STEM Gateway Course Reform Team project information for STEM Gateway website.

Course Name: Plant Form and Function (Lab)

Course prefix and number: BIOL 204L

Course-reform team members

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Background to course-reform effort

Biology 204 Plant and Animal form and Function was developed in 2004 and first taught in 2005 as part of a re-design of the Biology Department's core undergraduate curriculum (now consisting of Biology 201, 202, 203 and 204). Since then a core group of plant and animal biologists have worked together to implement and refine the course in a consistent manner. Our goals in the 2004 re-design included the development of an inquiry-based learning lab and to develop critical thinking skills.

Our prior efforts to teach through the practice of hypothesis-driven science were strongly motivated by studies of successful modes of learning in science courses. National reports on science curricula consistently state that "what students learn is influenced by how they learn" (NRC 1997, NRC 2000). Experimentation underlies all scientific knowledge and laboratory experiences should allow students to identify, discuss and solve real problems using the scientific method and to present findings in their own words (Kyle et al 1991). Science education researchers advocate using multiple approaches to teaching science. Inquiry-based learning is a critical component in this effort (Boyer report, Glasson 1989; Odubunmi and Belogun 1991, Roth 1993, Von Secker and Lissitz 1999), yielding students with better critical thinking and problem solving skills (Songer and Linn 1991). Inquiry-based physiology laboratories provide outstanding opportunities for students to apply concepts and knowledge learned in the classroom when exploring observations made in the laboratory. The intersection between knowledge and observations in laboratories stimulates curiosity, the development of interesting questions, and a "need to know" in students, effectively engaging them in the scientific process (National Research Council 2000). Once engaged, students develop hypotheses or explanations that can be tested through experimentation and priority is given to empirical evidence generated that either supports or refutes these ideas. Thus, learners formulate explanations from evidence and revise and revisit these explanations through further experimentation (Chin and Brown 2000, Lawson et al 2000, Myers and Burgess 2003, NRC 2000, Rivers 2002). Meta-analyses (Springer et al. 1999) suggested that minority students benefit to a greater degree than non-minorities from the small group inquiry-based approach. In their analyses, minority student academic achievement improved, attitudes towards science courses were more favorable and there was a 22% decline in student attrition from science courses that used inquiry-based instruction.

<u>Student learning outcomes for the course (existing):</u>
As part of our initial implementation, we brought in Dr. Gordon Uno (University of Oklahoma) for a workshop on inquiry-based teaching (Uno 2002) and the Department of Biology purchased new teaching lab equipment and remodeled labs to allow students to work in small groups. However, we did not have funding at to develop or implement a plan for student learning outcomes for the course. Therefore, we only have anecdotal information about the successes and failures of our existing program with respect to specific learning goals. The UNM CAPS 204 program has some data on current and recent students, and we also have data on success rate and repetition of the course that can be used as a baseline for performance. Lastly, we have compared performance in the lab portion of BIOL 204 with that of the lecture and found that students generally do better in

the lab than lecture, but they also spend much more time on the lab portion when it is only a third of their grade. Starting in fall of 2013, the grade for the lecture portion will be separated from the lab portion. The hope is that this will help students break out of a constant repetition of the course with the same result. If a student can pass the lab but not the lecture, then the second time they take the course the workload will be reduced and the student can just focus on lecture.

Preliminary course-reform plan

In the past 7 years, we have learned a lot about the logistics of running a large inquiry-based lab and have refined the course material to integrate into the overall Biology Department undergraduate curriculum. This has included the development of our own laboratory manual and a core lecture structure that was shared among instructors. Managing the rapid growth of the course during this same time period has consumed much of our existing efforts, but now that the course is near or at the limits of our physical space, we are prepared to implement the next phase of course reform.

Our preliminary plan is to improve the existing course by implementing or enhancing the 5 elements derived from the Carl Weiman Science Education Initiative and the Top 25 Project as recommended in the UNM STEM Gateway call for proposals. These are 1) specification of measurable learning goals, 2) rigorous objective assessment of student achievement of these goals, 3) implementation of teaching methods aimed at maximizing achievement with respect to the specified goals, 4) means for easy dissemination of materials, methods, and technology, and 5) sustainable and continued optimization based on results of assessment. The addition of these assessment-focused recommendations is desperately needed and is a major focus of our plan.

In addition, we will implement recommendations identified in the AAAS report "Vision and Change in undergraduate biology education: A call to action" that arose out of a 2009 national conference and was published in 2011 (http://visionandchange.org/). The major ideas in this report include teaching about the process of science, the interdisciplinary nature of "new biology", the role of science in society, competency in communication and collaboration, quantitative competency, and the interpretation of data. Other suggestions from this report are giving students experience with modeling/simulation and computational and systems-level approaches to biological discovery. Our current course addresses several of these recommendations, but we believe there that the largest needs for improvements are in quantitative competency and interpretation of data. We will maintain an inquiry-based lab environment but with a greater focus on the lower levels Bloom's taxonomy of learning.

Proposed Elements of the Reformed Course

- Develop measurable learning goals (outcomes).
- Develop and implement objective assessment of learning goals.
- Compile and supplement UNM Learn question database and course resources (for lectures).

- Improve web-based materials for labs including web data entry and sharing, especially designed to assist TAs with time invested in preparation and grading.
- Train BIOL 204 faculty and graduate students in the use of UNM Learn and help transition from WebCT.
- Develop exercises to improve quantitative competency
- Re-focus labs on data analysis and interpretation in addition to experimental design (especially basic statistics and graphing). Data analysis is an area identified by UNM CAPS where Biology students are underperforming.
- Develop tools to help students improve performance on first exam of the semester.
- Create a schedule for regular review and revision of materials among all instructors participating in Bio 204.
- Track how student performance is affected by the separation of grades for the lab and lecture portion. Does this reduce the amount of repetition and improve performance?

Learning/Achievement Gains Assessment

The evaluation plan consists of two related components that together will provide an assessment of the implementation of the revised curriculum, including targeted students, program elements, and participating faculty and teaching assistants. The first component is an implementation assessment that will document the development and implementation of the revised curriculum. The second component is an impact evaluation that will determine the extent to which the revised curriculum improves student outcomes (i.e. retention and achievement), improves student's knowledge of the practice of science and develops critical thinking skills, and provides students access to jobs.

Implementation Assessment: The implementation assessment will evaluate the development and implementation of the program. This will be done in order to measure how well the program matches its design and meets its goals. This component of the evaluation includes surveys or interviews of key faculty, teaching assistants and other project staff; observations of classes and meetings, and a document review (e.g. course syllabi and other materials). Surveys will be completed with students following the completion of sections of the curriculum. The results of this implementation assessment will be used in a variety of ways including to provide program staff with information useful for modifying or making necessary changes to the training program. An example of this type of response is the continuing modification of the lab activities themselves and the TA manual used to prepare TAs before each lab, in response to experiences and observations during each activity.

Impact Evaluation: The impact evaluation will use several data sources. First data will be collected from a sample of students. For each student we will collect demographic data, classes and earned grades, grade point average by semester, and other measures of academic progress (including which students are repeating and how students perform in UNM CAPS 204). These data will be automated and will be used to track the academic progress and professional development of students as they proceed through the program. Second, we will conduct baseline and follow-up surveys with the students. Information

collected will include: classroom and laboratory experiences, the climate of their department, career aspirations, relationships with faculty/teaching assistants and fellow students, how well the program is working for them, how satisfied they are, and suggested improvements. Together these two sources of information (official and self-report) will help us to complete with-in group comparison over time and document each student's progress, perspective and experience in the program.

Data collected for the implementation assessment will also be valuable for the impact evaluation. These data will help us measure program level outcomes. The impact evaluation will measure individual and program level outcomes. Individual outcomes will include academic progress, retention, and the development of critical thinking skills, quantitative competency, ability to interpret data and knowledge of the practice of science by targeted students.

References

Carnegie Foundation's Boyer Commission *Reinventing Undergraduate Education: A Blueprint for America's Research Universities* http://www.as.wvu.edu/~lbrady/boyer-report.html

Chin, C. and Brown, D.E. Learning in Science: A comparison of deep and surface approaches. J. Research in Science Teaching, 37:109-138, 2000.

Glasson, G.E. The effects of hands-on and teacher demonstration laboratory methods on science achievement in relation to reasoning ability and prior knowledge. J. Research in Science Teaching, 26:121-131, 1989.

Kyle, W.C., Linn, M.C., Bitner, B.L., Mitchener, C.P., and Perry, B. The role of research in science: An NSTA theme paper. Science Education, 75:413-418, 1991.

Lawson, A.E., Alkhoury, S., Benford, R., Clark, B.R. and Falconer, K.A. What kinds of scientific concepts exist? Concept construction and intellectual development in college biology. J. Research in Science Teaching, 37:996-1018, 2000.

Myers, M. J. and A. B. Burgess. 2003. Inquiry-based Laboratory Course Improves Students Ability to Design Experiments and Interpret Data. *Advances in Physiology Education* 27:26-33.

National Research Council. 1997. Science Education Reconsidered. Center for Science Mathematics and Engineering Education. National Academy Press. Washington, DC. pp104.

National Research Council. 2000. Inquiry and the National Science Education Standards: A Guide for Teaching and Learning. Ed., S. Olson and S. Loucks-Horsley. pp224.

Odubunmi, O, and Belogun, T.A. The effect of laboratory and lecture teaching methods on cognitive achievement in integrated science. J. Research in Science Teaching, 28: 213-234,1991.

Rivers, D. B. 2002. Using a Course-Long Theme for Inquiry-based Laboratories in a Comparative Physiology Course. *Advances in Physiology Education* 26:317-326.

Roth, W.M. The development of science process skills in authentic context. J. Research in Science Teaching, 30: 127-152, 1993.

Songer, N.B. and Linn, M.C. How do student's views of science influence knowledge integration? J. Research in Science Teaching, 28: 761-784, 1991.

Springer, L. M. E. Stanne and S. S. Donovan. 1999. Undergraduates in Science, Mathematics, Engineering and Technology: A Meta-Analysis. *Review of Education Research* 69:21-51.

Uno, G. 2002. Handbook on teaching undergraduate science courses – A survival training manual. Thomson Learning – Custom publishing.

Von Secker, C.E. and Lissitz, R.W. Estimating the impact of instructional practices on student achievement in science. . J. Research in Science Teaching, 36:1110-1126, 1999.