Active Learning in a Non-Majors Biology Class

Lessons Learned

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Abstract. This article describes how a traditional biology lecture course was transformed into an interactive class. A review of the activities used, changes made to grading policy, and practical tips for integration of active learning in the classroom are provided. Analysis of student responses to course assessments indicated that active learning experiences helped them focus on and understand key concepts of the course. Students performed as well as, or better than, those in previous classes that used a more traditional lecture technique. Active learning enriches the classroom learning experience and can be incorporated into a large lecture setting with relative ease.

For those of you who have begun or are thinking about implementing active learning, the following describes a personal journey into active learning and our “lessons learned.” In the process, we offer practical tips that you may wish to consider when planning a course.

In fall 2000 we co-taught two large introductory non-major biology courses. Lon has taught both lower and upper division courses at the university level for thirty-four years. I (Elaine) have taught lower division courses at the college level for fifteen years. The course we taught is lecture only, and although there is a laboratory component, students enroll in the lecture independent of the laboratories.

Lon’s teaching style is that of the traditional college professor, taking a “sage on the stage” (King 1993) approach. Although my initial teaching style was also the traditional lecture, I learned a more facilitative teaching approach after I left academia to work in business and industry. I have since returned to higher education, and my teaching style is now a more interactive “guide on the side” (King 1993) approach. When Lon and I decided to co-teach, the biggest challenge we faced was how to reconcile, and eventually combine, teaching styles that appear at first to be diametrically opposed.

In recent years Lon noticed a drastic decrease in student attendance at lectures and that those who attended class were often passive and unengaged. He was interested in seeking new ways to reach his students but unsure of what approach to take. After learning of studies that indicated that students in courses taught using active learning strategies have done as well or better than those taught in a traditional lecture mode, he was willing to explore these techniques (Black 1993; Paulson 1999). He also recognized that students have different learning styles and believed that multiple teaching strategies might engage those who did not respond to the lecture mode.

One of the significant things we learned was that it is helpful to start by selecting a strategy that is compatible with your teaching style and comfort level. Then develop the student learning outcomes for a topic, and select a corresponding active learning strategy that can help you achieve the goal. Share your ideas with someone who has experience in implementing active learning and seek dynamics, and student learning outcomes for an introductory non-majors biology course. The framework we used to design our classroom uses “instructional activities involving students in doing things and thinking about what they are doing” (Bonwell and Eisen 1991).

To ensure that students were evaluated on their participation as well as their scores on traditional multiple-choice exams, we modified the course syllabus. Previously the grading plan was based solely on three multiple-choice exams and a cumulative final. Our new course would measure achievement through three multiple-choice exams, a cumulative final, a reading reflection, study journals, a problem-based learning activity, and student formative and summative assessments of class activities. Instead of lecture only, we conducted mini-lectures (20 to 30 minutes) and in-class learning activities. We also included student assessments of the instructional strategies as a form of active learning. The complete list of active learning methods we used are described in the sidebar.
### Active Learning Techniques

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<th>Technique</th>
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<td><strong>Matrix</strong> (BSCS 1998)</td>
<td>A matrix is a chart that requires students to represent lecture material in a format different from the way it was presented. It focuses on key concepts and requires the use of higher-order thinking skills. One way in which we used a matrix was for comparing and contrasting the process and products of cellular respiration with photosynthesis.</td>
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<td><strong>Partial Outline</strong> (Angelo and Cross 1993)</td>
<td>The partial outline technique builds outlining and note-taking skills and allows students to focus on important concepts. We used this technique after a mini-lecture on basic chemistry and asked students to complete an outline by using the following main topics: definition of a type of chemical bond, significance in living things, and examples.</td>
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<td><strong>Think, Pair, Share</strong> (King 1993)</td>
<td>This technique is extremely versatile and may be implemented in a variety of ways. In general, students think about a question posed by the instructor and then pair with one or two others to share their responses. A final step, which we included, was a class debrief of pair responses.</td>
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<td><strong>Debrief</strong> (McClanahan and Wicks 1993)</td>
<td>A debrief is an instructor-guided discussion of student (individual or group) interactive work. This discussion validates student responses or corrects inaccurate responses. Students who did not respond to the question learn the correct response at this time.</td>
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<td><strong>Brainstorming</strong></td>
<td>Brainstorming generates ideas about a topic. All responses are accepted and written on a board, flip chart, or overhead transparency. We used this process to introduce topics and assess what students knew about them. We then tailored the mini-lecture or lecture that followed to build on student knowledge and/or clarify misconceptions.</td>
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<td><strong>Mini-Problem Based Learning Activity</strong></td>
<td>In this activity, small groups (class action teams) of three or four students work together to investigate a scenario or problem provided by the instructor. Mini-lectures on foundational principles are given at specific points. Each student within a group conducts a part of the research needed to solve the problem. Research is conducted outside of class and then shared with the group in class. Individuals synthesize final projects from pertinent information. Students determine the final format of their own projects. Our mini-problem based learning activity was completed during four class sessions and some outside-class time.</td>
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<td><strong>Reading Reflection</strong></td>
<td>A reading reflection is a one-page summary report based on reading course-related material on a topic the student finds particularly interesting. This reflection can be a review of a newspaper article, a journal article, on an article on an Internet site, a discussion of a concept read in the textbook, or a discussion of concepts read in a book related to the course topic. A rubric was provided to students describing how their reflection would be graded.</td>
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<td><strong>Study Journal</strong></td>
<td>The study journal is a brief questionnaire, administered periodically throughout the course that asks questions about the students’ study habits and the extent to which they think in-class learning activities increase their ability to learn.</td>
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<td><strong>Plus/Delta</strong> (McClanahan and Wicks 1993)</td>
<td>A Plus/Delta chart is a quick and easy way to obtain feedback from students about what is working for them in the class and what needs improvement. It can be used at the end of an assignment or class session, or as a periodic check throughout the semester. Pluses or deltas may address class activities, instructor or student performance, instructional materials, or the classroom environment. A plus identiﬁes elements that students believe worked well and helped them learn. For example, our students said talking to other students in class about what they had just heard in lecture often simpliﬁed the material and helped them learn. A delta describes how the students would change the existing learning situation to improve their learning. For example, our students suggested that we provide study guides for our exams. Individual student plus/deltas can easily be done by asking students to take a sheet of notebook paper and divide it into two columns. At the top of the ﬁrst column, ask students to write a (+). At the top of the other column, ask students to write a (Δ).</td>
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<td><strong>Final Course Assessment</strong></td>
<td>A comprehensive questionnaire is used as a final course assessment that basically evaluates the effect of different aspects of the class on overall learning. The speciﬁc assessment tool used can be viewed at <a href="http://www.wcer.wisc.edu/salgains/Instructor/ViewLearningGainsTool.asp">http://www.wcer.wisc.edu/salgains/Instructor/ViewLearningGainsTool.asp</a>.</td>
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Active learning experiences are important enough to do and important enough to be included as part of a student’s grade. For example, in our class, students who completed the first post-exam study journal received 10 points. A problem-based learning experience was worth 50 points. The students received a rubric explaining the criteria used to grade the activity. The total number of points in our class was 650; 150 of these points were assigned to active learning activities. The class syllabus should describe your grading policy for active learning experiences and how those grades factor into the student’s final grade. Clarify with the students that these points are not extra credit. These activities, just like exams, will be counted when grades are determined.

Make sure that active learning experiences are value-added—identify the purpose and student learning outcomes.

Before you use an active learning experience, clarify for yourself the purpose for using it. Do you think the activi-
ty will enhance student understanding of a concept? Will interacting with the material in some way other than listening (for example, developing a matrix or concept map, using manipulatives, or role playing), clarify concepts for students? Do you want to check for understanding—a quick assessment of learning? Think about what you want the students to know or be able to do as a result of the activity. If you are not clear about it, students will not be clear about it. They will not grasp the value of the activity and may see it as a waste of time.

Eliminate lecture material to provide the time for active learning.

Integrating active learning into class time means something must go—at least in terms of what you present. Don’t expect to cover everything you now cover in a lecture, as well as the new active learning experiences. If you do, you will find yourself perpetually rushing without accomplishing all of your instructional goals.

To determine what can be eliminated from lectures, review your presentation with your student learning outcomes in mind when planning your syllabus. Decide which information you must present and which concepts may be deleted or might be better learned through active learning experiences. This is a difficult step for a “sage on the stage” instructor, while for the “guide on the side,” it is easier to trust the process of active learning and believe that when students engage in the chosen activities, they will uncover and more easily understand concepts that used to be in lecture. This uncovering of content through active learning techniques is one way in which students create meaning of course content for themselves.

Debrief in-class learning activities.

Debriefing is critical to reach closure of a lesson. Students will feel more comfortable with the material if closure is reached. This does not necessarily mean that the instructor provides the students with the “right answer.” It does mean that the instructor guides the discussion in such a way that the correct responses emerge from the group or that a follow-up activity is generated.

Plan enough time in your lesson for students to complete each activity and for you to “debrief” the activity following its completion. The debrief may take many forms. One simple method is to ask students to share their work with the class. If no one responds, provide prompts to stimulate thinking and encourage students to make educated guesses. Usually, a student will respond to a specific prompt, and then you can facilitate a more general discussion.

Bracket mini-lectures with in-class active learning experiences.

Many students have difficulty focusing attentively for the traditional fifty-minute lecture and may find themselves overwhelmed by the amount and complexity of information that is presented. We found that breaking the lecture into smaller, more manageable bits makes it easier to process the information.

An effective way of creating bits of conceptual information is to use an activity before or after presenting key concepts. For example, in previous lectures on basic energetics in our classroom, we covered the first and second laws of thermodynamics and endergonic and exergonic reactions. This time, we introduced the first and second laws of thermodynamics and then did a “Think, Pair, Share” activity (sidebar). The activity gave students time to discuss the laws among themselves, apply the information to a specific situation, and discuss the information with their peers, fostering more thorough understanding. Debriefing in class allowed remaining student questions to be discussed and enabled us to determine how well the students comprehended the lecture before we moved on to the next set of concepts.

We found that the mini-lecture, combined with an active learning technique, may generate more questions from students and allow them to deconstruct difficult concepts.

Interact with students during active learning experiences.

Students rarely have individual time with professors in large lecture classes. Such classes tend to be impersonal, and some students find them intimidating. Breaking the class into smaller working groups frees the professor to walk around and interact with students more personally. He or she can respond to student questions, ask additional questions, or chat informally with students about the class. And because students perceive professors as more approachable when they are not standing in front of an entire class, those students who are reluctant to ask questions in a large group will often feel more comfortable questioning the material in a more informal class setting.

Determine how you will accommodate nonparticipation in learning activities.

Sometimes students reject working in groups. Some of our students commented on the final class assessment that they learned better on their own. Others felt that working groups can become too sociable. Student reasons for nonparticipation may include differences in learning styles, shyness, cultural diversity, a language barrier, or lack of confidence in their own or other students’ knowledge. You must decide beforehand how you would deal with the situation. In our classroom we decided to encourage students to work in pairs or threes; however, we did not force the issue. Some of our activities could be accomplished individually, and we allowed this as an alternative, as long as the students appeared to be working and were not disruptive. Later, we tended to seek out the loners and encourage them to interact with us.

Completing activities that were out-of-class experiences, such as study journals, the midterm plus/delta, and the reading reflection, were really matters of student choice. These activities earned points, and if students chose not to do the activity, they forfeited the points.

Use or respond to student feedback whenever possible.

One of the most powerful tools a teacher can use in the classroom is to ask students for feedback and then use it. Using student feedback to make improvements in the learning experience reinforces the notion that your class is a partnership and that you value your students’ ideas as means to strengthen that partnership and create more successful learning. On our final class assessment, the students commented how much they appre-
ciated that their feedback was used to tailor the class to their needs.

For example, after the class’s second exam, we put a simple plus/delta tool (McClanahan and Wicks 1993) to the test, asking students what aspects of the class helped their learning (plus), and what changes they would like made (deltas) before the next exam. Approximately 20 percent of the students responding said they wanted study guides prior to exams. We agreed and provided a study guide prior to their third exam. Grades on the third exam improved over those in the second exam (though we cannot claim that study guides were the sole reason for the improvement). Later, when asked on their final class evaluation to identify the learning experiences they found most valuable, 70 percent of the students stated that the study guides were very helpful. The students also noted on our final class evaluation that they felt their input into class policy also made a difference in their success.

Asking for the students’ input does not mean always using their suggestions. However, you are responsible for communicating to students your reactions to their suggestions and feedback. Otherwise, students may not take your requests for input seriously, and your credibility as an instructor might suffer.

Document observations and results of learning experiences in “real time.”

Immediately after class, or some time later in the day, jot down a few notes about the learning activity. You can use the plus/delta format for yourself—it is quick and easy to use. Identify what you thought worked and how you would change the experience next time. If time permits, do a plus/delta (sidebar) with students upon completing the activity. These notes are invaluable as you plan your next class. If you don’t document your experiences immediately, key insights may be lost.

Findings and Next Steps

Our evaluation techniques—the study journals, the plus/delta, and the final assessment—provided us with the basic information used to synthesize these suggestions. The assessments also provided valuable insights into how students perceived various classroom experiences. We were prepared to revert to the traditional lectures if students did not find that these strategies improved their understanding of major concepts. Our analysis of student responses indicated that they felt that the active learning experiences helped them focus on, and improved their understanding of, key concepts.

In a class of 78 students (66 responses), 64 percent said active learning improved their understanding of a concept presented during lecture to a great extent, 7 percent said they helped to a moderate extent, 28 percent said they helped to a little extent, and 1 percent said that the activities did not help at all. In a class of 96 (86 responses), 43 percent said active learning improved their understanding of a concept presented during lecture to a great extent, 7 percent said they helped to a moderate extent, and 50 percent said they helped to a little extent. Students also were asked to explain their responses. It became clear that little extent meant that the students still had not mastered the concepts, but if they did not engage in an activity, they would not have understood the concept at all.

Eliminating lecture material to provide time for active learning experiences is necessary. Often the information omitted from a lecture emerged during an activity or debrief. The mini-lecture combined with active learning techniques generated more questions from students than when lectures alone were delivered. We found an increase in the number of questions, the number of different students asking questions, and the quality of questions after a learning activity was used. We believe active learning strategies helped us to achieve our main purpose: to increase student participation. Students said the class was more interesting and engaging when we used active learning, compared with the class sessions during which we reverted to straight lecturing. The mini-lecture/learning activity/debrief learning cycle became a standard in our class, and one we think worked well.

The plus/delta chart and the summative assessment indicated that besides instructor generated study guides, the activity that most helped their learning was the problem-based learning activity focused on molecular biology. Students commented that this activity helped them to connect terms and concepts providing a greater depth of understanding of concepts that were unfamiliar. The students also stated that this type of activity helped them to retain information. Further studies will need to be done to investigate whether this perception is valid. And finally, students enjoyed this activity and particularly appreciated that they had a choice in how they presented the results of their research. Student projects demonstrated a level of creativity that exceeded our expectations.

Significant grade improvements occurred in classes taught with active learning techniques (fall 1999, 2000), compared to classes taught in spring 1999, where no active learning techniques were used. However, since no controlled experiments were run on these comparisons, the class improvements can be attributed only by inference to changes in pedagogical techniques. Our experiences suggest that students like active learning and find it beneficial. Inasmuch as the students performed as well, or better than, those in previous classes that used the lecture technique, we will continue to use active learning strategies in the future.

Key words: active learning, teaching strategies, student-teacher interaction, lecturing

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REFERENCES


