(5), 500-529.

Simon, Richard. (2010) Gender differences in knowledge and attitude towards biotechnology. Public Understanding of Science, 19(6), 642-653.

Parker, Lesley & Rennie, Leonie (2010).Teacher's implementation of gender –inclusive instructional strategies in single-sex and mixed-sex science classrooms. International Journal of Science Education, 24, 881-897.

SINGLE LESSON PLAN		
Teacher: Nigel Jagoo	**Content Area/Grade: 9th Grade Biology**	**Date: 06/23/2015**
Unit Name:	***DNA/RNA – Cracking the Codon*** (Subunit of Genetics/Heredity Big Idea)	

Unit Goal **What unit goal does this daily lesson address?**	**Standard(s)/Benchmark(s)** What standard(s)/benchmark(s) does this daily lesson address?
• Determine the protein coded for by a DNA or RNA molecule, and comment on how changes to the DNA / RNA molecule will affect the protein. • Understand the role of RNAi in the Central Dogma.	SC.912.L.16.4 DNA Mutations SC.912.L.16.5 Protein Synthesis/Central Dogma SC.912.L.16.9 Genetic Code SC.912.L.16.10 Evaluating Impact of Biotechnology
Students will understand that… **What should the students understand by the end of the lesson?**	**Essential Questions** **What essential question(s) does this lesson address?**
• Proteins can be prevented from being expressed by turning certain genes ON or OFF. • Gene silencing is one way to disrupt a gene. • RNA interference is a natural process that occurs in many organisms and involves the destruction of specific mRNA.	• Does every organism require a set of instructions that specifies its traits? • What are the consequences of a gene that gets turned ON or OFF? • Do mutations in the DNA sequence ALWAYS result in phenotypic change?
Connecting Concepts **How will you review yesterday's content and connect today's lesson to it?**	**Organizing Students for Learning** **How will students be organized for the lessons activities?**
• Student response systems – questions to review transcription and translation. • Introduction to gene expression - Hook Activity (TBD)	Students will be organized into pairs.

LEARNING EXPERIENCES, INSTRUCTION AND RESOURCES
What activities or experiences (from your Unit Plan) will students engage in today?

Lesson Sequence		
Activating Prior Knowledge	**Day 1** - **Student's pre-reading "*Chicken Dinosaur sheds light on bird beak evolution*" [Home work assignment].** - **Student Response systems** - **Show miniature clips – Jurassic World, The Amazing Spider Man, The Incredible Hulk, etc.** - **Placed heterogeneous groups of four to discuss a plan of action for their scenario: "You are part of a military group of scientists who are tasked with coming up with ways to**	☒ ABC Brainstorming ☐ KWL ☐ Anticipation Guide ☐ Card Sort ☐ Think-Pair-Share

	enhance soldiers. As a group, think of certain traits you would want to include in your newly designed militia. Please be as realistic as possible in your design. For example, try not to design humans who can breathe fire or can make ice from their hands. - **Students are told that before they can test their ideas out on human subjects that they need to see if it can be done on invertebrates first, such as worms.**	
Explicit Instruction	**Show different stages** - **C. elgans importance - Teacher demo** - **Students get into pairs and prepare their RNAi plates with mutant strain that is extra sensitive to RNAi.** - **Students will complete Part (I) of lab worksheet which involves them drawing and recording phenotypic descriptions of the worm at various life cycle stages.** **[At this stage, students have no knowledge of transcription and translation – Lesson takes a pause and teacher jumps into "Decoding the Flu" lesson]**	☐ Motivational Hook ☐ Lecture ☒ Demonstration ☐ Note-taking Guide
Lesson Sequence		**Resources and Materials**

Group Processing of New Information	**Day 4** - Students get into their pairs and do phenotype scoring of their worms - Students will complete Part (II) of their lab worksheet. - Students return to their Day 1 groups of 4 and engage in closing thoughts on their military design – Students will collaborate to bridge concepts they have learned from all lessons towards analyzing their military design - what type of phenotypic changes could they use based off of the worm activity towards their military design? - Each group is given a specific card to become experts in that particular role in the area of Designer Babies – Affluent Parents, Low Income Parents, Genetic Disease Child, Genetic Companies, Law Makers, Medical Research Center, Genetically designed child. [www.humansoul.com] [http://designerbabies-jtcc.blogspot.com/2009/06/stakeholders-in-designer-babies.html]	☒ Jigsaw ☐ Reciprocal Teaching ☐ Concept Attainment ☒ Think-Pair-Share	☐ Lab/Inquiry Activity	☐ Computer ☐ LCD Projector ☐ Paper ☐ Pencils ☐ Whiteboards ☐ Markers ☐ Butcher Paper ☐ Response Cards ☐ Post-it Notes ☐ Video Clip(s): ☐ Website(s): ☐ Lab Materials:
Elaborative Questioning	**Day 5** - Students continue their jig saw. They get into their differentiated roles to discuss each person's stance. Students are asked to corroborate to come up with a final law to be sent to congress for consideration. Their grade is dependent on their ability to provide come up with a suitable solution with strong evidence to support their law.	☐ Inferential Questions ☐ Analytic Questions ☐ Philosophical Chairs ☒ Jigsaw		
Demonstrating Understanding	- Students will use LDC template to present their final law [final claim, evidence, reasoning]	☒ Graphic Organizers ☐ Picture Notes ☐ Flow Charts		

		☐ Concept Maps ☐ Mnemonics ☐ Graffiti	
Reflection	- Students will engage in an online discussion board of a minimum of 5 sentences of what they took away from the unit. - Peer reflections (students can comment on other students' work).	☒ Reflective Journals ☐ Think Logs ☐ Exit Ticket (Student Learning)	
Daily Progress Monitoring Assessment	- Post Test	☒ Quiz ☐ Journal ☐ Exit Ticket (for Content) ☐ Response Cards	
Based on the results from your Daily Progress Monitoring Assessment, what concepts need to be revisited in the next lesson?			**Homework**

UNIT PLAN

Unit Title: ***DNA/RNA – Cracking the Codon*** (Subunit of Genetics/Heredity Big Idea)	Content Area/Grade: **9th Grade Biology**
Teacher: ***Nigel Jagoo & Amy Martin***	Implementation Time Frame: 3 - 4 weeks (50 min classes)

STAGE 1: THE DESIRED RESULTS
What are my learning goals?

Unit Goal Students will …	**Standard(s)/Benchmark(s)** What standard(s)/benchmark(s) does this daily lesson address?
• Understand how DNA is replicated. • Be able to describe the process of transfer of information during gene expression from DNA to RNA to protein and the relationship between these sequences. • Understand that each chromosome contains a large amount of information and that only a small part of this information is needed to code for a specific protein. Identifying information to make a specific protein requires the use of punctuation at both the DNA level and at the RNA level. • Determine the protein coded for by a DNA or RNA molecule, and comment on how changes to the DNA / RNA molecule will affect the protein. • Understand the role of RNAi in the Central Dogma • Discover the impacts of DNA Fingerprinting, PCR, Gene Therapy, Mutations, Cloning, and the Human Genome Project • Identify bioethical questions that have been raised with these new advances in science	SC.912.L.16.3 DNA Replication SC.912.L.16.4 DNA Mutations SC.912.L.16.5 Protein Synthesis/Central Dogma SC.912.L.16.9 Genetic Code SC.912.L.16.10 Evaluating Impact of Biotechnology
Related Misconceptions What misconceptions are predictable?	**Students will know…** Vocabulary, terminology, definitions
• Protein expression is a species specific phenomenon. • All mutations are bad. Students should understand that mutations provide variations among individuals in a population. Sometimes those variations are favorable and are maintained in subsequent generations as adaptations. • Changes in somatic (body) cells are inheritable. Students should understand that only sex cells contribute to genetic information in the next generation. • DNA in one organism is completely different from that in another organism. Students should understand that the basic structure of DNA is the same in all organisms. It is the sequence of nucleotides in the strands of DNA that result in different gene expressions in individuals.	**Vocabulary** Amino Acid Chart Artificial Selection Biotechnology Chromosomes Cloning DNA DNA Helicase DNA Polymerase DNA Ligase Exons Gel Electrophoresis Genes Genetic Engineering Heredity Human Genome Project Introns mRNA Mutation (Point, Frameshifts, etc) Okasaki Fragments Peptide bonds Protein Synthesis Replication RNA Polymerase RNAi Transcription Translation tRNA

- Cells within an organism have different DNA. Students should understand that the entire genetic code for an organism is identical in each and every cell of that organism.

Essential Questions
What questions will foster inquiry, understanding and transfer of learning?

- What is the Central Dogma?
- How does the impact of Biotechnology affect individuals, society and the environment?
- Does every organism require a set of instructions that specifies its traits?
- What are the consequences of a gene that gets turned on or off?
- Do mutations in the DNA sequence ALWAYS result in phenotypic change?

Students will know…
Key facts, formulas, critical details, important events, important people, timelines

Other Essential Knowledge

- 3' – 5' idea
- Okasaki Fragment formation
- Human Genome Project
- Gene Expression
- RNAi interference of a gene
- BLAST
- Watson & Crick, Miescher, Griffith and Avery, Franklin, Wilkins, Sanger, Sulston
- Mutations
- Central Dogma – what kinds of proteins are formed
- Gel Electrophoresis/PCR/DNA fingerprinting
- Cloning

Students will be able to…
Specific skills students will acquire as a result of this unit

- How to use a pipette
- How to run a gel electrophoresis and form a DNA Fingerprint
- How to silence a gene, transformation of a DNA sequence.
- Model the shape of a protein and understand how its shape affects its function.
- Code a protein from a given DNA sequence – transcribing, translating, and identifying the amino acid and protein strand formed.
- How to utilize the BLAST database and identify a gene
- Connecting this unit to Forensic Science and Gene Therapy

STAGE 2: ASSESSMENT EVIDENCE

What evidence will show that my students have achieved the learning goals?

Performance tasks:

Through what specific "real-world" performance task(s) will students demonstrate their understanding of the learning goals?

- Modeling the DNA replication process
- Producing an accurate "design" using a pipette
- Modeling the Central Dogma using the Decoding the FLU activity
- Using the BLAST database and successfully identifying a gene from a code
- Successfully getting a DNA fingerprint during a gel electrophoresis lab
- Successfully growing C. elegans that have silenced genes indicated.

Rubric

By what criteria will "performance of understanding" be judged?

SCORE	Performance of Understanding Mastery
4.0	Complete mastery of understanding in performance of tasks met
3.0	Very little remediation necessary, mastery of understanding in most performances met
2.0	Remediation of 3 or more tasks necessary, some mastery of understanding in performance
1.0	Remediation of 4 or more tasks necessary, small mastery of understanding in performance
0.0	Complete remediation of all tasks necessary, little to no mastery of understanding in performance

Other Evidence: What other evidence needs to be collected in order to monitor student progress on these concepts and skills along the way?	**Self-Assessment/Reflection** How will students reflect and self-assess their learning?
Pre/Post Assessments of mastery of content *Unit Assessment* *Lab Analysis* *Homework Checks* *Classwork Checks* *Attitude Assessments*	*Online Blog Type discussions* *Attitude Assessment* *Ticket out the Door* *Pair-Share* *E-Clicker Assessments during the learning process* *Homework Assignments*

STAGE 3: LEARNING EXPERIENCES, INSTRUCTION, AND RESOURCES What activities will help my students achieve the learning goals?	
What **H**ere	**What** is expected? How will you ensure that students are aware of the learning goals? **Where** are your students? How will you establish your students' prior knowledge?
	Understanding DNA/RNA processes and purposes. Posting Essential Questions at the beginning of the Unit – posting a word wall of key vocabulary, Pre assessments, and Identifying lesson goals. KWLs
Hook **H**old	How will you **hook** students at the beginning of the unit? How will you **hold** their attention throughout the units?
	Flag signaling (like in the Navy) to give the class a message – the code for the signals is on the board. Teacher waves 2 flags in a pattern based on a code. Have a signal that says "Attention", then spell out an instruction like "Take Your Seat." Then once the students have figured out your code, ask the students what you were doing. Then give them the connection to this unit on Cracking the Codon. Reconnect the importance of a correct code throughout the unit.
Experience **E**xplore **E**quip	What critical input **experience** will help students **explore** the key ideas and essential questions? How will you **equip** your students with needed skills and knowledge?
	Pipetting By Design Lab : How to use a pipette Decoding the Flu: Case Study that teaches the Central Dogma Building a Protein Model: Connection to form fits function with a change in an amino acid affecting the end size or shape of a protein affecting its function. How to utilize the BLAST database and identify a gene Reading With Restriction Enzymes: Teaches how an electrophoresis works with DNA Restriction Enzymes to create a Fingerprint Nature's Dice Lab: Actually teaches how to run a real gel electrophoresis and interpret results. C. elegans' RNAi Gene Silencing Lab: How to silence a gene, transformation of a DNA sequence. Connecting this unit to Forensic Science and Gene Therapy
Reflect **R**ethink **R**ehearsing **R**evising **R**efining	How will you encourage students to **reflect** and **rethink**? How will you guide students in the process of **rehearsing**, **revising**, and **refining** their work?
	Having them make critical connections of how one process affects the other as new processes are taught then returning to the original hook – how does this relate to/affect a "Code".
Exhibit **E**valuate	How will you help students to **exhibit** and **self-evaluate** their developing skills, knowledge and understanding throughout the unit?
	Modeling, allowing them to practice, then perform a task. Several activities and labs have predictable outcomes – they will be able to self-evaluate their skills if they reach the desired outcome. Pre/post testing, ticket out the door, online discussion boards, will allow them to demonstrate understanding as things are covered.
Tailor	How will you **tailor** your instruction to meet the different needs, interests and abilities of all learners in your classroom?
	Scaffolding the information, peer mentoring for labs, differentiated analysis for different abilities.
Organize	How will you **organize** and sequence the learning activities to maximize the engagement and achievement of all students?
	Teach: Structure Of DNA, Replication of DNA, Central Dogma, What goes wrong with the code, how scientists are using the information of the Human Genome for Gene therapy, Forensics, Genetic Engineering etc., Bioethics involved with different scientific advancements.

Big Idea:		**Standard(s)/Benchmark(s):**
Unit:		**Sample Activities**
Grade:		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**	
Score 3.0	**The student:** **The student exhibits no major errors or omissions**	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** • Recognizes or recalls specific terminology • Performs basic processes, such as: **However, the student exhibits major errors or omissions regarding the more complex ideas and processes**	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**	
Score 0.0	**Even with help, no understanding or skills demonstrated.**	