

Breeding Scientific Understanding and Ideas Through Change!

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Abstract:

Teaching science concepts in isolation or as dictated by a textbook or district adopted curriculum guide often encourages teachers to teach the width of their content with limited depth. My focus has always been to approach the application of scientific concepts through real world problems, topical reading assignments and data collection and analysis. I have the luxury of designing my curriculum to fit this teaching methodology because my courses are not state tested (marine science) or I am the only one who teaches it (AP biology). However, despite this flexibility there are areas of needed improvement in both of my courses. In addition, the recent introduction of an introductory science course for our incoming freshman class provides an opportunity to focus on problem based learning in that course sequence/curriculum. This action proposal is applicable to my current position as a teacher leader in my building. I spend 40% of my teaching assignment within my own classroom with my own students, and 60% of my teaching assignment working with other teachers. As a result this action proposal has three parts. One focuses entirely on my Advanced Placement biology class of which many of the biotechnology concepts addressed in the Catalyses institute utilized and the depth of knowledge is on level with aspects of the course requirements. The second part focuses on my marine science course, which has largely been taught from an ecological approach with limited inclusion of biotechnology content and skills. Finally the most ambitious portion of my action proposal focuses on an extensive unit development for our newly adopted 9th grade environmental science course sequence. This aspect hopes to encourage teachers to assist in the development of a multiday unit of study that incorporates reading and writing in the content area with exposure to lab techniques associated with biotechnology.

Rationale-Problem Based Learning

Problem based learning (PBL) has been a teaching strategy for over 30 years with some authors going on to say that it is “the most innovative instructional model conceived in the history of education” (Hung et al. 2008) and it is “the most significant innovation in education for the professions for many years (Boud and Feletti 1997). A cursory google scholar search produces a multitude of articles, books, studies etc. dedicated to its practice. A limited survey of the sources provided through this search seem to emphasize the use of problem based learning in undergraduate programs and post graduate programs such as medical school. The benefits of this learning style are lauded over the traditional lecture that often drives curriculum at institutions of higher education (Westervelt 2017). Results indicate a higher percentage of student success measured by reduced failure rates (Freeman et al. 2014) in a PBL classroom than in a traditional classroom. Despite these benefits, PBL is infrequently integrated into undergraduate graduate programs because of the level of “disciplinary expertise” required (Wieman 2014). If a limitation to the implementation of PBL at post high school institutions is limited by teacher “expertise” it stands to reason that the development of accurate problem based learning curriculum at the high school level is also limited. Programs provided by the Center for Precollegiate Education and Training (CPET) provide high school teachers with the exposure to experts for content and experimental techniques that can give them the necessary skills to build problem based learning around complex topics like biotechnology.

Rationale-AP Biology and Cell Communication: Thanks to my previous work with CPET through their Bench to Bedside program, much of my AP biology curriculum has already been positioned in such a way that genetic disorders drive much of our unit by unit calendar of study. Gaps in the current curriculum are apparent in our unit on cell communication. The abstract nature of this content often makes it difficult to present in an interactive way and I often turn to traditional lecture in order to “push” though the chapter. As this is not the way the majority of our class is structured the disengagement in learning is obvious (as measured through direct observation and post unit test scores. **By incorporating a communicable disease connection into this unit of study as well as a scar tissue formation/surgical recovery “case study” it is expected that this unit will improve student participation, appreciation and assessment results.**

Intervention-AP Biology and Cell Communication: As previously noted, this unit often falls into a traditional lecture/direct instruction method of delivery. Students will instead enter the unit with a particular disease/infection/disorder (taken from Catalyses participant William Furiosi and possibly integrating plant pathogens if relevant literature can be found) and be required to do the following:

- Identify the cause of the disorder (genetic/infection pathogen/lifestyle etc.)
- Describe the symptoms associated with the disorder
- Describe the normal signal pathway that would be affected by the disorder
- Describe how the disorder influences that pathway.

Students may present their cell communication/pathway in a number of different ways (research poster format, video, animation, cartoon etc.). In addition to this case study, students will engage in a

traditional team based learning lesson that focuses on the concept of cell communication and data analysis. In this portion of the unit students will be required to do the following:

- Review figures and summary slides or read abstracts related to Dr. Charles Schultz's lecture on scar tissue formation.
- Answer scenario based questions in the simultaneous response format modelled by Dr. Wayne McCormack

Data Collection and Analysis: Student performance can be measured by pre and post Individual Readiness Assessment Tests (IRAT) and Team Readiness Assessment Tests (TRAT) and a reflective survey using the Likert scale to determine student attitudes towards the content. Since the majority of the units in my AP course are focused around problem based learning, student based performance on the IRAT/TRAT assessments should be similar or higher than other units previously attempted

Rationale-Marine Science-Ecology and Biotechnology: My marine honors course is also focused around a problem based learning approach. However, as we transition into our fish and fisheries unit (usually around mid April) I use an article focusing on the spread of introduced lionfish as a pivot point from our coral reef unit into our fish unit. What has been missing is any kind of lab activity that focuses the students' attention on the role scientists are playing in determining the effects of the lionfish invasion. **Several hands on activities will be introduced into this unit to focus the students' attention on stomach content analysis of lionfish while also introducing them to biotechnology techniques that many of them will not have experienced before. As a result an increase in understanding of biotechnology procedures, biotechnology applications and the ecological impact of lionfish will be evident through a variety of measurement tools (pre/post test, RAFT writing assignments and surveys)**

Intervention-Marine Science-Ecology and Biotechnology:

Although not directly related to the content of emerging pathogens, the intervention for this unit came from Simone Barnes's (a Catalyses participant) best practice presentation, and many of the biotechnology skills were demonstrated throughout the institute. During this unit students will engage in the following activities:

- [Inquiry Video-Fish Work Up-Michael Sipos University of Florida Graduate Student](#)
- [Introduction to lionfish/invasive species through text article](#)
- [Hands on lab activity-Identification of fish stomach contents or simulation from Monterey Bay Aquarium](#)
- [Use of Simulations for introduction of DNA Isolation, PCR and Gene Sequencing](#)
- Modified Pipetting by Design Kit to teach pipetting techniques to students.
- [Actual lab experience isolating DNA of unknown animal samples-potential modifications to a Carolina Biological Kit and use of CPET Biotechnology equipment \(PCR thermocycler\)](#)
- Simulated Blast activity by analyzing DNA sequences derived from peer reviewed literature:[Cote et al. \(2013\)-Diet richness of invasive Indo-Pacific lionfish revealed by DNA barcoding.](#)

Data Collection and Analysis: Unlike my AP biology students that require the focused biotechnology content in our course, the marine science course does not. In order to gauge the declarative knowledge (standards based fact retention) and procedural knowledge (process and application) associated with

biotechnology concept mapping demonstrated during the Catalyses institute and revised as described by [Rice et al. \(1998\)](#) will be used pre and post unit. Also, students understanding of biotechnology concepts, applications and ecological impact of lionfish can be demonstrated through formative pre and post tests and summative writing. Students will complete a Role, Audience, Format, Topic (RAFT) assignment where they will assume the following:

Role=Biotechnology Lab Technician

Audience=Marine Ecologist

Format=DNA Sequence Data Analysis and Results

Topic=Report on Lionfish Stomach Content

Rationale-9th Grade Environmental Science and Biology-Multidisciplinary Unit on Zika and Mosquitos:

Our school and district has had steadily declining Biology EOC scores. A proposed solution to the problem has been to reintroduce environmental science as a course in our science sequence. Students who score a 3 or lower on their previous year's FSA Reading test will be automatically placed in the environmental science course, with biology to follow in their 10th grade year. Students testing a 4 or higher will be placed in either biology or honors biology. Anecdotal conversations with previous biology teachers always seem to fall on several deficiencies that the students lack that limit their success on the stated mandated end of course exam: 1-High degree of reading deficiency in biology classes, 2-Inability to analyze data, draw conclusions and apply the scientific method, 3-A high enrollment of second language learners.

Our current administration wants to see the environmental science team collaborate to fully integrate reading strategies into their curriculum. As described by [Gutherie and Davis \(2010\)](#) students that progress from elementary to middle school (especially in those that are low level readers) often lose intrinsic motivation for reading. That lack of motivation in reading does not mean a lack of motivation in other aspects of their curriculum. For example "a student may be engaged in doing labs in science, but not in reading about science" ([Gutherie and Davis 2010](#)). As a result I believe that if the school's administration or its environmental science teachers attempt to focus on reading or labs in isolation limited impacts from both a scientific knowledge perspective and attitude towards reading and overall reading comprehension will be limited. **As a result I am hoping to initiate a curriculum writing team that will develop a multiday unit of study designed around the environmental, biological, ecological, historical and geographical nature of mosquito transmitted pathogens, with an emphasis on the Zika virus. Success can be measured on three distinct tiers: 1-Recruiting teacher involvement in the process (grant writing/curriculum development) 2-Implementation and data collection of curriculum in teacher's classroom at South Fort Myers High School and 3-Long term data analysis to determine if application of components of the curriculum had a positive correlation to student's performance on the Biology End of Course Exam the following school year.**

Intervention-9th Grade Environmental Science:

In my previous action research proposal for Bench to Bedside, I adopted a similar approach to developing lesson plans for teachers in my building. I was met with limited "enthusiasm" due to time constraints of the End of Course Exam and what I assume was a lack of ownership over the content. As a result I had limited opportunity to implement aspects of the Bench to Bedside curriculum in other

classrooms. My hope that the “buy in” for this intervention will come from the opportunity to co-author a grant to help construct this curriculum and then establish a “development committee” to fine tune aspects of the Catalyses curriculum into appropriate lessons for our Zika virus based focus. Below is a “wish list” of potential areas of curriculum development. Each intervention step is led by a problem statement that will introduce the “real world” concept associated with the reading or hands on activity that the lesson focuses on. The problem statement is followed by a bullet point list of potential intervention activities and resources (hyperlinked when possible). Lastly a justification for the reasoning behind the activity is provided and rough estimate of the time required for that aspect of the curriculum’s lesson.

1. Introduction to Zika Outbreak

- **Problem Statement-What is the zika virus? How is it transmitted and what does it do?**
 - [World Health Organization-Zika Virus and Complications](#)
 - [The conversation](#)
 - First half of [Zika Fever Ted Talk](#)
 - Excerpts from Spillover Documentary
 - Mosquito egg trap activity and data submission to IFAS
 - Pipetting by design activity
 - Justification:Prior to delving into the application/implication of the Zika virus it is important for students to gain basic background knowledge as well as some hands on skills that will be used later-**Estimated time 1 block (84 minutes)**

2. Tracking the Zika Outbreak

- **Problem Statement-Where did zika come from, where is it going?**
 - [Zika virus: a previously slow pandemic spreads rapidly through the Americas-Journal of General Virology](#)
 - [Zika Digital Timeline-World Health Organization](#)
 - [Explainer:Where did Zika virus come from and why is it a problem in Brazil?-The Conversation](#)
 - Justification:Students are very geographically ignorant, this cross curricular lesson can follow a similar structure as the Tracking Ebola Activity with supporting questions to guide students through the reading articles provided and the mutations that have occurred and the reasoning behind the abundance of cases in South America and the Caribbean. **Estimated Time 1 block (84 minutes)**. Could be cotaught in 9th grade biology with their AP Human geography course or Cultural Geography course.

3. Zika ELISA-Who is infected with Zika?

- **Problem Statement-How do you know who is infected with zika?**
 - [Testing for Dengue Antibodies-CPET Activity](#) (could it be modified to support Zika)?
 - [BioradKit #- #166-2400EDU Protocol III](#) (\$138/kit)
 - CPET Equipment Locker?
 - Possible extension for biology students-Dengue Electrophoresis (could it be modified to support Zika)?
 - Justification:Students that are low level readers are often deprived of genuine hands on experiences because of behavioral issues, inexperience or discomfort

in classroom teachers with complex lab techniques, or a curriculum that does not support these lab investigations. **Estimated Time 2 blocks (168 minutes).**

4. Preventing Zika-Utilizing current Lee County mosquito control educational materials
 - **Problem Statement-What methods do we currently rely on to control mosquitos and reduce Zika transmission.**
 - [Determining the Level of Toxicity of Bacillus sphaericus to Culex Mosquito Larva](#)
 - [Determining the Susceptibility or Resistance of Culex Mosquito Larvae to Malathion](#)
 - Justification: These are well established labs and are cotaught with the help of local mosquito control educators, however, they are largely underutilized in our school. **Estimated Time 2 blocks (168 minutes).**
5. Mosquitos and South Florida History-“A Board Game”.
 - **Problem Statement-How did mosquitos influence the development of south Florida and what are the long term impacts of our attempts to control their environment?**
 - [The Swamp by Michael Grunwald](#)
 - Justification: Students can engage in an exploration of the major developers of Florida that attempted to drain and develop the Florida Everglades. Students can assume the role of one of the major players in South Florida History and using reading passages and game cards recognize the difficulties and long term impacts of their efforts. **Estimated Time 1/2 block (44 minutes).** Could be cotaught in 9th grade biology with their AP Human geography course or Cultural Geography course.
6. Mosquitos and Biodiversity-
 - **Problem Statement-Mosquitos, what are they good for?**
 - Requires intensive development with Dr. Roxanne Conelly and Larry?
 - Students will be introduced to the concept of biodiversity (species richness/indexes etc.)
 - Students could either:
 - [Simulate DNA extraction](#) or conduct a DNA extraction using a variety of pre made kits (Carolina biological price varies \$65-\$150)
 - [Simulate PCR](#) or conduct an actual PCR using a variety of pre made kits (Carolina biological/Edvotek price varies \$200-\$275)
 - Simulated DNA/Amino Acid Sequence/Mitochondrial DNA BLAST Activity to determine species richness.
 - Justification: Once again students at this level are often deprived on genuine hands on activities of this nature. In addition, this offers an opportunity to bridge two distinct fields in biology/environmental science. **Estimated Time 3 blocks (252 minutes).**
7. Genetically Modified Organisms
 - **Problem Statement-Should genetically modified mosquitos be used to control the mosquito population and their disease spreading capabilities?**
 - [Zika Fever Ted Talk](#)
 - [Controversy of Genetically Modified Organisms-NPR Newscast/Story](#)
 - [Mosquito vs. Mosquito-New York Times Article](#)
 - Justification-Students need to engage in class conversation about complex issues while supporting statements with evidence derived from informational

sources. Teaching strategies like [philosophical chairs](#) and [socratic seminar](#) can utilize the students' current body of knowledge and then push them to use text sources to support their position **Estimated Time 1 block (84 minutes)**.

- Optional Biotechnology Component-Conduct a bacterial transformation (PGlo) used in mosquito genetic engineering to determine which mosquitos were successfully transformed (Carolina Biological/Edvotek/Biorad price varies \$100-\$150)
 - Justification: Students that are low level readers are often deprived of genuine hands on experiences because of behavioral issues, inexperience or discomfort in classroom teachers with complex lab techniques, or a curriculum that does not support these lab investigations. **Estimated Time 3 blocks (252 minutes)**.

8. Mosquitos in our Community-Jigsaw.

- **Problem Statement-How do different perspectives influence the way people approach mosquito control?**

- A jigsaw style activity designed to provide students with a different perspectives on the control of mosquitos.
- [Zika Prevention-WHO](#)
- [How to prevent mosquito breeding grounds around your home-WHO](#)
 - Jigsaw Role-Mosquito Control "enforcement/awareness officer"
 - Jigsaw Role-Homeowner?
 - Jigsaw Role-Bromeliad nursery owner?
 - Jigsaw Role-Health care worker?
 - Justification:It is easy to lose site of the implications and difficulties that are associated with solving complex scientific problems. This activity allows students to see the aspect of mosquito born virus control from a variety of different and often conflicting perspectives.

Data Collection and Analysis-9th Grade Environmental Science

A curriculum of this nature will require extensive financial resources and collaboration between myself, interested environmental science teachers, our school's administration, our local mosquito education program and staff at CPET. The primary goal is to secure funding through grants that will also allow teachers to have buy in (both financial for curriculum writing and input for the curriculum itself). I have identified several grants below that could be possible sources of funding:

- <http://www.honda.com/community/applying-for-a-grant> Due August 1st, \$20,000-\$75,000 range.
- https://www.cybergrants.com/cybergrants/plsql/ao_login.login?x_gm_id=1240&x_proposal_type_id=27993 By Invitation, amount unknown.
- <https://www.toshiba.com/taf/612.jsp> Due August 1st if >\$5000, otherwise rolling submission.
- https://www.toyota.com/usa/community/articles/community_grants_foundation.html Rolling submission, \$50,000 to 500,000.

If funds are not received or buy in from environmental science teachers is limited because of the scope of the possibilities outlined above a "triage" approach will be adopted looking for areas of greatest impact from which to begin. If funds are received than the data collection and analysis will most likely

be determined by the grant itself. However some possible data collection methods can include but are not limited to:

- Concept mapping as outlined in the Catalyses institute
- Pre/Post Surveys on the Likert scale
- IRAT/TRAT-Team Based Learning techniques
- Reflective Writing/Journaling

[Link to presentation powerpoint.](#)

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UNIT PLAN	
Unit Title: Ecological Impact of Lionfish	Content Area/Grade: Marine Science/10-12
Teacher: Steven Wilkie	Implementation Time Frame: 2 weeks (5 blocks)
STAGE 1: THE DESIRED RESULTS	
What are my learning goals?	
Unit Goal Students will understand that...	Standard(s)/Benchmark(s) What standard(s)/benchmark(s) does this daily lesson address?
<ol style="list-style-type: none"> 1. Invasive species like lionfish can have an impact on local marine ecosystems. 2. Biotechnology can be applied to solve complex ecological problems. 	<p>SC.912.L.17.8-Recognize the consequences of the losses of biodiversity due to catastrophic events, climate changes, human activity, and the introduction of invasive, non-native species.</p> <p>SC.912.L.16.12-Describe how basic DNA technology (restriction digestion by endonucleases, gel electrophoresis, polymerase chain reaction, ligation, and transformation) is used to construct recombinant DNA molecules (DNA cloning).</p>
Related Misconceptions What misconceptions are predictable?	Students will know... Vocabulary, terminology, definitions
<ol style="list-style-type: none"> 1. Biotechnology is unrelated to marine ecology. 2. Digested stomach contents cannot be identified. 3. DNA cannot be obtained from stomach contents. 4. DNA analysis and identification is inaccessible. 	<p>Vocabulary</p> <p>Invasive Species, Venemous, Micropipette, Microliters (um), DNA Isolation, PCR, Primer, Electrophoresis, DNA Sequence, BLAST</p>
Essential Questions What questions will foster inquiry, understanding and transfer of learning?	
<ol style="list-style-type: none"> 1. What is the impact of the introduction of the invasive lionfish species to the coral reef ecosystem of the Florida Keys? 2. How can biotechnology processes be applied to aide scientists in understanding how lion fish are influencing the coral reef ecosystem of the Florida Keys? 	
Students will know... key facts, formulas, critical details, important events, important people, timelines	
Other Essential Knowledge	
<ol style="list-style-type: none"> 1. The consequences of changes to a marine food chain/web. 2. How scientists use quadrat studies to collect ecosystem based data. 3. The importance of marine ecosystems like coral reefs. 	
Students will be able to... Specific skills students will acquire as a result of this unit	
<ol style="list-style-type: none"> 1. Students will be able to use text evidence to identify the potential impacts of the introduction of lionfish to the coral reef ecosystems of the Florida Keys. 2. Students will be able to identify prey species of the lionfish by analyzing stomach contents. 3. Students will be able to conduct a DNA isolation, PCR and electrophoresis gel. 	

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?

- How do scientists use field data to determine the impacts that an invasive species like lionfish is having on the coral reef ecosystems of the Florida Keys?
 - Background knowledge through inquiry video (fish work up) and article review.
- How do scientists use stomach contents to determine the feeding habits of invasive species like the lion fish?
 - Application of proper dissection techniques.
- How do scientists isolate, amplify and confirm the presence of DNA from stomach contents of marine organisms.
 - Application of appropriate aseptic techniques to isolate DNA, amplify DNA and run and electrophoresis gel.
- How can you use a DNA database to determine the contents of a lionfish stomach?
 - Using the BLAST website to determine the contents of a lionfish stomach and determine their ecological impact.

Rubric

By what criteria will “performance of understanding” be judged?

Summative Assessment will be graded via a RAFT assignment where the students will present their understanding based on the following requirements:

Role=Biotechnology Lab Technician

Audience=Marine Ecologist

Format=DNA Sequence Data Analysis and Results

Topic=Report on Lionfish Stomach Content

A [rubric](#) will be provided prior to the assessment to ensure students understand the expectations required.

Other Evidence:

What other evidence needs to be collected in order to monitor student progress on these concepts and skills along the way?

Students will complete a pre unit concept map and a post concept map assessment to determine how they relate the procedural knowledge of biotechnology and the ecological impact of invasive species like lionfish.

Self-Assessment/Reflection

How will students reflect and self-assess their learning?

Individual readiness Assessment Tests (IRAT) and Team readiness Assessment Tests (TRAT) will be conducted as formative assessments during the unit.

STAGE 3: LEARNING EXPERIENCES, INSTRUCTION, AND RESOURCES

What activities will help my students achieve the learning goals?

	<p>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?</p> <p>Students will understand how scientists use biotechnology to determine ecological impact of an invasive species like the lionfish. Prior knowledge will be determined through a pre concept mapping assignment similar to that conducted in the Catalyses training.</p>
<p>Hook old</p>	<p>How will you hook students at the beginning of the unit? How will you hold their attention throughout the units?</p> <ul style="list-style-type: none"> • Inquiry Video-Fish Work Up-Michael Sipos University of Florida Graduate Student • Hands on lab activity-Identification of fish stomach contents or simulation from Monterey Bay Aquarium • Actual lab experience isolating DNA of unknown animal samples-potential modifications to a Carolina Biological Kit and use of CPET Biotechnology equipment (PCR thermocycler)
<p>Experience xplore quip</p>	<p>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?</p> <ul style="list-style-type: none"> • Introduction to lionfish/invasive species through text article • Use of Simulations for introduction of DNA Isolation, PCR and Gene Sequencing • Modified Pipetting by Design Kit to teach pipetting techniques to students.
<p>Reflect ethink ehearsing evising efining</p>	<p>How will you encourage students to reflect and rethink? How will you guide students in the process of rehearsing, revising, and refining their work?</p> <ul style="list-style-type: none"> • Individual reflection/discussion if IRAT/TRAT results warrant it. • Offer opportunity for rewrites of RAFT assignment
<p>Exhibit valuate</p>	<p>How will you help students to exhibit and self-evaluate their developing skills, knowledge and understanding throughout the unit?</p> <ul style="list-style-type: none"> • Small group discussion if necessary based on IRAT/TRAT results
<p>Tailor</p>	<p>How will you tailor your instruction to meet the different needs, interests and abilities of all learners in your classroom?</p> <ul style="list-style-type: none"> • Reading articles can be tailored to specific reading articles if necessary. • Collaborative groups to support student strengths (compass activity-North, South, East and West)
<p>Organize</p>	<p>How will you organize and sequence the learning activities to maximize the engagement and achievement of all students?</p> <ul style="list-style-type: none"> • Logical progression for overview of ecosystem impacts to specific measurement of ecosystem impacts through biotechnology techniques.

