Project Based Learning and the Cell Cycle: A Proposal for Application.

By Edwin Meagher
Atlantic High School Science Teacher
edwin.meagher@palmbeachschools.org

Abstract:

Different methods or activities can increase student engagement which is directly linked to learning gains. This proposal lays out a plan to apply Project Based Learning (PBL) to teach The Cell Cycle to 9th grade biology students. This proposal uses a set of lessons titled "The War of the 21st Century: The Cell Cycle, Cancer, and Clinical Trials." This lesson set was developed by the University of Florida Center for Precollegiate Education and Training. A review of the PBL framework is included along with an assignment that will teach standards related to the cell cycle and cancer causing genes.

Rationale:

"Students engaged in school are more likely to earn high grades and test scores, and have lower dropout rates. In contrast, students with low levels of engagement are at risk for a variety of long-term adverse consequences, including disruptive behavior in class, absenteeism, and dropping out of school." From "Relationships Matter: Linking Teacher Support to Student Engagement and Achievement" by Adena M. Klem and James P. Connell, 2004.

This proposal lays out a plan to embrace a simple idea; more engagement equals more learning. "Regardless of definition, research links higher levels of engagement in school with improved performance" (Klem and Connell, 2004). Increased engagement and achievement is always apart of an educator's year long plan. One method that is supported by research is Project Based Learning (PBL). Teaching the cell cycle using the PBL system is likely to increase student engagement, interests, and achievement.

There are several goals when a teacher uses PBL. "Project-based learning involves completing complex tasks that typically result in a realistic product, event, or presentation to an audience" (Barron and Darlin-Hammond 2008). Students complete tasks that will create a product. The educator acts as a facilitator in assigning and assisting with each task. As the students participate, they will build toward finalizing a product (usually of their choice).

The tasks used must be designed with care. The entire project in general should be central to the curriculum and designed using standards. It should also embrace inquiry to drive student questioning. The students are at the center of the tasks, using questioning to complete each part. In addition, the tasks should be authentic and relate to the real world (Barron and Darlin-Hammond 2008). Finally, to complete the project, students design a product. This product can be of their choice (which is common in PBL design) or whatever deemed appropriate by the teacher. Using PBL in a lesson will create a unique environment that will increase student engagement. Increasing student engagement will lead to increased student achievement.

Intervention:

A lesson will be designed that will incorporate PBL strategies and lesson components of the booklet titled "The War of the 21st Century" to discuss the cell cycle and cancer genes. Specifically, lesson 4 from the booklet titled "Losing Control: The Cell Cycle and Cancer." The overall project will be assigned early in the lesson. Part of the lesson components will be utilized as tasks. As each task is completed, it will be used to assist students with developing their final product. The main goal being, if the teacher provides inquiry based tasks, then it will increase student engagement and facilitate the completion of a product. Upon the completion of this product, the students will have learned about the cell cycle and cancer genetics.

Project Based Learning can be simplified into four key points:

1. Start with a clear problem that is authentic.
2. Have a scheduled plan that will assign inquiry based tasks and will keep students accountable.
3. Include points of assessment to provide feedback and reflection.
4. Evaluate a created product.

To properly design a PBL assignment, other core components of PBL should be considered.

- The first component; set a clear goal. Use standards to develop the goal and relate it to the real world.
- The second component; design a plan. Start with inquiry based tasks. Provide various resources for the students to reference.
- Third; layout a schedule. Have students working on a specific task during each portion of instruction. Include deadlines for each task.
- Fourth; monitor. Students should be accountable for the time provided. Provide rubrics and assess students with the rubric at specific deadlines. Another possibility is to assign journal reflections.
- Fifth; assess the outcome. Use the given rubrics to assess. Having student-teacher conferences provides an opportunity to discuss outcomes (Buck Institute of Education, 2015).
- Lastly, evaluate the experience. Students must reflect on their final product. This can be done individually, as a group, or as a class. Also include time to discuss components that were successful and that were unsuccessful (www.edutopia.org).

This proposal will apply these factors to designing a lesson on the cell cycle in a high school biology course that is apart of the Middle Years Program at Atlantic High School in Delray Beach, Florida. Using this guidelines, a lesson will be created that will increase student engagement which will lead to increased achievement.

Changes to Intervention

After looking over the lesson and reviewing how it would be applied in the timeframe provided, several adjustments were made. First, in place of answering reflection questions at the end of each class period, one written reflection was done at the end of the project that included several of the same questions. This change was made due to time constraints. Another change was to require the project product to be a 2-3 minute video created by a pair of students. This change was made as a personal decision. During the school year students had created presentations, informative flyers, and diagrams. A video was a unique idea that I believed would encourage engagement due to the novelty of the product.

Connections to Bench to Bedside Summer institute:

This proposal will design one lesson for the cell cycle. It will utilize a booklet developed by the University of Florida Center for Precollegiate Education and Training as a part of the Bench to Bedside program. The booklet is titled “The War of the 21st Century: The Cell Cycle, Cancer and Clinical Trials.”

The specific lesson is titled “Keeping it All in Check: The Life of a Cell in the Cell Cycle.” This proposal will modify the lesson in order to comply with the parameters of a PBL based lesson.

Data Collection and analysis:

An anonymous survey will be developed that will measure the students interest in the lesson and confidence in the material. The survey will be completed by the students before and after the lesson itself. The survey is constructed from another survey used by Williams, Kiesha, Kurtek, and Sampson in a paper titled "The affective elements of science learning” (See appendix for survey). Their research assessed how students view the science classroom and their general attitude toward science. Teacher journaling and observations will also be used. The goal will be to compare student experiences in participating in a PBL lesson versus a traditional lesson that utilizes lecture and note taking. To measure achievement, test scores of the same non PBL lesson from a previous year will be compared to the test scores of this particular cohort.

Changes to Data Collection and Analysis

Unfortunately, a survey was not conducted before or after the lesson due to time constraints. Instead, I measured student interest by reviewing the reflections, which asked the students what they enjoyed and what they did not enjoy about the assignment. The reflections revealed that the overall most challenging aspect of the project for the students was the technical recording of a video. I demonstrated how to use the class set of laptops to record a video to the entire class. Yet, many students required my assistance to properly record the video. I am encouraged by this due to the fact that students only had positive thoughts on the material of the lesson.

When I compared the 2016-2017 class with the 2015-2016 class their test scores were very similar. The average was higher in the 2016-2017 class by 2% (78%). This value is not significant. The 2015-2016 class was taught in a more traditional format that included lecture, socratic questioning, and rote practice. This observational comparison does show that the PBL format used in this lesson is equal in efficacy to the format used in the previous year.

Personal observation supports increased student engagement and an increase in overall enjoyment. Students had to make personal choices at each step of the project and they gained pragmatic experience with using technology. The PBL format also resulted in an increased amount of time required to cover the unit, an additional 100 minute class period was required. Given these considerations, I plan on continuing to use the PBL format. In addition, I will also continue to use the lesson titled “The War of the 21st Century: The Cell Cycle, Cancer, and Clinical Trials.” One change I would make with this part of the lesson would be to skip the introduction of the cell cycle and start the lesson with the printed material provided by “The War of the 21st Century.”

Literature cited:

1. Jennifer Broo and Jessica Mahoney (2013). “The War of the 21st Century: The Cell Cycle, Cancer, and Clinical Trials.” *University of Florida Center for Precollegiate Education and Training.*
2. Adena M. Klem and James P. Connell (2004). “Relationships Matter: Linking Teacher Support to Student Engagement and Achievement” *Journal of School Health* Vol. 74, No. 7, 262-273.
3. **http://www.edutopia.org/project-based-learning-guide-implementation#pbl_question**

4. Brigid Barron and Dr. Linda Darling-Hammond (2008). “Teaching for Meaningful Learning A Review of Research on Inquiry-Based and Cooperative Learning” *The George Lucas Educational Foundation.*
5. Buck Institute of Education (2015). “Gold Standard PBL: Essential Project Design Elements”
6. Williams, Kiesha, Katrina Kurtek, and Victor Sampson. "The affective elements of science learning." *The Science Teacher* 78.1 (2011): 40-45.

Permissions:
No permissions are required. The survey will be conducted anonymously, this way the data collected will be completely private.

Lesson Plan

Title:
The Cell Cycle and Disease Genes

Key Questions:

1. How does the cell replicate?
2. What are the two main stages of the cell cycle?
3. What are the main stages of cellular division?
4. What is a check point?
5. How do genes affect the cell cycle?
6. How are checkpoints involved?

Science Subject:
Biology

Grade and Ability Level:
9th Grade Middle Years Program (part of the International Baccalaureate Program)

Science Concepts:

- The cell cycle
- Mitosis
- Mutations and uncontrolled cell growth

Overall Time Estimates:
Four 100 minute class periods.

Learning Styles:

- Cooperative learning
- Collaborative learning
- Inquiry based learning
- Group discussion
- Project development

Vocabulary:

- Cell Cycle or Mitosis
- Cellular Division
- Synthesis
- Apoptosis
- Interphase
- Prophase
- Metaphase
- Anaphase
- Telophase
- Checkpoint
- Cytokinesis
- Gap 0, Gap 1, Gap 2

- Restriction point
- Oncogene
- Tumor suppressor gene
- Mutation

Lesson Summary

In the first block of a 100 minute class, a brief introduction on the cell cycle will be given in order to present the main goals of the lesson. Students will then complete the activity "Keeping it All in Check: The Life of a Cell in the Cell Cycle" with some basic modifications and in groups. After going through cellular division, interphase, and checkpoints, disease genes will be given to each group of students. The project will consist of each group of students researching their gene. They will be assessed based on their cooperation, their product, and a written paper. Each individual student will turn in a written paper.

In the following blocks, students will be given tasks to complete each component of their project. Then, on the day the projects are due, as a class we will review and observe each product from each group. I will assess them during this time and provide feedback. After viewing each product, students will complete one reflection that reviews their experience.

Student Learning Objectives with Standards:

- SC.912.N.1.4 Identify sources of information, and assess their reliability according to the strict standards of scientific investigation.
- SC.912.L.16.14 Describe the cell cycle, including the process of mitosis. Explain the role of mitosis in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction.
- SC.912.L.16.8 Explain the relationship between mutation, cell cycle, and uncontrolled cell growth potentially resulting in cancer.
- SC.912.L.16.2 Discuss observed inheritance patterns caused by various modes of inheritance, including dominant, recessive, codominant, sex-linked, polygenic, and multiple alleles.

Materials:

- Class set of printouts from "Keeping it All in Check: The Life of a Cell in the Cell Cycle."
- Group sets of printouts for each step of the lesson.
- Class set of project overviews.
- Class set of rubrics.
- Laptops/computers for research
- Posters
- Markers and/or crayons
- Tape

Background Information:

The main goal of this lesson is to utilize Project Based Learning to teach the cell cycle. The educator will need to review the referenced publications to fully understand PBL and its methodology.

In addition, a review of the booklet "The War of the 21st Century: The Cell Cycle, Cancer, and Clinical Trials" will be necessary to understand specifically what standards are addressed.

Advance Preparation:

- Review "Keeping it All in Check: The Life of a Cell in the Cell Cycle" and the materials associated.
- Print needed sets of handouts, project assignment, and rubrics.
- Use videos associated with "Keeping it All in Check: The Life of a Cell in the Cell Cycle" to facilitate lecture and introductions to the cell cycle.

Procedure and Discussion Questions with Time Estimates:
(block schedule - 100 minutes)

1st Class of Lesson

1. The instructor will begin with a 10 minute introduction to the cell cycle. Standards will be mentioned. The goals of the unit will be explained.
2. The lesson "Keeping it All in Check: The Life of a Cell in the Cell Cycle" will begin. The instructor will explain the activity. Each student will receive a handout of the cell cycle chart with the outlined vocabulary. They will also receive cutouts of cellular division (set 1). Groups will be assigned by the instructor in order for students to use the vocabulary to try to piece together the cell cycle.
    a. Inquiry questions: How does the cell replicate? What are the two main stages of the cell cycle? What are the main stages of cellular division? What is a check point?
    b. Inquiry questions will be asked to random groups to facilitate group discussion. This will take place after students have put down their guesses on the sequence of the cell cycle.
3. Time will be provided for students to figure out the proper order of cellular division.
4. As a class we will review the proper order and how we know the proper order (based on the vocabulary).
5. Now the students will receive cutouts of the stages of interphase and cutouts of the checkpoints (sets 2 and 3). They will be given time to figure out the proper order of sets 2 and 3.
    a. Inquiry questions 2: What is the difference between the gap phases and the S phase? What is a checkpoint?Which check point is the most important?
    b. Inquiry questions will be asked to random groups to facilitate group discussion. This will take place after students have put down their guesses on the sequence of the cell cycle.
6. As a class we will review the proper order of sets 2 and 3.
7. Next, each group will receive a gene from the set labeled "Genes" in the lesson. The project will be explained. Each group will do research on their gene. They will discover how the gene works and how it affects the cell cycle. Rubrics will be used to assess teamwork, the product created, and a written paper.
    a. Inquiry questions: How do genes affect the cell cycle? How are checkpoints involved?

8. Reflection questions: Briefly explain the cell cycle (1-2 sentences). Describe your initial thoughts on how you will start your product OR your paper (1-2 sentences). List questions you have about the project or paper.

2nd Class of Lesson

9. Students will begin Task 1 (as seen on the project handout). The instructor will explain the proper types of sources to use as a reference and the proper form to use when citing references.
10. Students will be given time to find examples of sources and confirm them with the instructor. They will also practice citing them in the proper way. The instructor will observe each group as they work for 15-20 minutes.
11. Next, students will begin Task 2. Students will create a detailed summary of the gene and the disease linked to the gene.
12. The last part of this class will be task 3. Students will review the cell cycle. They will explain how the gene they are researching is linked to mitosis.
    a. Reflection questions (completed at the end of the class): What disease is caused by your gene? Briefly describe the disease (2 sentences). How is this disease related to the cell cycle? (2 sentences)

3rd Class of the Lesson

13. Students will complete task 4, where they will decide what product they will create and then start creating it.
14. Next, students will complete task 5. They will write a rough draft of their written paper.

4th Class of the lesson

15. This class will provide extra time for students to finish off parts of their project.

5th Class of the lesson

16. Students will present their products to the class. Students will be able to ask questions at the end of each presentation.
17. Each group will get together and I will go to each group to discuss their grade.
18. As a class, we will discuss what the students enjoyed and what they did not enjoy about the project.
    a. Reflection: What did you enjoy the most? What did you enjoy the least? What recommendations do you have?

Assessment Suggestions:

The students will be assessed by observation of their collaboration, their final product, and a written paper. This lesson is a part of a complete unit, at the end of which they will be given a multiple choice test on the entire unit.

Resource/References:

1. Jennifer Broo and Jessica Mahoney (2013). “The War of the 21st Century: The Cell Cycle, Cancer, and Clinical Trials.” *University of Florida Center for Precollegiate Education and Training.*

2. Adena M. Klem and James P. Connell (2004). “Relationships Matter: Linking Teacher Support to Student Engagement and Achievement” *Journal of School Health* Vol. 74, No. 7, 262-273.
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4. Brigid Barron and Dr. Linda Darling-Hammond (2008). “Teaching for Meaningful Learning A Review of Research on Inquiry-Based and Cooperative Learning” *The George Lucas Educational Foundation.*
5. Buck Institute of Education (2015). “Gold Standard PBL: Essential Project Design Elements”

Appendix

Student Survey

Optional:
Name
Date
Period
Gender

Please use this scale to make your choices for the statements below:

- SA: Strongly agree
- A: Agree
- U: Unsure
- D: Disagree
- SD: Strongly disagree

Write one choice for each item:

1. I can succeed in science.	1. _____
2. I am confident that I understand science.	2. _____
3. I can solve complex problems in science.	3. _____
4. Science is too hard.	4. _____
5. I can interpret data tables and graphs in science.	5. _____
6. I can create scientific explanations using evidence.	6. _____
7. I can understand new ideas quickly when they are introduced to me in the science classroom.	7. _____
8. I understand scientific theories, laws, and concepts.	8. _____
9. I understand the language of science.	9. _____
10. I see myself pursuing a career in or relating to science.	10. _____
11. It is important to be able to create scientific explanations.	11. _____
12. I want to take more science classes.	12. _____
13. The activities in science class trigger my curiosity.	13. _____
14. I enjoy science class.	14. _____
15. I like planning scientific investigations.	15. _____
16. I enjoy creating explanations for natural phenomena.	16. _____
17. I like solving scientific problems.	17. _____
18. Science is interesting.	18. _____
19. Science is important.	19. _____
20. I want to succeed in science.	20. _____
21. I want to be able to design a scientific investigation.	21. _____
22. I want to understand scientific concepts.	22. _____
23. I want to understand theories, laws, and concepts.	23. _____
24. I think doing well in science is important.	24. _____
25. It is important for me to know how to write in a scientific manner.	25. _____

Optional - Please explain your responses.