Creative course redesign in General Education Faculty Grant Competition 2009

Submitted by Nora Egan Demers and Charles W Gunnels

Proposal for substantive redesign of existing General Education Course

Course Description from the course catalog:

BSC 1010C - Gen'l Biology w/Lab I - 4 credit(s) Intended for science majors. The principles of biology are studied from the molecular to the cellular level. Topics may include basic biochemistry, the cell doctrine, the physical phenomena of life, elementary bioenergetics and biosynthesis, cellular and organismal reproduction and the gene concept. The curriculum is inquiry based and fully integrated with a laboratory that emphasizes active learning strategies.

General Education Subject Areas: Natural Science course.

Course objectives for enhancing student learning General Education Subject Area:

- Describe the scientific process.
- Describe organic and inorganic compounds, their roles in biological systems, and their bonding properties.
- Describe the properties of water and how they make life possible.
- Describe how pH and buffers influence life processes
- Identify and describe the structure and function of the 4 biological macromolecules that compose all life on the planet.
- Describe dehydration synthesis and hydrolysis reactions and their importance in living systems.
- Describe the role of enzymes in regulating life processes.
- Distinguish between prokaryotes and eukaryotes.
- Explain the interrelationship of structure and function in biological membranes.
- Describe the major cellular organelles and their functions.
- Explain the importance of membranes and compartmentalization of cellular functions.
- Describe the importance of membrane proteins including serving as receptors, regulating metabolic pathways, facilitating cellular communication, and establishing cellular identity.
- Explain the basic laws of thermodynamics and their application to living organisms.
- Explain the metabolic pathways through the study of cellular respiration (including glycolysis, krebs cycle, electron transport chain) and photosynthesis.
- Differentiate between somatic (mitotic) and germinal (meiotic) reproduction.
- Explain the Central Dogma (from gene to protein) and its centrality to life.
- Explain, in simple terms, the molecular evidence for evolution.
- Describe basic Mendelian genetics and be able to correctly predict outcomes from monohybrid and dihybrid crosses including those involving traits that are X-linked, show co-dominance, are controlled by multiple alleles, or are complicated by crossing over.
- Explain the chromosomal basis for genetics.
- Describe the shortcomings of Mendelian genetics as applied to modern genetics.
- Describe how the genetic message can be altered through mutation and recombination.
- Explain gene regulation through study of the lac operon, the trp operon, and/or Arabinose metabolism.
- Be able to explain genetic engineering including the techniques involved in electrophoresis, creating recombinant DNA, cloning, PCR, DNA sequencing, and restriction mapping.
- Explain how genetic engineering is currently being used in society and how it may be used in the future, including its role in gene therapy and development of genetically engineered crops, and livestock.

General Education Competencies Addressed:

1. Quantitative reasoning
   a. Solve mathematical problems
   b. Analyze and interpret quantitative data
   c. Summarize data into graphic and tabular formats
   d. Make valid inferences from data
   e. Distinguish between valid and invalid quantitative analysis and reasoning
2. Critical thinking
   a. Identify assumptions and underlying relationships
   b. Synthesize information and draw reasoned inferences
   c. Formulate an appropriate problem solving strategy
   d. Evaluate the feasibility of the strategy

Description of Course objectives for enhancing student learning in each General Education Competency:

1. Collect, calculate and interpret graphical representation of data including means and standard deviations
2. Interpret experimental designs and analysis of results to understand and interpret empirical data and develop critical thinking skills for awareness of positive and negative controls and their role in scientific processes.

Plan and criteria for assessing Student achievement of each General Education Competency:

1. Quantitative Reasoning
   a. Be able to explain how to calculate molarity and percentages for preparing chemical solutions. Assessment is achieved by laboratory worksheets and examinations.
   b. Quantitative data is routinely collected during the term, from the first measurement lab to labs in glycolysis, cellular respiration, and photosynthesis. During each lab students collect and share results. In addition, students are asked to interpret and explain data.
   c. On several occasions during the labs, students are expected to prepare graphs and tables with results from the data they collect. On other occasions they will be asked to review data shown in scientific articles. In addition they will be expected to interpret graphs and tables including means, standard deviations and other graphical data on examinations.
   d. Students will be asked to explain results of collected data through brief oral and written descriptions.
   e. Students will contrast expected results with those obtained. Student will determine whether the obtain data support or reject the reasoning that led to the expected results. In addition, students will report on their findings in class, provide worksheets, and respond on homework, labs and examinations.

2. Critical thinking
   a. Starting with the first day of class, students will be challenged to address their assumptions and the underlying relationships by a structure-function lab-in-a-bag activity that identifies the relationship between structure and function. Pre and post tests will be given for the molecular and chemical bonding properties of water, which will be recorded and assessed as part of an action-research project. In-class assignments, labs, homework and examinations will be used to assess these skills.
   b. Similar to the quantitative reasoning skills described above, students' ability to critically think will be enhanced and assessed as they work through and practice laboratory and classroom

activities that demonstrate the fundamental and powerful concepts in the molecular and cellular biological sciences; concepts that are difficult to see, and therefore require a good imagination and thinking skills to visualize these difficult ideas.

c. Students will be required to use newly acquired knowledge to tackle probing questions that expand on course material. For example, students are asked to determine whether humans have evolved in southwest Florida over the past 500 years after learning about the four mechanisms that can result in biological evolution.
d. Students will be asked to select a piece of scientific literature during each of 4 units (a peer-reviewed journal article that describes an individual experiment) and explain how the scientists developed their experimental design (c) and consider the feasibility of the design in understanding the research question being examined. (This also addresses Competency 3 Written communication)
e. Additionally, students and professors are challenged to consider when and how experiments can be developed and carried out at numerous times during the term. Assessment will be through written summary of the article under examination, and perhaps short answer questions on the final exam.

All sections of BSC1010C offered currently provide students with opportunities to improve their abilities at all four of the General Education competencies (including the two not emphasized here of oral and written communication). We are simply attempting to enhance our students' General Education competencies within this General Education course redesign.

Description of creative and innovative course design features:

This semester we are spending 2.5-5 hours per week in preparation to better integrate lecture, discussion content, and concept material with hands-on/inquiry-based activities that have the students actively engaged in their education. This integrated strategy is more in keeping with the original goal and vision of the SCALE-UP (Student Centered Activities for Large Enrollment Undergraduate Programs) that the classrooms in Whitaker Hall were designed to serve. We've both been teaching the course for several semesters (4 to over 18 respectively) with various levels of integration and various models of 'team' teaching. This term we are focusing on complete and more seamless integration between the different learning processes, and working to increase the number and types of pretests/posttests and assessments that are made available for students and faculty alike to understand what and how students are learning.

Our collaborative integration of content materials is the focus of this grant proposal. We have been working to fully integrate different teaching methods with the goal of helping the largest number of students. As evidence by comments that we have received from students in an anonymous feedback, the students appreciate this variation. Some students thrive in the hands-on activities, some enjoy the lectures, others mentioned the importance of the lab activities, and still others commented enthusiastically on the probing questions. To date, we have dramatically reorganized and clarified both hands-on activities and lecture material to enhance our integrative approach. We think that our success results from this integration.

So far this semester (spring 2009), integrative tools have included:

- Lecture discussion describing characteristics of life paired with hands-on structure-function lab in a bag activity where students visualize how structure effects the function of an object.
- Lecture material discussing four biologically significant emergent properties of water paired seamlessly with a series of hands-on activities where students manipulate water models to illustrate underlying concept.

- Extension of water models activity with a group activity by applying critical thinking skills to explain how water moves up a tree. Activity followed by class discussion summarizing capillary action in trees where random students were called to piece together the process.
- Conceptual atom diagrams that illustrate how electrons are used to bond elements to make compounds integrated with explanations of role of atomic elements and importance of understanding these basic concepts in order to be able to apply them to biological principles.
- Group activities to better understand electronegativity of elements integrated with lecture explanations of the arrangement of the periodic table. Students then illustrated the orbit of shared electrons around different compounds to explore difference in potential energy within different bonds.
- Worksheets and molecular models illustrating functional groups and biological macromolecules integrated with explanations of the polarity and nonpolarity of macromolecules and their importance in understanding of the functional properties of cells, organelles, and macromolecules.
- Group work and critical thinking to determine which amino acids would be found in different cellular environments (extracellular, trans-membrane, intracellular)
- Oral group work on the white board integrated with laboratory activity to determine how pH indicators work.
- Application of the critical thinking and written communication skills about the process of science by providing written summaries of peer-reviewed scientific research papers (emphasis on critical thinking outcome)
- Group and individual activities integrating metaphors to compare cellular mechanisms to a pizza restaurant with explanation about cellular organelles and microscope laboratory exercises on viewing various cells from plants, animals, algae and protists.
- Further integration yet to be developed.

Assessment of efforts and other activities we are considering integrating include:

- Pre/post test for fundamental and powerful concepts of water and its chemical properties.
- Analysis of test questions, homework, and in-class worksheets so that the material conveys the language employed in class.
- Metaphors to compare metabolic pathways to processes of students selected processes.
- Greater emphasis on evaluation and assessment of graphical data collection and explanation.
- Anonymous feedback on teaching strategies that work.
- ”Think, Pair, Share” on how cell organelles are organized.
- “3/2/1” 3 things they have learned, 2 things they are still confused by, and 1 thing they have learned about their learning to help students organize their study strategies by identifying the material that they need to reinforce.
- Additional assessment strategies to be developed.

Letter of support from Dean

January 30, 2009

Dear General Education Council:

I am writing to support the proposed course redesign of Biology I submitted by Nora Egan Demers and Charles W. Gunnels. This proposal calls for a redesign of BSC 1010C by integrating lecture-discussion content/concept material with hands-on/inquiry-based activities that actively engage the students in the course material. As a required course in the general education program for most science majors, implementation of this project will ensure that the majority of FGCU science majors will be able to critically analyze scientific work.

I support the proposed redesign and can assure you that the redesigned course will be offered in the next academic year.

Best regards,
Donna Henry