Unlocking the Future of Stem Cells

Use of Decellularization Techniques to Bioengineer Organs

Bench to Bedside Action Research Proposal 2015

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Abstract:

This action research will focus on student understanding of stem cells, how they are cultured in a lab, and the potential of engineering an organ with newly introduced stem cells to one day cure disease and reduce the need for organ transplants.

Throughout a series of lessons students will conduct a web based activity to learn about the four major types of stem cells, cell differentiation, and germ layer formation. Later, students will have lab experiences where they will apply the previous content to explore applications of stem cells and learn how stems cells might potentially be transferred into patients by creating an organ scaffold.

Decellularization techniques used will follow Robb Bartenslagar's curriculum, *Bioengineered Livers in the Classroom, You Can't Really Do That?* Modifications to pre/post test include more of an emphasis on stem cells, cell reproduction and cell differentiation to align with biology course standards.

Rational:

As a biology teacher with nine years of experience, I have consistently encountered difficulties engaging students to learn higher complexity standards. However, the process can be more enjoyable for both the teacher and the student when classrooms are more interactive with hands-on activities that vary from the traditional lecture note-taking variety. A Chinese proverb that always sticks out in my mind and is reflective of my personal teaching philosophy is "Tell me, and I'll forget. Show me, and I'll remember. Involve me, and I'll understand". I feel this couldn't be better stated and is a valid description of the learning process. Students need to be actively engaged, especially when doing science. "Study after study has shown the value of hands-on learning. Students are motivated, they learn more, even their reading skills improve. How can you justify not doing hands-on science?" (Haury and Rillero). High quality learning activities can greatly improve learning motivation and bridge the achievement gap between students who are not exposed to hands-on instruction.

Furthermore, Piaget stressed the importance of learning by doing, especially in science. According to Piaget, "a sufficient experimental training was believed to have been provided as long as the student had been introduced to the results of past experiments or had been allowed to watch demonstration experiments conducted by his teacher, as though it were possible to sit in rows on a wharf and learn to swim merely by watching grown-up swimmers in the water. It is true that this form of instruction by lecture and demonstration has often been supplemented by laboratory work by the students, but the repetition of past experiments is still a long way from being the best way of exciting the spirit of invention, and even of training students in the necessity for checking for verification" (McAnarney, 1978, p. 31). By including these lessons to standard biology curriculum, I will create a classroom environment where students will have the opportunity to interact mentally and physically with the instructional material directly affecting their learning gains.

"Piaget's research clearly mandates that the learning environment should be rich in physical experiences. Involvement, he states, is the key to intellectual development and for the

elementary school child this includes direct physical manipulation of objects" (McAnarney, 1978, p. 33). Hands-on learning and varied instruction throughout the unit will aim to achieve significant learning gains.

The lab *Bioengineered Livers in the Classroom, You Can't Really Do That?* , will provide a real world application and concreteness to scientific concepts. Additionally, there are a plethora of benefits that teachers and curriculum developers adduce to hands-on learning to justify the approach in science. Benefits for students are believed to include enhanced learning; increased motivation to acquire knowledge; heightened enjoyment of scholastic pursuits; elevated skill proficiency, including communication skills; a boost to independent thinking and decision making based on direct evidence and experiences; as well as increased perception and creativity. Research supports many of these claims by providing evidence that the learning of various skills, science content, and mathematics are enhanced through hands-on science programs. Students in activity-based programs have exhibited increases in creativity, positive attitudes toward science, perception, logic development, communication skills, and reading readiness. These benefits seem more than sufficient justification for promoting hands-on learning (Haury and Rillero). Given the recent concerns about science anxiety and avoidance, enjoyment of science learning seems a worthy goal to be considered in choosing instructional approaches in science. The research also suggests a strong relationship between student's motivational interests and their preferred mode of instruction.

By using hands-on instruction, educators are fostering the 21st century skills that students need to be successful. The most essential of these are critical thinking, communication, collaboration, and creativity. Hands-on activities encourage a lifelong love of learning and motivate students to explore and discover new things (Bridging the Achievement Gap with Hand-On Teaching). Teaching concepts like decellularization in a high school setting to freshman is taking these 21st century advances from the research lab to the classroom.

CPET programs provide the opportunity to learn new teaching strategies and content that can be translated into the classroom for students to experience as well. The experience at Bench to Bedside has exposed me to new exciting research, innovative labs and meaningful collaborations among colleagues.

Given the extremely rapid pace at which basic developmental biology is growing, human embryonic stem cells will link this progress even more closely to the prevention and treatment of human disease. In short, it is an exciting time to be a science learner.

Action research intervention:

The following are interventions that will be taken during the action research: I will incorporate a pre and post test as an assessment tool. These assessments will be modified from the curriculum of *Bioengineered Livers in the Classroom, You Can't Really Do That?* The pre/post test will be adapted to meet biology standards, which are from the Cell Reproduction unit scope and sequence provided by the School District of Palm Beach County. I will make observations about student's learning gains based on hands-on activities. A science motivation questionnaire, a Likert scale, developed by Shawn Glynn at the University of Georgia will be used to gauge student interest in science hands-on learning.

Connections to Bench to Bedside Summer Institute: Bench to Bedside Summer Institute concepts in biotechnology, data collection, and stem cell research will be applied by using proscribed materials found in the UF CPET 'equipment lockers'. Bioengineered Livers in the classroom curriculum will be adapted to fit within biology content and suggested pacing guide. In addition, learning modules and the e-learning site will also be accessed during the year.

Data collection and analysis: Quantitative data will be collected in the form of a pre and post test to determine student learning gains. The data will be used to make adjustment to future teaching strategies and establish if the content or parts of the objectives need re-teaching. Students will use a science motivation questionnaire and reflective journal prompts as a means of obtaining self assessments.

The above mentioned quantitative day will be analyzed by graphing data findings and comparing pre and post test scores. It will be summarized using a median or mode; displaying the distribution of observations in chart format.

Literature cited:

"Bridging the Achievement Gap with Hands-On Teaching." Resource Area for Teaching. 1 Feb. 2013. Web. 24 June 2015.< http://www.raft.net/public/pdfs/case-for-hands-on-learning.pdf >

Collier, Christine, Judith Johnson, Lisa Nyberg, and Virginia Lockwood. "Learning Science Through Inquiry." Learning Science Through Inquiry. 2015. Web. 25 June 2015. < http://www.learner.org/workshops/inquiry/resources/faq.html#1>

Haury, David .L; Rillero, Peter, "Hands-On Approaches to Science Teaching: Questions and Answers from the Field and Research." Hands-On Approaches to Science Teaching: Questions and Answers from the Field and Research. Web. 25 June. 2015. <http://www.academia.edu/1770243/Hands-On_Approaches_to_Science_Teaching_Questions_and_Answers_from_the_Field_and_Research>

Haury, D. L. (1993b). *Teaching science through inquiry*. Columbus, OH: ERIC Clearinghouse for Science, Mathematics, and Environmental Education. (ERIC Document Reproduction Service No. ED 359 048)

McAnarney, H. (1978). What direction(s) elementary school science? *Science Education, 62*(1), 31-38.

Budget and budget justification:

Use of mobile computer lab for webquest provided by Palm Beach Central at no cost

Copies of student handouts also provided at no cost

Science take out kit - stem cells UF equipment locker no cost

Bioengineering a liver – UF equipment locker no cost

Permissions: No additional permission will be needed to implement action research proposal as principal and science assistance principal are aware of my involvement with the program.

SINGLE LESSON PLAN

Teacher: Denisse Conway	Content Area/Grade: Bio Hon/9th	Date: 06/23/15

Unit Name:	Cell Growth and Division

Unit Goal What unit goal does this daily lesson address?	**Standard(s)/Benchmark(s)** What standard(s)/benchmark(s) does this daily lesson address?
- The cell cycle and mechanisms of regulations, the phases of mitosis and meiosis, basic principles of inheritance and the role genes play in development.	SC.912.L.16 Evaluate the impact of biotechnology on the individual, society, and the environment, including medical and ethical issues. SC.912.L.16.14 SC.912.N.1.1
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?
-Evaluate examples and explain the possible impact of biotechnology -Some of the possible benefits and issues associated with stem cell research -application of stem cell research	-What possible outcomes does the engineering of organs hold for the future? -How will technological developments in organs help improve health and quality of life? -How does a single undifferentiated cell lead to a complex multicellular organism?
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?
During an opening bell-ringer and open discussion	Small learning group 2-4

LEARNING EXPERIENCES, INSTRUCTION AND RESOURCES

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

Lesson Sequence

Activating Prior Knowledge	-At the start of the unit instruction, students will take pre-test to assess prior knowledge, answer bell ringer questions reviewing prior content and opening up class discussion	☐ ABC Brainstorming ☐ KWL ☐ Anticipation Guide ☐ Card Sort ☐ Think-Pair-Share
Explicit Instruction	-Students will watch Dr. Anthony Atala's TedMed video -Pre-lab- I will demonstrate key parts of the lab, elaborate on how to use new lab equipment (i.e. stir plates), review lab safety,	X Motivational Hook ☐ Lecture X Demonstration ☐ Note-taking Guide

<table>
<tr><th colspan="4">Lesson Sequence</th><th>Resources and Materials</th></tr>
<tr><td>Group Processing of New Information</td><td>-Students will conduct decellularization lab by following lab procedures

-Student will work in small cooperative learning groups

-Students make observations and answer analysis questions</td><td>☐ Jigsaw
☐ Reciprocal Teaching
☐ Concept Attainment
☐ Think-Pair-Share</td><td rowspan="3">X Lab / Inquiry Activity</td><td rowspan="5">X Computer
X LCD Projector
X Paper
X Pencils
☐ Whiteboards
☐ Markers
☐ Butcher Paper
☐ Response Cards
☐ Post-it Notes

X Video Clip(s): http://www.ted.com/talks/anthony_atala_growing_organs_engineering_tissue

X Website(s): http://prod.cpet.ufl.edu/wp-content/uploads/2013/10/Bioengineered-Livers-in-the-classroom-you-cant-really-do-that-by-Robb-Bartenslager.pdf

X Lab Materials: fresh chicken liver, scalpel, flask, stir bar, stir plate, Triton X solution, SDS solution, colored pencils, camera, dissection tray, ruler, foil</td></tr>
<tr><td>Elaborative Questioning</td><td>-What is the purpose of the experiment?

-Predict the outcome of the bioengineered liver?

-What future steps can be taken with the scaffold?

-Summarize the potential benefits and issues of regenerative medicine.</td><td>☐ Inferential Questions
X Analytic Questions
☐ Philosophical Chairs</td></tr>
<tr><td>Demonstrating Understanding</td><td>-I will listen carefully to students as they work
-Students will be graded on their answer on lab report
-I will observe students individually and with others as they perform the task.
-I will ask students to repeat the task & detail their steps multiple times for reliable results.
-Students will create a concept map using the terms from previous lesson (journal article), unit</td><td>☐ Graphic Organizers
☐ Picture Notes
☐ Flow Charts
X Concept Maps
☐ Mnemonics
☐ Graffiti</td></tr>
<tr><td>Reflection</td><td>Reflective journal prompts in science journals
-What is today’s critical information & why is it important?
-What did you find difficult or easy today?
-How would you rate your effort today?
-What are some questions I have about today’s lesson?
What in today’s lesson was thought provoking?</td><td>X Reflective Journals
☐ Think Logs
☐ Exit Ticket (Student Learning)</td></tr>
<tr><td>Daily Progress Monitoring Assessment</td><td>-Engage students in class discussion
-Ask questions, vary difficulty level
-Pay attention to who is participating, call on non volunteers
-Ask students to elaborate on previous answer or add comments
-Post quiz</td><td>X Quiz
☐ Journal
☐ Exit Ticket (for Content)
☐ Response Cards</td></tr>
<tr><td colspan="4">Based in the results from your Daily Progress Monitoring Assessment, what concepts need to be revisited in the next lesson?

I will use the information gathered from the assessments to determine which portion of the lesson, if any, needs to be reviewed or remediated.</td><td>Homework</td></tr>
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UNIT PLAN

Unit Title: Cell Reproduction	**Content Area/Grade: Bio Hon/ 9th**
Teacher: Denisse Conway	**Implementation Time Frame: 12-15 days**

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

Unit Goal
Students will understand that…

-The importance of the transmission and conservation of DNA during cellular reproduction and its impact on genetic variation.
- The cell cycle and mechanisms of regulations, the phases of mitosis and meiosis, basic principles of inheritance and the role genes play in development.

Standard(s)/Benchmark(s)
What standard(s)/benchmark(s) does this daily lesson address?

SC.912.L.16.14	SC.912.L.16	SC.912.N.1.1
SC.912.L.16.3	SC.912.L.16.8	SC.912.N.2.1
SC.912.L.16.16	SC.912.L.16.17	SC.912.L.15.15
SC.912.N.1.6		

Related Misconceptions
What misconceptions are predictable?

-Anything can be cloned
- The only use of stem cells is to create human clones
-Mitosis happens after the cell cycle is finished and is not a part of it. –Stems cells are the cure for everything
-Mutations are always harmful for organisms.
-Meiosis results in four cells that are all identical.
- Human cells only go through meiosis and not mitosis.
- DNA is in the blood. –All stem cells come from embryos

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

What are the four phases of the cell cycle? What are the implications of an abnormal cell cycle? How might the cell cycle help us to understand human cell repair? How to identify the phases of the cell cycle? Why is stem cell research important?

Students will know…
Vocabulary, terminology, definitions

Vocabulary

Stem cells, Pluripotent, Multipotent, Totipotent, Scaffold Extracellular matrix, Cell cycle, Apoptosis, Bioengineering Decellularization, Embryonic stem cell, IVF, SDS, Triton X, Dependent variable, Independent variable, Control group Asexual reproduction, Binary fission, Budding, Chromosome, Cleavage, Clone, Diversity, DNA, Fertilization, Fission, Gamete, Germination, Genetic, Haploid, Life cycle, Heredity, Meiosis, Mitosis, Mutation, Nucleus, Offspring, Ovary, Pollen, Pollination, Reproduction, Sexual reproduction, Spore, Cancer, Conservation, Crossing over, Diploid, Formation, Genetic variation, Independent assortment, Relate, transmission

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

Other Essential Knowledge

Cell cycle, cell structure and function, cellular basis of life

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

- recognize that many aspects of cell structure and function are inferred from observations
- evaluate the impact of biotechnology on society in terms of bioethics and religion
- recognize that not all questions can be answered through scientific investigation
- describe the process of differentiation, and define stem cells and explain their importance.
- identify the possible benefits and issues relating to stem-cell research.

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?

- Answer questions
- Participate in class discussion
- read scientific articles
- conduct exploration labs
- enhance knowledge with follow up questions
- reflective journaling
- compare and contrast using Venn diagram
- form an opinion and be able to support with evidence

Rubric

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

Level of understanding	Rubric	Student Action
Exceptional	Student demonstrates superior understanding of the standard, the way in which it relates to other concepts, and can use knowledge to solve complex problems or teach others	Evaluates, creates, relates, communicates
General	Student demonstrates understanding of the big idea of the concept and can apply it to basic problem-solving situations; misses subtle details or is unable to explain the relationship to other ideas	Applies; explains; compares
Developing	Student demonstrates that they understand portions of the standard but are missing the "big picture" of the concept; may confuse terms or ideas, or are unable to apply to basic problem-solving situations. May require assistance from teacher to meet the standard	Identifies; remembers; recalls
Beginning	Student demonstrates recall of some facts, but is significantly lacking in understanding; although they may be able to recite terms or portions of an idea/concept, their use of knowledge is comparable to guesswork	Recites
Incomplete	No evidence of understanding was available upon which to evaluate student's learning	N/A

Other Evidence:

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

-Student artifacts
-science journals
-classwork/homework
-lab reports
-exit questions
-class discussion

Self-Assessment/Reflection

How will students reflect and self-assess their learning?

Likert scale, exit questions, reflective journal prompts
Example questions: What is today's critical information & why is it important?
What did you find difficult or easy today?
How would you rate your effort today?

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?
	-Students are expected to participate, work in collaborative groups and be independent critical thinkers -Learning goals will be displayed and reference at the begin and the end of the class as a wrap-up -Pre test will be used to assess prior knowledge
Hook **H**old	How will you **hook** students at the beginning of the unit? How will you **hold** their attention throughout the units?
	-Discuss regeneration of organs, show video clip (TedMed – Dr. Anthony Atala) -Hands-on activities, discussing current research and possible applications
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?
	-Students experiences include the webquest, student driven activity and bioengineering liver lab -I will facilitate the learning process provide working computers and set up lab. I will also reinforce key concepts by explaining and asking probing questions. Have class discussions
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?
	-Students will have reflective journal prompts to complete -Class discussions -Provide immediate feedback
Exhibit **E**valuate	How will you help students to **exhibit** and **self-evaluate** their developing skills, knowledge and understanding throughout the unit?
	-Students will perform tasks on their own within groups, following lab procedures -Lab outcome
Tailor	How will you **tailor** your instruction to meet the different needs, interests and abilities of all learners in your classroom?
	-Additional time - Chunking -Extended discussion -Appeal to various learning styles
Organize	How will you **organize** and sequence the learning activities to maximize the engagement and achievement of all students?
	Start and end class with a review, about < 20 min. direct instruction, then activity time **Hook with regenerative video clip -** Surface area to volume ratio -Chromosome structure - Cell cycle meiosis will be used to begin -Mitosis/cytokinesis - Regulating the cell cycle/cancer – Cell differentiation

Big Idea: Growth, Development, and Reproduction		Standard(s)/Benchmark(s): SC.912.L16.8 SC.912.L.16.14 SC.912.L.16.16
Unit: Cell Reproduction **Grade: 9th**		**Sample Activities**
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** -Students will make an inference beyond what was explicitly taught. - Students apply learned content	Develop an argument for the sequence of events in the cell cycle and justify their level of importance within the cell.
Score 3.0	**The student:** - Compare and contrast mitosis and meiosis -Explain the significance of surface area and volume ratio to cell division -List and describe phases of the mitosis and compare to meiosis - List and describe the stages of the cell cycle -Can explain how cells differentiate -Student makes no major errors or omissions regarding the score 3 content	Given a random set of cell cycle events, sequence the events in their proper order. Given a diagram of each stage of the cell cycle, in the correct order, describe one event that is happening in that stage. Make a Venn Diagram showing the similarities and differences between the final products of mitosis and meiosis and how those cells are used
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** • Recognizes or recalls specific terminology - Defines mitosis and meiosis -Defines structures associated with cell division -Defines stem cell, IVF, embryo, tissue, organ • Performs basic processes, such as: - Determine surface area and volume of a cell -Lists the phases in order of mitosis and meiosis	Match the specific events of the cell cycle to the specific stages of the cell cycle to include G1, S, G2, the major stages of mitosis, and cytokinesis. Recall definitions
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.**	