Using the team-based-learning strategy and biomedical applications to increase AP Biology student enrollment, retention, engagement and success

"Teaching is not about covering content, it is about uncovering and discovering content"-Wayne McCormack

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Abstract

South Fort Myers High school (SFMHS) is an academy based high school, two of our academies (vet and medical) feed students into the AP science program. Past efforts to increase enrollment in AP courses in hopes of better preparing medical and vet students for the rigors of course work they will be exposed to in their post secondary education has proved to be futile. Exit surveys conducted on past AP students indicate a disconnection between the content of AP biology and the applications in their pursuit of medical or veterinary science careers. In order to improve that connection the AP Biology sequence used at SFMHS will be restructured to highlight the connections between required AP content and the biomedical fields associated with the Bench to Bedside program. Units of study will be anchored around a disease or genetic disorder in order to support the central dogma and emergent properties associated with AP biology. To reduce the attrition rate of students enrolled in the course and improve student success on the AP exam a team based learning approach will be utilized to increase accountability for student preparedness and instill a support structure within the classroom that students can rely on to improve their collaborative success. Preparation for AP science courses must start years before they actually enroll, in order to improve students analytical and laboratory skills aspects of the bench to bedside curriculum modules will be implemented with introductory biology, chemistry and medical students with the eventual goal of increasing AP science enrollment and success.

Rationale: South Fort Myers High School is an academy based school. Students enrolled in academies earn certifications in their fields of study that make them directly employable in the real world and increase their ability to pursue their post-secondary goals. The majority of the AP Biology (85%) and AP Chemistry (90%) students that are also enrolled in our medical or veterinary medicine academies. Despite this strong correlation between the students in the two programs, little has been done to coordinate skills and content between AP Biology and the two academies (AP chemistry will be offered for the first time on our campus in the 2015-2016 school year), as a result there is a disconnect between the value of a course like AP Biology and interests of the students.

During the past two years I have visited both the medical and veterinary students during their sophomore and junior years and used the degree requirements from medical and veterinary programs like UF, USF, FGCU and Santé Fe college as way to increase their awareness of the courses they will need to successfully pursue their goals of advanced degrees in their fields. Despite these efforts enrollment in AP Biology has remained stagnant. Over the last 2 years that the course has been offered the enrollment at the beginning of each school year has averaged 27 students, while the 4 years prior to that enrollment averaged 25 students.

Studies of college entrance criteria across the country illustrate that although AP exam scores do factor into offers of acceptance, they are much lower than actual enrollment and grades earned in that coursework (Klopfenstein and Thomas 2009). Although I emphasize this fact with my students and work closely with them to overcome their obstacles to success the attrition rate of my AP Biology course remains high. The past two years have seen a drop rate of 62% and 76% from the beginning of the school year to the test date in May. Students dropping the course often cite the level of difficulty of the course, their preconception that they will not earn a passing score on the AP exam and a disconnection between the early content of the course and their post secondary goals. SFMHS is rolling out a new academic initiative from College Board called the AP Capstone Diploma. Students can earn this diploma by successfully completing a preset number of AP courses in their areas of interest. In order to improve student interest, retention and success we owe it to the students to do a better job of catering to their areas of interest (while still maintaining the stringent guidelines of the AP courses) while offering a way to increase their ability to navigate the rigors of AP courses with success.

Action Research Intervention-Retention/Success: During the 2014-2015 year I flipped my classroom to focus the students' preparation at home freeing up time in the classroom to expand inquiry and applications during regular class time. As noted earlier the attrition rate actually increased in comparison with the previous year. Davidson et al. (2014) emphasize the need to assess and reward the students for their effort in preparation in timely manner. The team based learning strategy structures the learning time so that individuals are held directly accountable, but encourages group collaboration to identify and overcome misconceptions in the background knowledge. The team based learning approach is especially effective in course where thinking skills are emphasized (Michaelson et al. 2004). The redesign to the AP course emphasizes analytical and data analysis skills over memorization. The long term teams that are set up early in the school year and the emphasis placed on the team based learning structure (Individual Assessment-Group Assessment/Discussion-Application) will foster a level of support that will increase student retention and success in individual units of study and will provide them with the ability to successfully navigate complex issues anchored by biomedical case studies and lab based skills.

Action Research Intervention-Engagement/Success: To increase engagement I will begin to shift the courses sequence and focus away from a more ecological based offering (my bachelors and masters research are in marine ecology) and to one that centers around humans systems and biomedical

research. I have always designed my course as an investigation of complex biological issues by addressing the concept of emergent properties where increasing levels of biological complexity add more complex properties and interactions. Shifting the focus from an ecological perspective where the crescendo of each major unit of study was a ecosystem based application to one in which a human system or biomedical application/case study is the focus will allow students to see an ongoing connection to their future areas of study in medicine and veterinary science. Examples of how the concept of emergent properties and human systems can be weaved together will be implemented in the first unit of study in the course. This unit will introduce the central dogma of AP Biology (DNA-mRNA-Proteins-Phenotype) by using the Pompeii study to address the increasing level of complexity associated with DNA, transcription and translation into proteins and the effect that alterations in gene sequences have on those processes. The culminating activity will look at the impact that the disorder has on the cellular organelles (lysosomes) and the muscle systems of the body. This process will be mirrored throughout much of the first semester.

Action Research Intervention-Enrollment: My position as a teacher leader at SFMHS gives me the opportunity to work with other teachers and their students to implement new techniques and ideas to increase their engagement and improve the teacher's proficiency within areas of need. The advantages of establishing new pedagogical approaches to increase student support and engagement within the AP course itself will have a positive impact on the students willing to challenge themselves with the AP course by their own determination. The best approach to increasing enrollment in AP courses and translating that into success for those students is through preparation in earlier grades (Doughtery et al. 2005). As a result I intend to introduce biomedical techniques/case studies, utilizing the Bench to Bedsides locker program, into three courses of study offered at SFMHS. Our introductory biology course is a 9th grade course that all freshman must take and pass in order to graduate. By analyzing recent end of course assessment data and discussing areas of focus with teachers I can find a course of action to bring in biomedical techniques into the classroom. Anecdotal evidence indicates DNA, protein synthesis, and mitosis/meiosis are areas of needed intervention all of which were supported through the learning modules in the bench to bedside program.

For the first time SFMHS will be offering a medical skills course to 9th grade students thinking about entering our medical/vet academies during their sophomore year. This course has never been taught in Lee County before and offers an excellent opportunity to seed the curriculum with biomedical related content and skills in hopes of increasing our medical/vet enrollment and AP science courses. Finally, since much of biology is chemistry I hope to work closely with our chemistry/AP Chemistry teacher to find ways to continue to support the medical academy and increase student’s success as they migrate the AP capstone process.

Anticipated Bench to Bedside Elements: Since I have not met with our biology/chemistry professional learning community and a teacher of the medical skills course has yet to be identified I can not clearly identify B2B elements that will be utilized, although as mentioned earlier, DNA replication, protein synthesis and cell cycle are anticipated areas of intervention. If that is the case I foresee using the Pompeii predicament and War of the 12st century learning modules. A list of anticipated applications in my AP biology course are listed below:

- Central Dogma-Micro pipetting activity, Pompeii predicament Jigsaw/Assay, Science Take Out-Protein Folding
- Genetics Introduction-Disease/Blast sequencing
- Enzyme Structure and Function in Detail-Science Take Out Kit-Huntington’s disease or Lactose Intolerance

- Cell Transport-Science Take Out-Diagnosing Kidney Disease
- Cellular Respiration-Glycogen Storage Disorder background information, modified Clinical Trials Web Activity, Liver Decellularization Inquiry Lab and Stem Cell Webquest
- Cell Communication-War of the 21st Century Keeping it all in check and clinical Assay, Pharmacogenomics webquest and drug efficacy assay
- Genetics and Gene Regulation-Bacteria Transformation and C. Elegans siMRNA inquiry lab

Data Collection and Analysis: Retention data can be compared from the past two school years at the beginning of the school year, at the 4 week point and 9 week point (usually when I see the highest drop in enrollment), and at the semester when we "lock" our rosters in the AP courses. A t-test can be used to compare the change in enrollment at each of those intervals.

Student success can be measured both quantitatively and qualitatively. Quantitatively pre and post tests can be used when appropriate and analyzed using an ANOVA and a comparison of individual (IRAT) assessments and team (TRAT) assessments can be monitored to see if they align with expected increases in content comprehension described by McCormack. Correlations can be utilized to determine if scores on the TRAT can be good predictors of individual performance on cumulative assessments throughout the course of the semester. A qualitative approach will focus on student reflection journals employed through google classroom to determine students attitude towards the content being discussed and identify areas of difficulty individual students are having. These reflective journals can also serve as a point of intervention to reduce the drop rate in the course since I will have a more definitive understanding of the students' level of engagement and difficulties.

To increase student performance in freshman course and increase enrollment in the medical, vet and AP sciences (Biology and Chemistry) collaborative planning with the teachers during our professional learning communities can identify the needed areas of intervention and pre and post assessments can be co-created and analyzed using an ANOVA to determine the effectiveness of implementing biomedical based strategies with those teachers and their students. A survey will be employed to determine the students' attitudes towards the medical/vet academies, AP courses and biomedicine in general prior to implementation of any new teaching strategies/curriculum and then compared at the end of the intervention.

Culminating Activity (Anticipated Spring of 2016)/Budget Requirements-A current grant funded by Society for Science and the Public is designed to promote student based research in the classroom. Using funds from this grant students from each of the targeted classes (Biology, Medical Skills, Chemistry and AP Biology) will participate in a trip to UF's facilities to hear from experts in the biomedical field (area of focus to be determined later) and participate in an in depth laboratory investigation that bridges the content of all of those courses. This will both support and increase the reach of our current grant which up until now it has focused mainly on the ecological sciences and worked with faculty from Florida Gulf Coast University. This grant will also be used to support the application activities in the team based learning process in my AP biology class. State issued high cost science funds can be used to purchase any necessary supplies not available through the equipment lockers.

Literature Cited

Davidson, N., Major, C. H., & Michaelsen, L. K. (2014). Small-group learning in higher education—cooperative, collaborative, problem-based, and team-based learning: An introduction by the guest editors. *Journal on Excellence in College Teaching, 25*(3&4), 1-6.

Doughtery C., Mellor L., Jian S. (2006) The relationship between Advanced Placement and college graduation. *2005 AP Studies Report-National Center for Educational Accountability*

Klopfenstein K and M.K. Thomas (2009). The link between Advanced Placement experience and early college success. *Southern Economic Journal* 75(3), 873-891.

Michaelson, L.K., Bauman A., Fink, L.D. (ed.) (2004) *Team Based Learning:A Transformative Use of Small Groups in College Teaching*. Stylus Publishing L.L.C, Sterling, Virgina (p. 23).

SINGLE LESSON PLAN

Teacher: Wilkie	Content Area/Grade:AP biology	Date:

Unit Name:	Introduction to Central Dogma (DNA-mRNA-Amino Acid Sequence-Protein-Phenotype)

Unit Goal What unit goal does this daily lesson address?	**Standard(s)/Benchmark(s)** What standard(s)/benchmark(s) does this daily lesson address?
Unit Goal- Biological systems are influenced by the information encoded in the genetic material (DNA) and instructions in DNA are translated into proteins that influence the physical traits of the organism Daily Goal-Students will be able to use a DNA sequence to predict the resulting amino acid sequence and predict the outcome if mutations in the genetic code occur.	SC.912.L.16.5-Explain the basic process of transcription and translation and how they result in the expression of genes. SC.912.L.16.4-Explain how mutations in the DNA sequence may or may not result in phenotypic change.
Students will understand that… What should the students understand by the end of today's lesson?	**Essential Questions** What essential question(s) does this lesson address?
Students will understand that the sequences of DNA (genes) code for specific molecules (proteins) that are responsible for much of the physical traits a person exhibits. Students will correctly predict the mRNA sequence from a provided sequence and then translate that into an amino acid sequence. Students will predict the impact of a change in the genetic dode (mutation) to the final amino acid sequence.	How is the genetic code used to generate an amino acid sequence (transcription/translation).
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 today for the lessons activities?
From flipped classroom background knowledge-IRAT/TRAT team based learning assessments.	Students will be organized into teams based on previous groupings associated with the team based learning process.

LEARNING EXPERIENCES, INSTRUCTION AND RESOURCES

What activities or experiences (from your Unit Plan) will students engage in today?

Lesson Sequence

Activating Prior Knowledge	IRAT/TRAT Multiple Choice Questions to ascertain individual preparedness for the lesson and group collaboration to reduce misconceptions or misunderstandings in basic information associated with the central dogma.	☐ ABC Brainstorming ☐ KWL ☐ Anticipation Guide ☐ Card Sort ☐ Think-Pair-Share
Explicit Instruction	Direct instruction on how to interpret DNA sequences associated with the Flinn Scientific Kit describing protein synthesis.	☐ Motivational Hook ☐ Lecture ☐ Demonstration ☐ Note-taking Guide

<table>
<tr><th colspan="3">Lesson Sequence</th><th>Resources and Materials</th></tr>
<tr><td>Group Processing of New Information</td><td>Transcripton/Translation Activity tied to “challenge questions” associated with the transcription/translation activity (previously released AP multiple choice and short response question)</td><td>☐ Jigsaw
☐ Reciprocal Teaching
☐ Concept Attainment
☐ Think-Pair-Share</td><td rowspan="3">☐ Lab / Inquiry Activity</td></tr>
<tr><td>Elaborative Questioning</td><td>How would changes to the DNA sequence influence the outcome of your amino acid sequence?

What types of changes would have the greatest/least impact on the eventual structure of the amino acid sequence?</td><td>☐ Inferential Questions
☐ Analytic Questions
☐ Philosophical Chairs</td></tr>
<tr><td>Demonstrating Understanding</td><td>Correct amino acid sequence based on DNA sequence provided.

Flow chart of the central dogma and a brief explanation of the role of the major molecules/organelles (DNA, mRNA, tRNA, Amino Acid, Protein, Nucleus, Ribosome)</td><td>☐ Graphic Organizers
☐ Picture Notes
☐ Flow Charts
☐ Concept Maps
☐ Mnemonics
☐ Graffiti</td></tr>
<tr><td>Reflection</td><td>Data tracking IRAT/TRAT Data

Exit ticket-DNA to Amino Acid Challenge Question

Reflective Journal through google classroom.</td><td>☐ Reflective Journals
☐ Think Logs
☐ Exit Ticket (Student Learning)</td><td rowspan="2">☐ Computer
☐ LCD Projector
☐ Paper
☐ Pencils
☐ Whiteboards
☐ Markers
☐ Butcher Paper
☐ Response Cards
☐ Post-it Notes
☐ Video Clip(s):

☐ Website(s):

☐ Lab Materials:</td></tr>
<tr><td>Daily Progress Monitoring Assessment</td><td>Formative assessment based on application activity (released multiple choice and short response questions from college board’s AP Biology website)</td><td>☐ Quiz
☐ Journal
☐ Exit Ticket (for Content)
☐ Response Cards</td></tr>
<tr><td colspan="3">Based in the results from your Daily Progress Monitoring Assessment, what concepts need to be revisited in the next lesson?</td><td>Homework
Flipped Classroom lecture-Mutations, Enzymes and Biological Functions</td></tr>
</table>

UNIT PLAN

Unit Title:AP Biology-Intro to Central Dogma	**Content Area/Grade:AP Biology (11/12th grade)**
Teacher: Wilkie	**Implementation Time Frame:6 Days**

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?
Biological systems are influenced by the information encoded in the genetic material (DNA) and instructions in DNA are translated into proteins that influence the physical traits of the organism	SC.912.L.14.6 SC.912.L.16.2 SC.912.L.16.3 SC.912L.16.4 SC.912.L.16.10
Related Misconceptions What misconceptions are predictable?	**Students will know…** Vocabulary, terminology, definitions
1-DNA is the most important molecule in living things. 2-The information encoded in DNA is so vast that small changes have little impact on living things. 3-All diseases are easily treatable with current medicine. 4-Understanding how DNA influences phenotype is so expensive that little advancement has taken place.	**Vocabulary:** **DNA** **mRNA** **Amino Acid/Protein** **Transcription/Translation** **Primary, Secondary, Tertiary, Quaternary Structure** **Mutation (Insertion, Deletion, Substitution, Nonsense)** **Genotype/Phenotype/homozygous/heterozygous/dominant/recessive** **Nucleus/Ribosome/Endomembrane System/Lysosome** **Glycogen/Glucose**
Essential Questions What questions will foster inquiry, understanding and transfer of learning?	
How does the information encoded in the DNA (genome) of an organism influence the physical traits of that organism? How are genetic diseases connected to changes in the genetic code?	

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

Other Essential Knowledge:DNA Structure vs. RNA structure, Basic Genetic information (punnett square, phenotype and genotype terminology), basic pipetting skills, writing detailed conclusions supported with lab data

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

1-Use DNA sequences to predict mRNA and Amino Acid Sequences
2-Predict the impact of a variety of mutations on the final protein structure.
3-Use basic pipetting skills to collect assay data and use that data to draw conclusions.
4-Report the outcome of a patients' diagnosis based on "lab data".
5-Use a Blast database to determine the genetic defects and the symptoms associated with common genetic disorders

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?

1-Assay Data Collection and Interpretation
2-Using genetic information to complete a pedigree analysis
3-Reading, interpreting and discussing a scientific journal article
4-"Grand Rounds" Report of the implications of mutations in the genetic code and the influence it has on a particular genetic disorder (Pompeii disease).
5-Using a genetic database and external resources to determine genetic disorders and the symptoms/treatment associated with those disorders.

Rubric

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

Summative-1-General background knowledge will be determined using short entrance quizzes (IRAT/TRAT) through out unit associated with assigned background information.
Formative-2-Application activities will use released multiple choice and short response questions from AP central to determine students understanding of the complex activities extending their independent/team background knowledge.
Formative-3-Jigsaw answer keys for Pompeii activity
Formative-4-Assay results (actual vs. expected)
Summative-5-Grand Rounds Rubric (data collection, analysis and interpretation0
Formative-6-Blast/disease posters
Summaative-7-Cumulative Multiple Choice and written response test

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?
Reflective (qualitative journals) on student learning assigned periodically through the unit to ascertain student misconceptions and obstacles to understanding.	IRAT and TRAT assessment through out the unit. Exit tickets at critical junctures in the unit

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?
	1-Use of IRAT/TRAT to increase accountability for preparation 2-Flipped Classroom Lectures strategically placed through out the unit: Central Dogma=DNA-mRNA-Amino Acid Sequence-Protein Structure-Phenotype Genetics "reintroduction"=Genotype vs. phenotype, homozygous/heterozygous etc.
Hook **H**old	How will you **hook** students at the beginning of the unit? How will you **hold** their attention throughout the units?
	1-Calum's story or a similar story associated with glycogen storage disease 2-Using hands on activities to advance students understanding of the central dogma. 3-Using the collaborative effort associated with team based learning to hold each team member accountable to each other.
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?
	1-DNA-MRNA-Amino Acid Sequence Activity/Impact of Mutations 2-Calum's Story Jigsaw activity for reinforcement 3-Science Take Out Activity-Protein Structure and Function 4-GAA Activity Assay/Grand Rounds Presentation 5-Extension-Blast Activity-Identify other genetic disorders and their phenotype effects.
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?
	Use of the IRAT/TRAT process to support student preparation and identification of misconceptions and continuous areas of misunderstanding. Relflective "journaling" delivered through google classroom at critical learning junctures in the lesson.
Exhibit **E**valuate	How will you help students to **exhibit** and **self-evaluate** their developing skills, knowledge and understanding throughout the unit?
	Personal Data Tracking (IRAT vs. TRAT scores) Use of collaborative directed questions (Jigsaw/Science Article Interpretation) Rubric Based Grand Rounds Reporting Blast Reference sheets to determine accuracy of genetic sequence information.
Tailor	How will you **tailor** your instruction to meet the different needs, interests and abilities of all learners in your classroom?
	Team based learning will be used to and will rely on groupings established prior to the unit to organize teams into teams to emphasize each team members skills. Using IRAT/TRAT assessments to determine ongoing misconception with individuals or groups where specific intervention strategies can be employed.
Organize	How will you **organize** and sequence the learning activities to maximize the engagement and achievement of all students?
	Flipped Classroom to collect basic background knowledge-IRAT/TRAT to increase accountability and reinforce background knowledge-application activities aligned with released multiple choice and short response questions from college board-rubric based assessment in culminating activities (grand rounds)

Big Idea: AP biology Central Dogma		Standard(s)/Benchmark(s):
Unit: Protein synthesis		Sample Activities
Grade: 11-12		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**	Students will be able to utilize DNA sequence data and predict the phenotypic effects in relationship to Pompeii disease and extend their understanding to describe the potential impacts of genetic mutations on other diseases.
Score 3.0	**The student:** **The student exhibits no major errors or omissions**	The student can use a DNA sequence to predict the mRNA sequence and the resulting Amino Acid sequence. The student can determine the impact that alterations in the DNA have on the structure and function of the resulting protein.
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**	The student understands that DNA is the genetic code and can recognize the structure of a DNA molecule. The student knows that DNA is converted into mRNA and then into an amino acid sequence. The student knows that the amino acid sequence influences the structure of the final protein. The student knows that proteins are responsible for "displaying" much of the physical traits (phenotype) that result from the instructions in the DNA. The student understands that mutations are changes in DNA and they affect the final structure/function of a protein.
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.**	