CELLULAR MACHINERIES: UNRAVELLING THE COMPLEXITY OF BIOLOGICAL MOLECULES AND THEIR CONTROLLED MANIPULATION IN SYNTHETIC ENVIRONMENT

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ABSTRACT

The educational innovation encompasses aspects used in the course developed at West Virginia University, entitled "*Cellular Machinery*". The course includes: (1) Portfolio (pre and post class evaluations); (2) Group activities; (3) Virtual lab; (4) Research project with Paper/ Presentation performance based on case studies; (5) Tests/ Final, all aimed to evaluate student active learning. Visual and auditory materials facilitate optimal learning while addressing the need for improving understanding of what attracts students to biomedical engineering. Drawing upon "*Quality, Relevance and Impact*" and highlighting student-centered pedagogies while providing practical examples of integration of research and engineering education, leveraging partnerships among different researches in the campus as well as between the campus and governmental agencies, my innovation creates a foundation for understanding how to increase student interest in bioengineering.

INTRODUCTION AND OBJECTIVES

The course is being offered as part of the Biomedical Engineering Certificate in the College of Engineering and Mineral Resources. By teaching the fundamentals of cell structure, organization and function and how the interactions within the cells, whether physical or functional, are instrumental in understanding the cellular machineries, this multidisciplinary course provides an overview of the "*Cell Operating Like a Factory*". The course also reveals practical examples of how cellular components can be manipulated in synthetic environment for applications in bioengineering.

The student learning outcomes are:

1. Understand and explain the metaphor: "*The cell operates like a factory*"
2. Analyze the relationship between structure and function of cells and cellular components *in vivo* and *in vitro* drawing upon applications in the next generation of bioengineered machines
3. Describe the fundamental chemistry of living cells and cellular networks and how they can be used *in vitro* to engineer biosensors
4. Evaluate the flow of energy and matter; relate to construction of bionanomachines
5. Evaluate the transport of materials in and out of the cells; transfer cellular principles to synthetic environment for engineered applications
6. Relate principles of evolution to biological diversity; relate biological diversity to bioengineered-based applications
7. Rate the applicability of different correlations between cellular machineries and synthetic machineries.

DEVELOPMENTAL HISTORY OF INNOVATION

- I wanted my students to do more than simply listen to a lecture. I am a firm believer that when students are doing something including discovering, processing, applying information then they become engaged and the process of learning is more rewarding.
- The principles of Biomedical Engineering can be difficult to grasp. I realized that using visual and auditory materials is a creative alternative presentation mode for my course material. This alternative generated student debates and gave students experience with verbal presentations and critical thinking/analysis of the material presented.
- "Seeing is Believing"! Talking about using biological machines in synthetic environment is not an easy concept to get familiarized with. Thus, as part of the innovation in my class I introduced real lab hands-on demonstrations.

LEARNING ACTIVITIES AND MATERIALS

1. Illustration of a visual material used to reveal the complexity of a "*cell factory*"

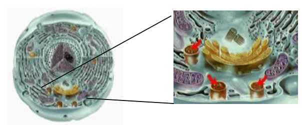


Figure 1: a) Cell. b) Zoom in: the "shipping and power unit" of the cell factory.

2. Manipulation of DNA in synthetic environment leads to DNA networks to be used for nanoelectrical circuits

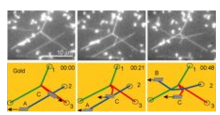


Figure 2: DNA labelled and manipulated on surfaces by motile microtubules.

3. Hands-on- lab demonstration of biological nanofibers imaging

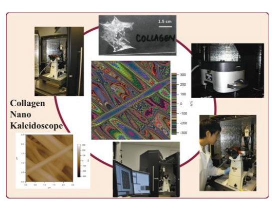
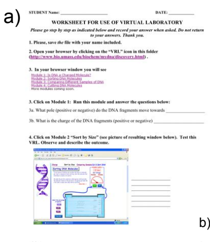


Figure 3: Collagen nanofibers scans. An atomic force microscope was used.

EXECUTION

-Portfolio (pre and post class evaluations)
-Group activities
-Virtual lab (VRL) incorporated as an instructional innovation to increase students' active learning.

a) 

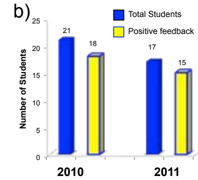
b) 

Figure 4: a) VRL worksheet. b) Number of students participating in VRL and student feedback.

-Project/Paper/Presentation. Students were required to provide an accurate and complete explanation of key concepts and theories, drawing upon relevant literature supporting their studies. In making statements to peers about their own thoughts on the assigned topic, students were required to articulate the critical analysis of the papers, to offer synthesis, and evaluation of case studies, e.g., put together pieces of the discussion to develop new approaches to be used in future research.

a) 

b) 

Figure 5: a) Student projects-selected examples. b) Grading form and criteria.

-4 Tests/Final (compiled multiple choice, short answer, essay, true/false, fill in the blank, etc. questions).

MAJOR ISSUES TO RESOLVE

-Complement VRL with hands-on experiments
-Provide practical examples of the experiments to be performed during the VRL
-Integrate group activities in lab environments

STUDENT FEEDBACK

-"Class is great and very interesting and really enjoying it" (Shannon Gribbons, 2011)
-"I think the structure is very good and the visual aids are very helpful; I personally learnt a lot" (Zahra Ronaghi, 2011)
-"Classes are dynamic, interactive, which facilitates the learning" (Reem ElDawud, 2011)
-"I am learning a lot. This class is fun." (Patrick McBurney, 2011)

DISCUSSION

I became a teacher because I wanted to learn! Since the next generation of engineers can be developed only through interdisciplinary courses, experiential learning and entrepreneurship opportunities, I believe that my participation will provide me with requisite leadership skills to make an impact in engineering education. Moreover, I will acquire the skills to encourage women to pursue careers in engineering.

ACKNOWLEDGMENTS

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