

Title of Project: *Integrating the Learning Cycle into Population and Ecosystem Biology*

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Summary

All students are equipped with prior knowledge about how the world works, and this prior knowledge may affect the way that they integrate information received in science classes. The Biology Department at Birmingham-Southern College currently faces the challenge of teaching both majors and non-majors in their introductory biology course, Population and Ecosystem Biology. As a result, students in this course tend to have a wide range of perspectives and misconceptions. Identifying and teaching to misconceptions can be an effective way to bring order to students' understanding of basic biological processes; however, it is often difficult to bring these misconceptions to light in a typical lecture class that enrolls over 50 students. The purpose of this proposal is to employ the learning cycle method outlined by Ebert-May et al. (2004) to fulfill the following two goals: (1) to bring out and clarify varying perspectives and misconceptions in a class with diverse prior knowledge and (2) to enhance learning by all students through interactive exercises. The learning cycle method involves several phases, including (1) engaging students with a question or activity that probes their prior knowledge and focuses their thinking, (2) having students explore their ideas and concepts with the instructor and other students, and (3) explaining the concepts and clarifying common misconceptions. It also incorporates assessment of student understanding and common misconceptions held before, during, and after instruction, so that the effectiveness of both teaching and learning can be evaluated. Upon implementing the learning cycle method, students will achieve a greater understanding of their personal misconceptions as well as those held by other students. These activities will also increase student understanding of basic biological concepts. This proposal will have a large impact on our Institution, because over ½ of our students enroll in Population and Ecosystem Biology during their years at Birmingham-Southern College.

Project Description

Goals and objectives:

All students are equipped with prior knowledge about how the world works, and this prior knowledge may affect the way that each student integrates information that he or she receives in science classes. The Biology Department at Birmingham-Southern College currently faces the challenge of teaching both majors and non-majors in their introductory biology course, Population and Ecosystem Biology (BI 105), where the split is approximately 1:1. As a result, this class is composed of students with a wide range of perspectives and misconceptions. Identifying and teaching to misconceptions can be an effective way to bring order to students' understanding of basic biological processes (Ebert-May et al., 2004). While our faculty members appreciate the diversity of perspectives that arise from a course involving both majors and non-majors, we are often unaware of many of the misconceptions that are brought into the classroom, and typical lecture courses have proven to be difficult venues for drawing out the varying perspectives. The purpose of this proposal is to enhance the BI 105 course at Birmingham-Southern College by integrating the "learning cycle" teaching model (Bransford et al., 1999; Possner et al., 1982) for at least 12 (approximately 1/3) of the lecture periods. The goal of this approach is two-fold: (1) to bring out varying perspectives and misconceptions from a class with diverse prior knowledge and (2) to enhance learning by all students through interactive exercises.

Background and significance

The learning cycle is a teaching method that is based on cognitive research suggesting that students learn more effectively when they are able to reconstruct their understanding through interactive exercises (Bransford et al., 1999). The method involves several phases, including (1)

engaging students with a question or activity that probes their prior knowledge and focuses their thinking, (2) having students explore their ideas and concepts with the instructor and other students, and (3) explaining the concepts and clarifying common misconceptions. The method also includes assessment of the level of student understanding and common misconceptions held before, during, and after instruction, to evaluate the effectiveness of both teaching and learning (Ebert-May et al, 2004).

Detailed project plan

My plan is to integrate the learning cycle into Population and Ecosystem Biology by following the general model outlined in Ebert-May et al. (2004). In their paper, they provide instruction on how to use this method to unveil student misconceptions about the carbon cycle and its effects on climate change. Below, I summarize their method.

Engagement—Ebert-May et al. (2004) use pop culture to engage students in thinking critically about climate change, as portrayed in the recent movie “The Day After Tomorrow”. The last ten minutes of the prior class are spent asking students who saw the movie to describe the scientific concepts as they were depicted in the movie. Then, an assessment (non-graded) quiz is administered to identify the current level of understanding of the class. Without revealing the answers to the quiz, the instructor then assigns the class to read a paper describing the carbon cycle. Ebert-May et al. (2004) suggest Beedlow et al. (2004), which discusses rising atmospheric CO₂ and carbon sequestration by forests. Students are asked to bring to the next class a drawing of a simple model of the forest ecosystem and the flow of carbon and nitrogen through the system, based on their understanding of the assigned reading. Students are also informed that they will be quizzed on the material from the reading during the next class. Giving assignments

and alerting students to an upcoming quiz forces them to be accountable for their reading, which in turn facilitates classroom discussion.

Exploration—For the first 15 min of the next class, the instructor administers the same quiz as the previous class, only this time the quiz will be graded. Administering the same quiz holds the students accountable for the reading, while also allowing assessment of changes in misconceptions held before and after the reading. The results of the quiz can provide direction and focus for the remainder of the class period. After the quiz, students form small groups (2-4) for 5 minutes, where they discuss their justifications for their quiz answers. Afterwards, the instructor asks several students to write their answers and justifications on the board, so that the pending discussion can focus on the misconceptions still held by the class.

Explanation—Approximately 15-20 min are devoted to explaining the basic processes of the carbon cycle and how it relates to global climate change. During the explanation phase, students are asked to identify the misconceptions that were presented in the quiz and written on the board, explaining why someone might have these misconceptions. The instructor should help guide this discussion, and provide clarification when necessary. Students then work in groups, where they use their drawings of the carbon and nitrogen cycles to answer questions such as, “How will changes in atmospheric CO₂ alter photorespiration rates?” and “Under what conditions does elevated CO₂ increase forest carbon sequestration?” They are required to provide scientific justification for their answers. A few volunteers are asked to explain their models to the class. This again provides an opportunity for the instructor to dispel misconceptions.

Assessment—At the end of class, the instructor assesses the students’ understanding by using a quick writing assignment in which the student is asked to write for 1-5 minutes on a

question that will probe the level of their understanding. For example, “Describe two factors that might limit forest carbon sequestration”. By assessing students before, during, and after the learning process, the instructor can assess how many (and perhaps why) students still have misconceptions about the concept.

I hope to utilize tactics similar to those described above to approach topics such as:

- Human alteration of ecosystem nitrogen dynamics
- The effects of introduced species
- Impacts of natural disasters on ecology
- Population dynamics of sickle-cell anemia
- Group selection, kin selection, and reciprocal altruism
- Misconceptions related to the theory of evolution and why Intelligent Design is not a scientific theory
- Adaptive radiation and rapid speciation on the Galapagos Islands
- Genetic modification for use in agriculture
- Human evolution

Prior activities and research

In my Population and Ecosystem course this semester (Fall 2005), I followed the guidelines from Ebert-May et al. (2004) to utilize the learning cycle for instruction on the carbon cycle. One of the limitations of the learning cycle as explained above is that there is no way to receive immediate feedback of class responses from the quiz assessment conducted after the reading. Therefore, although the model assumes that the instructor can teach to misconceptions held by students based on the results of the quiz, there is no way to identify those misconceptions without grading the quiz before the explanation phase of the learning cycle. In a class of more than 50 students, this is not an efficient use of time. Fortunately, our large classrooms are currently equipped with a Personal Response System (PRS), which allows students to answer multiple choice questions anonymously in class, after which, a bar graph can be immediately projected to demonstrate the distribution of answers. This technique has been extremely useful, because students can immediately determine where they fit within the distribution of answers

(e.g., with other students who held similar misconceptions). I used PRS in BI 105 for the assessment prior to the assigned reading, and then again to replicate quiz answers for the assessment after the reading. After the quiz, I was able to see that most of the misconceptions that were present before the reading were still evident. This alerted me to the fact that students had not fully understood the reading, and allowed me to focus time on helping the students understand the important concepts from the paper. Although I currently use PRS in almost every class period, I have applied the learning cycle for only one lesson. Overall, the method proved to be much more interactive than a typical lecture class, and students were more involved than they would be in a class with a more traditional format. In the class following the learning cycle method, I asked students to use the PRS to assess the effectiveness of the prior class; 52% of students had positive responses (17% had neutral responses).

Projected timetable:

Jan 2006: Begin identifying review articles that are appropriate for discussion in BI 105

Summer 2006: Develop new lessons using the learning cycle method

Aug 2006: Attend the teaching initiative symposium at the Annual Meeting of the Ecological Society of America in Memphis.

Fall 2006: Share (with other BI 105 instructor) and integrate the new lessons into all sections of BI 105

November-December 2006: Assess and analyze the results of implementation

Spring or Summer 2007: Attend appropriate conference to disseminate results (for example, the annual meeting of the Ecological Society of America or Alabama Academy of Science)

Requested budget

I request \$7000 for the following items:

- \$5000 summer stipend to Megan Gibbons for lesson development
- \$1000 for travel to the 2006 Annual Meeting of the Ecological Society of America in Memphis (Aug 6-11). Each year, ESA sponsors at least one symposium on teaching strategies at their annual meeting. In 2005, the symposium was entitled, "Pathways to Scientific Teaching in Ecology Education". This meeting will give me the opportunity to participate in discourse about improving teaching in Ecology. I also hope to gain perspective on appropriate topics that I can implement in my course using the learning cycle.
- \$1000 to travel to appropriate conferences where I can present results of implementation; for example, the Annual Meeting of the Ecological Society of America, Alabama Academy of Science, or ACS conference).

Context of course in curriculum and impact on the Institution.

At Birmingham-Southern College, we strive to give students the tools that they need to be well-rounded, well-informed adults. To this end, we have a number of disciplinary foundations requirements that must be met by all students, including at least one laboratory science course. Currently, Population and Ecosystem Biology is the most popular course chosen by non-science majors to meet this requirement. Therefore, for many students, it is the only natural science course they will take while at Birmingham-Southern College. BI 105 is also the first course in the three-term introductory sequence for biology majors. As a result of these factors, all of our biology majors (except those with AP or transfer credit) and approximately half of our non-science majors will participate in BI 105. We typically enroll approximately 220

students in this course per year (two sections of 60 each Fall and two sections of 50 each Spring). Therefore, this proposal will have a significant effect on our institution. Although I generally teach only $\frac{1}{2}$ of the students enrolled in BI 105 each semester, I plan to share the newly developed lessons with the other instructors teaching this class, who have agreed to implement at least some of them when they teach the course in the future.

Evidence of Institutional support.

This grant is supported by the Division of Science and Mathematics (see attached letter) and the chief academic officer of Birmingham-Southern College. The Division of Science and Mathematics currently maintains the multi-media technology (including PRS) available in the classroom in which BI 105 takes place. This proposal requires continued, but not increased financial support from the Institution.

Evaluation, Dissemination, and Continued Support

Evaluation/assessment process

To evaluate the learning cycle method for effectiveness, I will assess the students' understanding of concepts both before and after each lesson, according to Ebert-May et al. (2004). This will allow me to determine if students are gaining pertinent information through assignments and interactive activity. I will record changes in assessments for each new lesson and compile results at the end of the semester.

We currently have students complete evaluations of the course (using a Linkert-type scale) at the end of each semester. Students have the opportunity to answer a variety of questions about the effectiveness of the professor and the course in general. Assessment of the new pedagogy will be assessed by comparing past answers from evaluations to evaluations after implementation of the technique. The topics that are currently listed in the evaluation and that I believe will be most affected by the learning cycle teaching method will be:

- 1) The course's influence on the students' critical thinking and reasoning ability
- 2) The professor's ability to facilitate comprehension
- 3) The professor's openness to questions/comments
- 4) The professor's overall teaching effectiveness
- 5) The students' motivation to work hard in the course

I will also add several questions to the student evaluation form for Population and Ecosystem Biology after the implementation of the proposed instructing method:

- 1) Did class discussions (i.e., learning cycle lessons) help you to understand biological concepts that you had previously found confusing?

- 2) Did it help you to understand concepts more fully when common misconceptions were identified and then clarified?
- 3) Did you gain new perspectives by discussing your quiz answers with other classmates?
- 4) How effective did you find the discussion classes (i.e., learning cycle lessons) compared to typical lecture classes, in terms of your level of understanding?

The answers to these questions will provide insight into the effectiveness of the specific teaching style, separate from the effectiveness of the class as a whole.

I will also administer the Science and Math Values Inventory (SaM-VI) at the beginning and again at the end of the Fall 2006 semester of BI 105, so that I can assess how student attitudes about science have changed during the course of the semester.

Dissemination of results

(1) Comparisons of assessments taken during each lesson, (2) a comparison of course evaluations from Fall 2006 and previous semesters, (3) student responses to general questions concerning the learning cycle style, and (4) results of the SaM-VI will be included in the final report to the ACS and discussed and distributed throughout the Biology Department. If this method proves effective, we may begin to implement this method in other biology courses. In addition, I plan to present the results of this grant at appropriate conferences or workshops, such as the 2007 Annual Meeting for the Ecological Society of America or the Alabama Academy of Science. If appropriate, I will prepare a manuscript describing one or more of the lessons in a journal such as *Journal of College Teaching*.

Literature Cited

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Disclosure Statement

I have no other pending or on going grant activities that will coincide with the submitted proposal.

Megan E. Gibbons