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Using Multiple Choice Questions During Lecture to Create an Active Learning Atmosphere

Logan Mathew Newman

The College at Brockport, Logan.Newman@RCSDK12.ORG

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Using Multiple Choice Questions During Lecture to Create an Active Learning
Atmosphere

by

Logan Mathew Newman

August 2006

A thesis submitted to the
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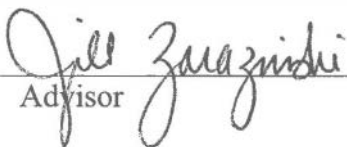
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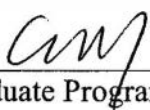
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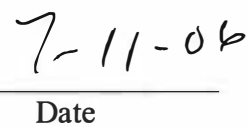
Advisor



Date



Director, Graduate Programs



Date

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Abstract

Prior to this research, lecture was the primary instructional method used to teach an urban high school Advanced Placement (AP) Biology class. Students often lose focus during the first 15 minutes of lecture (Mazur, 1997). As a result, multiple choice questions were added to each lecture every 15-20 minutes. Students were encouraged to actively discuss the questions as a group to determine the correct answer. The focus of this method is increasing student involvement in lecture and critical thinking of the class material. Informal interviews of students and instructor observations provided qualitative data regarding the efficacy of this strategy, while tally sheets of the groups' correct answers and student survey results quantitatively provided evidence of its success. Continued use of this method as a strategy of increasing student involvement is suggested, with the caveat of development of more complex and topic encompassing questions being applied.

Chapter 1: Introduction

Problem Statement

In beginning my first year of teaching Advanced Placement (AP) Biology I realized that my lecture intensive class was quickly losing students' attention; I decided to add multiple choice questions to the lectures as a way of increasing student focus. This action research project focuses on the effects of this strategy on students' understanding and mastery of the material, their attention in class and their ability to stay focused and involved in the lecture.

Significance of the Problem

AP Biology is a college level course given to high school students that encompasses a major sampling of all biological sciences and culminates with a standardized test given in early May. This class is six weeks less than the normal school year and requires a great deal of work by the students and instructor to finish the curriculum in the allotted time frame. Students taking this class are generally of a much more determined nature than students in the general education classes, but they are prone to the same attention issues as any other student.

A traditional method of instruction for AP Biology involves the use of lecture to facilitate transfer of information students are required to master. In beginning my first year of teaching this course I began a traditional lecture format using PowerPoint's (PPT's) that I had spent a great deal of time preparing. Most students were not used to this kind of instruction and I quickly noticed that I was rapidly losing students' attention through this lecture format. In addition, I realized I wasn't receiving any feedback on how well they understood the material we were covering.

As anyone who has sat through a lecture can attest, students can follow the first 15 minutes of lecture without much difficulty. When the student loses the thread and idea of the lecture they are lost although they continue to take the class notes (Mazur, 1996). When a lecture moves beyond 15 minutes and the students lose focus, learning possibilities diminish. In addition, it is often difficult for the instructor to maintain student focus and have a majority of the students actively involved during lecture. Llewellyn (2003) noted that students who take an active role in their learning are less likely to lose interest and more likely to internalize the data. Wyatt (2005) provides anecdotal evidence suggesting that the key to good science education is to allow students to conduct their own inquiry-based experiments as opposed to using cookbook labs where students seek pre-determined explanations. These types of activities, however, often require students and teachers to “rethink and redesign experiments,” (Wyatt, 2005, p.84) which can be very time intensive. Active learning classrooms and activities are more likely to both keep a student’s attention and promote internalization of information; unfortunately the types of activities suggested often take far more time than traditional lectures and more time than is available to some classes. How then can the information the students are responsible for be passed on during a lecture and at the same time maintain student engagement?

Purpose of Action Research

In thinking about how best to address student attention problems I decided to try to combine the lecture and active learning concepts by adding multiple choice questions to the lecture PPT’s at the end of every idea within the topic. The questions appeared in the lecture roughly every 15 – 20 minutes, and the students answered

these as a group, based on the students they sit with at their lecture tables. My hope was that by working together to answer the questions, students who understood the particular material better might be able to assist a weaker student understand the ideas in a way that I was unable. The focus of this technique, therefore, was to have more class involvement, use this as a method of instant feedback of student understanding of the material, and have students who understood the material explain it to those students who might still be confused.

Several focus questions are important in attempting to increase student involvement and, ultimately achievement, through the use of multiple choice questions during lecture. These guiding questions, addressed in the literature review and action research project, are:

- 1 How can lecture promote active learning in the student?
- 2 Does inclusion of higher-order questions into lecture PPT's cause students to think critically about the information?
- 3 Will the inclusion of Think-Share strategies during lecture promote internalization of information?

Rationale

Mazur (1997), a Harvard University physics teacher, developed a technique called ConcepTests that he uses in his physics classes. These tests consist of multiple choice questions every 15-20 minutes. Several of his papers correspond to my action research project; notably, the use of questions and the results obtained by using this technique. Other key papers have focused on the addition of multiple choice questions to lectures as a way of increasing student involvement and understanding of

the data, as well as using this as a way to check for student understanding. This technique is an amalgam of two different teaching methods, active learning and lecture. The active learning focus is on the practice of engaging students in thinking tasks designed to build curiosity, conceptual understanding and higher-order thinking skills. Lecture is being used as a way to transfer the large amount of information the students are responsible for in as short a time period as possible, while still doing justice to the key ideas and themes. In addition, this is my first year teaching this subject and I felt it necessary to build my own personal understanding of the concepts and did not feel comfortable using class time to focus on activities where I might not be able to answer student questions.

Definition of Common Terms

Throughout this paper I will make references to the use of multiple choice questions, lecture, and PPT's. When discussing multiple choice questions I am referring to questions that include a statement and 5 potential answers, but only one correct answer. Lecture is referring to a teaching method in which the class is primarily teacher driven, fueled by information the instructor feels is important, and normally interrupted only for student questions for clarification. PPT's refer to the Microsoft PowerPoint program that allows for customizable slides to be designed, which may contain either words, pictures, animations, or any combination thereof. As stated earlier, active learning is referring to the use of techniques that involve students' active engagement in their learning, whether it is hands-on or directed towards the development of thinking skills.

Summary

The purpose of this action research project is to question the research technique I have been using in my classroom for the past year. My technique focuses on the use of multiple choice questions as a way of actively engaging students in the lecture. To begin any assessment of this teaching technique it must first be decided whether or not this is a viable use of class time. The first question that needs to be addressed before moving into a study of my personal technique is an analysis of the concept behind it, namely the combination of lecture and active learning. The true focus of this research is whether these two concepts, lecture and active learning, are mutually exclusive or if they are able to be combined to build a comprehensive learning environment for the student. If they can be combined, as I did in the following research study, does the amalgamation of these two styles, with the multiple choice questions as the bridge between them, cause students to think critically about this information? By using this technique it is my hope that I can increase student achievement. I am not, however, ready to stop with simply having the student think about the correct answer. Student groups were encouraged to discuss the multiple choice questions until a consensus of the right answer was reached. In an attempt to assess if this helped students to better understand the concepts or if it caused greater confusion with the subject a focus question addresses these group discussions.

Chapter 2: Literature Review

The idea of using questions in lecture as a strategy for increasing student participation relies upon three guiding questions. A review of educational research and literature was done to address those questions. The questions that are addressed within this literature review are:

- 1 How can lecture promote active learning in the student?
- 2 Does inclusion of higher-order questions into lecture PowerPoint's cause students to think critically about the information?
- 3 Will the inclusion of Think-Share strategies during lecture promote internalization of information?

How can lecture promote active learning in the student?

In 1999, The National Research Council (NRC) stated that there was an overwhelming amount of evidence indicating lecture is an ineffective instructive tool for teaching concepts of any kind. Isaacs (1994) surveyed 100 faculty members at a large Australian university to determine their standard teaching practices and their reasons for using them. His response of 70% allowed for a comprehensive survey of the main respondents in the health sciences. Isaacs asked a variety of questions about the use of lecture including what the instructors hoped the students would get out of the lectures. Of the respondents, 44 rated lecture as very important to help students to think critically about the subject and an additional 15 said that it was very important. What this indicates is that instructors' use of lecture is meant to help the students think about the information that is being presented and each lecturer uses different techniques to make that possible. One of those techniques is the use of prepared notes

to help the students with the class information (44 of the respondents) and to increase the amount of student participation in the lecture.

An obvious issue with Isaacs' paper is the small number of respondents to the survey and the fact that it was done at a university outside of the United States. Parallels can be drawn, however, to the techniques used by instructors in any country and at any grade level. Mazur (1996) talks of lecture as a technique that instructors use because this was the way that they were taught. He states that this is not the best way to teach students to think about the material because listening itself does not require the student to think, act, or respond to the material and form their own ideas. He argues that student's best way to learn in a lecture setting is to read the book before the lecture and have the instructor then point out the salient portions of the reading (Mazur, 1996). The problem with this method is that not everyone will read the designated readings and even those who do will not have a firm grasp on the material. Perhaps a better solution would be the one that 44 of the respondents to Isaacs' survey found to work well for them. If you give students notes you add a touch of active learning to the lessons.

In the course of teaching freshman non-science majors, Stencel (2001) has found that "students who take their own notes end up with fragmented, perhaps, incorrect, bits of information and lack the time to record it all or process it for understanding" (p.403). To counter this problem he gave students an "interactive" notebook that contained all the lecture notes for the class so that they could pay attention to the lecture instead of rushing to record every written word the instructor utters. He also included diagrams that were presented in class and encouraged the

students to use the overheads that he projected to color coordinate the diagrams. In the course of using this notebook he gave the students a survey using the Likert scale and found that the majority of the students liked this technique and would enjoy it in other classes. Unfortunately he provided no data as to the effectiveness of this technique in students' performances on exams; therefore, the effectiveness of this style of note taking cannot be fully examined.

Katayama (2000) studied the use of note taking strategies and their effectiveness using a variety of mediums under the view that note-taking serves two purposes: encoding of information into the brain and external storage of the information. His study took place over three class periods during a one week period and was quantified using the students responses to a chapter test for which they used notes taken to study immediately prior to the test. Two types of note techniques were used: graphic organizers and outlines. These fell under three main headings: skeletal, partial, and complete notes. Over two 40 minute class periods 117 students read and completed notes. On the last day they had 10 minutes to review their notes and then a 35 minute test was administered. A noteworthy discovery with this study was the findings that the partial-notes group did outperform the complete notes group in the exam but did not outperform the skeletal group. According to the study, findings indicate that those students who took notes out of a book using a skeletal outline performed better than those who used partial notes. These results are significant in that they help direct towards the types of notes that could be used in a lecture setting to promote active learning. The use of skeletal notes, however, would probably cause most students to lose focus during a topic and only be able to come back when they

recognize a word from the notes. Katayama suggests that the encoding benefits of partial notes are better for students to use as they have some of the information and helps prevent the individual from becoming overwhelmed by the information and notes that need to be taken.

Other studies have looked at ways they could infuse active learning into a classroom without focusing on notes and note-taking skills. Sokolove (1998), in attempting to promote active learning in a large class to increase student understanding of the complex issues being discussed, used a variety of techniques. Each of these techniques has its advantages and disadvantages and each are used in other studies which examined their beneficial uses in other active learning settings. At the beginning of the course all students were issued name badges to help personalize the class. This is a terrific idea in a class of 240 students, but a lot of preparation. Another idea used was the random assigning of students to cooperative learning groups of four students. These groups were made in order to foster dialogue during teacher driven activities that were designed to help the students understand the concepts in class. Most students felt that this was a beneficial addition to the class although there were problems of group dynamics. Sokolove avoided some of the problems with this by having students grade their own and other students' contributions to group work, an efficient way to avoid the pitfall of one student doing all the work. His findings are similar to those of other studies that indicate the use of cooperative groups is an excellent way to build understanding. Another change that varied from the normal lecture of the class was the addition of in-class written responses to questions that were posed to the class. These consisted of both

knowledge and feedback questions. They used these as a guide to determine if the students were developing misconceptions about material that needed to be corrected during the next class. One problem with using the written response for this is that it leaves the misconceptions in place for far too long and will continue to impede student and class progress during the beginning of the next class period.

Research in an Introduction to Psychology course provides suggestion of how to fix this problem. Butler, Phillman, & Smart (2001) used the minute paper technique described above to have their students answer short, broad questions regarding the class that day and then paired this technique with think-pair-share of activities to help correct student misconceptions before the period ended. By doing this they missed problems that Sokolove faced by having his students believe incorrect information until the next class period. Butler, et. Al (2001) however, found that when students who used these techniques were tested against students who received a traditional lecture, 4 out of 12 questions showed significant gains in understanding and 7 out of 12 showed no gain. This indicates that a small deviation from standard lecture can provide increased understanding of the materials and raise student enjoyment of the class.

In the spring of 2004 and 2005 Knight and Wood (2005) decided to test the use of a more interactive classroom and less lecture in a large enrollment Developmental Biology course at the University of Boulder, Colorado. They used cooperative learning and student participation during class time as well as administering pre and post-tests to the students to help assess conceptual understanding of the materials. They compared the student scores on the finals to

those of students from the fall 2003 class that was taught using primarily lecture.

They also assessed the student's feelings on these changes by means of an anonymous class survey using a Likert style scale with space for student comments at the end of the semester. Using the student scores they were able to quantify the results of the student experience and to judge gains in understanding and growth made by the students.

The results of this study support those of Butler, et. Al (2001), indicating that the use of small interactive changes in a class will give at least moderate increases in student achievement over the use of standard lecture. Student responses to the interactive measures used in the class varied from favorable to frosty. Most of those who did not appreciate the changes did so because they were unhappy with their class group. This is common in any class and activity, and can be easily dismissed and changed by allowing students to pick their own groups. Indeed, the researchers did this during the spring semester of 2005 and found that the students had a much greater appreciation for the work and functioned better as a group.

The previous research papers all seem to indicate that the use of any techniques in a classroom lecture that will help students work on the information will provide even small benefits. In particular, Allen and Tanner (2006) have seven strategies they advocate. The ones that are relevant to this study are peer-led instruction and "bookending" the lecture with multiple choice type questions as a way to assess student learning and to break up the lecture into smaller groups. Their research into techniques that can be used led them to suggest breaking a 50 minute lecture into three 10-12 minute segments each of which has questions that "bookend"

it. They suggest that these “question and response sessions are the simplest and shortest types of active-learning” (Allen & Tanner, 2006, p.263) activities that can be used by almost everyone. These can include the peer-led instruction as a way to help all students understand the ideas and concepts being used. They propose the following stipulation to the use of the questions in the lecture: use good questions that test a students understanding not their recall of facts. These questions should be open-ended questions that foster dialogue between the students so that active learning can take place.

Mehta (1995) states that some characteristics defining an active learning classroom are that students are engaged in activities such as reading, writing, and discussing of information and they are involved in higher-order thinking. These higher-order thinking activities should create student analysis, synthesis, and evaluation. One of the ways that an active learning classroom can be developed is through the use of questioning. When students are actively involved in answering instructor questions, they are more likely to be intellectually stimulated by the information and the instructor can get a better grasp of the level of success each student has achieved with the information. Students, unfortunately, are often not interested in the questions and have lost interest in the subject. He created a method that he called Mehta’s Magic to counter the trend of students losing interest and therefore not comprehending the information. This method involved having written multiple-choice questions after a section of lecture, similar to the “bookend” technique suggested by Allen and Tanner (2006).

At the end of the semester the class was given a survey and “100% indicated

that this technique was effective or very effective in improving their learning in the classroom” (Mehta, 1995, p. 298). This article also lists a guide of question types based on Bloom’s taxonomy that describe what the different levels should be doing for the students. Unfortunately this article does not talk about the types of questions that were used and how effective they were at improving the student scores in the classroom.

Does inclusion of higher-order questions into lecture PowerPoint’s cause students to think critically about the information?

Earlier studies (Fasko, 1998) hypothesized that asking tougher higher-order questions during a lecture would cause students too much anxiety and would therefore decrease in value as a learning tool. Fasko suggested that these questions actually detracted from lecture and caused students to lose confidence in their knowledge and abilities to do well in the class. His idea was to instead use lower-order thinking skills that would bolster a student’s confidence and cause them to understand and retain lecture information better. After applying several research and testing surveys he found that students were less motivated by the use of no questions than he had previously reported in his other papers and that there was no significant difference in student confidence in levels of questions asked. The results indicate that students attention is much better focused in a class that uses questioning and that there is a need for more research into the types of questions that should be used.

Gledhill (2001) suggests that it doesn’t matter what type of questions you ask in a classroom, the key is in how you ask the question. This is not referring to the inflection of the voice but whether the questions are open or closed. A closed

question is one that calls for a yes/ no answer or recall of a particular fact about the lecture. Open-ended questions are those that ask a student to think about the information and apply it to the current question. These questions often have more than one answer. An idea that is most useful to the current study is one that he termed “Pitch and Putt” (Gledhill, 2001, p.1407). This technique suggests posing a question at the student’s intellectual level, perhaps right above what was just discussed, and making it clear so they can find their way to the correct answer. This should not be the stopping point of these questions though. Perhaps he could have built on this current idea through the addition of a pairing of questions. Higher level questions could be paired with the building question previously discussed and the student can then build their way to a higher-order question technique that would help students to think critically about the topic.

Marbach-Ad and Sokolove (2000), in an article that discusses the need for students to ask good science questions, state that good science begins with good questions. By good they mean those questions that are higher-level questions and “are original and insightful ones about how the world works” (p. 192). They had students write questions after reading the chapters and assigned a numerical score to the questions based on what type of question the student was asking. For instance, a “why does this happen” question that could be answered from the reading was given a low score. They found that students initially asked these types of lower-order thinking questions; however, as the semester progressed they began asking higher-order thinking questions. This fact helps to show that as an individual acquires more knowledge about a topic they ask better questions, most likely because they have a

better understanding of the material and can think more critically of the information. This idea suggests that the use of questions in a lecture will help to build a students' understanding of the lecture topic and will help foster critical thinking.

What kinds of information should be included in these questions for them to foster the critical thinking that is necessary to science? "Promoting the conceptual understanding of science" (Gabel, 2003, p.71) suggests several teaching strategies that can be used to educational settings to increase student understanding. The two best strategies are the use of real-life situations and analogies to connect the students to the information. Since the current question is asking how we can increase critical thinking about a subject both of these techniques can also be thought of as excellent ways to connect students to multiple choice questions found in a lecture. These strategies will cause the student to think critically of the science topic and retain the information regarding the subject.

Cardellichio and Field (1997) also make many of the same suggestions as they suggest "seven strategies that encourage neural mapping" (p. 33). In seeking to develop science thinkers there is a need to exercise the brain using practice methods that are designed to stimulate thought outside of the students' normal patterns. This change in thought must cause students to change their perceptions of a concept from one that is incorrect to one that includes the correct mechanism, pathway, or design. The strategies that are espoused in this article have the ultimate goal of creating divergent thinking among the students. This article then helps to pinpoint some of the types of questions that should be asked to help foster meaningful connections in the students' minds. Two of these are hypothetical thinking, where the student is asked to

take an idea and apply it to a different situation; and analogy, where a concept is compared to a similar concept to analyze their components. These are the types of questions that should be asked to build critical thinking skills.

To encourage critical thinking in the multiple choice questions requires more than just the use of effective question design. It also requires the use of verbal techniques in the way that the question is asked and length of time that is employed after the question. While these techniques are generally thought of as being part of the domain of verbal classroom questioning, they are also important in designing and using multiple choice questions. Instructors need to have a period of silence immediately following the reading of a question. This “think-time” (Stahl, 1994, p.3) should be three seconds so that all students have time to process the question and develop an answer that can then be shared with their group for assessment. Any more than three seconds and students’ start to lose focus and might go off topic. Less than three minutes and only the most advanced students’ will have completely developed an answer. In addition, the multiple choice questions cannot be approached by the instructor as just another question. This will turn the student off to the task at hand. Instead the questions must be sprinkled with scientific inquiry and questioning (MacKenzie, 2001). Questions that are designed to only ask for rote memorization or the spitting back of facts will not challenge the students to think critically or to create excitement about science. Questions should be ones that ask the student to ask themselves, “what if this happened or didn’t happen?”

Harris (2000) says that “questions can be used to reduce student passivity” (p.25). They can do this by sparking class discussions, determining student’s

knowledge and what they have learned, as well as by sparking that ‘Ah-ha!’ moment. Questions that do this are designed well and help to build the critical thinking skills that are so vital to science class. However, not every question can be great. Harris cedes that it is the rare person who can ask or design 10 out of 10 questions well. Instructors, he suggests, should seek to have at least 3 out of every 10 verbal questions be quality queries. This means it is acceptable to have a few questions that are less than stellar and it will not harm the student’s ability to think critically overall. Harris’ research shows that classes that use good questions at least 30% of the time have students who more completely understand the material and are more learner centered.

Mazur (1997) developed a technique in the early 1990’s to help increase the number of students who retained information from his lectures. He decided to break his lecture up into several sections, each defined by a specific point that he felt was needed to understand material. After each of the sections he administered a ConcepTest. A short multiple-choice conceptual question based on the subject taught was designed (Mazur, 1997). He offers a few basic criteria for the development of these ConcepTests. They are:

1. Focus on a single concept
2. Not be readily solvable by relying on equations
3. Have adequate multiple choice questions
4. Be unambiguously worded
5. Be neither too easy nor too difficult. (p. 121)

Each of these principles has importance in designing questions that build critical

thinking of the materials. By having the question focus on a single concept the student can apply what they have just learned and focus only on that so there is little confusion. While number two is not always directly applicable to biology, it does have its merits in that the questions should not be easily answered by looking at a diagram or chart and simply following the path. It must have merit on its own and cause the student to contemplate the information. By having an adequate number of multiple choice questions, including those that Mazur calls detractors, it is possible to have the student develop the ability to read a question and critically examine it for flaws in logic and theory. The last two standards are important to ensure that the student does not get lost in the question and spend too much time trying to decipher the meaning; on the opposite side, if the question is too easy it neither stimulates critical thinking nor effectively uses class time. By utilizing the criteria set forth by Mazur it should be possible to ask questions that stimulate critical thinking and have the ability to spark further questions and conversation between the students and the instructor.

Other instructors have utilized similar techniques for lecture with similar goals. Ehrlich (1995) designed his class so that he gave a quiz every lecture as a way to build student confidence and attendance in his George Mason University physics class. Ehrlich states that when he started giving these quizzes he integrated difficult concept and understanding questions, but the students often missed them and thus felt that they could not succeed in the class. The quizzes that he administered at the time of this article were designed to check student understanding of the basics of what was just presented in lecture. The quiz questions tested students' understanding of how

variables worked together or other basic information. The current quiz types were not designed to foster critical thinking, but rather to build confidence in the students and in their ability to understand the material. This type of approach could then cause students to overestimate their comprehension of the material and lead to a false sense of security when test time comes.

Does the inclusion of Think-Share/Peer Instruction strategies during lecture promote internalization of information?

In the article “Active Learning in the Lecture Hall,” Anderson (1997) talks of her desire to involve students in their own learning. She discusses how she implemented new techniques in her course to create an active learning classroom. Among the methods she used were concept mapping, group projects, essays, and other techniques designed to stimulate the individual through interaction with others. Although a large amount of work was assigned to the groups and to the classes’ course surveys came back very positive and supportive of changes in the class. Students indicated a belief that they had learned much more information during the group activities than had been expected going into the class setting.

Cooper and Robinson (2000) discuss many examples of informal small-group strategies that can be used to increase student understanding through the use of just a few minutes of lecture time. They discuss the great variation in the strategies, the uses of them and how they are effective at getting students involved in their own learning without taking significant time from the primary purpose of the class. Two of the strategies they discuss, think-pair-share and peer instruction, are useful in that they are best used during a lecture or structured inquiry type of setting (Colburn, 2004). In

the structured inquiry setting, results are predetermined and set procedures are generally carried out. Using the think-pair-share and peer instruction techniques allows us, at any one time, to engage 100% of the learners in thinking about the problem or issue at hand. Cooper and Robinson (2000) suggest using these techniques to start class discussions, break up lectures for comprehension checks, and closing class with small-group discussions.

Mazur (2000) uses the term “peer instruction” to describe the interaction between students as they work to answer the questions he has assigned after 15-20 minutes of lecture. The technique has students answer the question first on their own and then they must convince their partner of the validity of their answer. Mazur claims that this technique can be used to engage students in higher-order thinking skills as they convince others of their responses. This also provides the instructor with an immediate quantifiable measurement of the number of students who understand the concept and the number who need further assistance. He found that, on average, 22% of the respondents will answer incorrectly twice, while 6% of the respondents will change from a correct to incorrect answer; 40% of the respondents will answer their question correct twice and 32% will change their answer from incorrect to correct. This means that roughly 72% of the students obtained a correct answer for the question posed and, it is assumed, that 40% understood the material well enough to convince another individual that their answer was correct. While the responses to the in-class questions provide some evidence that student learning has occurred, it is Mazur’s data on the students exam scores that is important. When compared to students who did not have ConcepTests in class, those who did have them performed

better on both the traditional problem solving and the concepts that were tested. This indicates that there is some degree of internalization occurring and corroborates Knight and Woods (2005) claim that any change in active learning will provide increases in student achievement over traditional lecture settings.

Wimpfheimer's (2002) article on the use of ConcepTests in a chemistry classroom also gives some ideas as to the uses of this technique in a smaller setting. Most of the previous articles have dealt with larger classes and, while this one deals with only 15 students, similar results are obtained overall. Wimpfheimer found, however, that because of the small class size and the lack of anonymity, students were self-conscious of their answers. He also found that some students were only emulating the high academic achievers and were not using their own ideas and answers. This problem was self-correcting as these top students missed some early answers, causing the eavesdroppers to get the wrong answer and, conversely, building their own confidence to make more of an effort. Wimpfheimer states that one of the benefits he enjoyed about this method in a small setting was that students were better able to be called upon and heard as they described their reasoning for achieving a specific answer. This resulted in the students becoming even more actively involved in their learning and fulfilling the need and use of peer instruction. Students gained critical thinking skills and internalized the science concepts presented in lecture.

Crouch and Mazur (2002) polled current and past peer instruction users via a web-based poll. The survey covered many aspects of peer instruction and teaching practices of the respondents. An important finding was that, of the respondents, over 80% said they found their implementation of peer instruction to be successful. By this

statement it can be assumed that instructors who use the active learning approach have found an increase in the scores of their students as compared to previous years.

Conclusion

Cooper and Robinson (2000) state “through brief in-class discussions that begin, end, or punctuate a lecture, students can prepare for the lecture, check their understanding, or refocus on the material presented” (p.17). The data presented here shows lecture can create active learning in the students of many disciplines. The use of higher-order multiple choice questions presented during lecture can stimulate discussions, build connections with prior knowledge, and check for understanding. The implications of this literature review indicate that, by actively involving students in peer-instruction activities, the student’s attention span may be greatly increased, the use of lecture is not wasted after the first 20 minutes, and a significant amount of learning is occurring. These are all desired outcomes of active learning and can be seen in classes that use multiple-choice questions as a way to break up lectures and check for student learning.

Chapter Three: Applications and Evaluation

Introduction: Target group, goals, objectives, and participants

AP Biology is a course designed by the College Board, a non-profit institute working to increase student success in college. It is designed to be a rigorous class that covers all the topics covered in three semesters of a college introductory biology course. Students are taught a prescribed curriculum, including specified laboratory experiences, and are tested at the end of the course using a standardized exam. The course runs from the beginning of the school year until the exam in the beginning of May. The standardized exam consists of 100 multiple choice questions and 4 essays; everything that is required to be covered by the curriculum is covered on the test.

The urban district that these students come from is labeled a low-income school and roughly half of them come from economically deprived families. The school population is approximately 85% African-American, 11% Hispanic, and four percent other. Most of these students plan to continue on to college and, for them, taking this class is a way to improve their attractiveness to college admission counselors. The current class consists of 20 students, of whom there are 3 males and 17 females; 7 are African-American and 13 are Caucasian; 6 are juniors and 14 of the students graduate this year. Of the 14 graduating seniors 4 of them have told me of their plans to continue on in the science field, while several others took the class to improve their high school transcripts. All of the students have taken the New York Living Environment course that is required, but only 7 have previously taken an Advanced Placement science course before this year.

As this was my first year teaching this course I decided to use lectures and

PPT's as the primary method of instruction. I felt this would allow me to cover topics more completely than any other style of instruction. After the first few weeks I could tell this was very boring for the students and they were not paying attention to the subject matter the way they needed to for the scope of the exam. In deciding what to do to improve the course I decided to continue to use the lecture PPT's, but make some changes to the lecture delivery in order to add more student participation. The main objective in increasing participation was a desired increase in retention and comprehension by the students so as to maximize educational possibilities.

Procedures of Study

One change made was to give the students abbreviated versions of the PPT lecture. The student versions were not complete and required the students to pay attention and fill in some missing information. It was hoped that students would accept more responsibility for the information we were discussing and they would participate more actively in the lectures.

Another implemented change was the addition of multiple choice questions to the lecture PPT. Lectures consist of basic ideas or topics connected in a linear fashion so as to create a pattern of information that will, hopefully, assist the student in building a knowledge base. I decided that a good way to create an environment where students were actively participating in lecture was to use questions from the textbook test bank, and integrate these into lecture. The questions were added approximately after every topic and showed a multiple choice question or statement along with 5 potential answers. The questions were displayed on the projector screen and I would read the question aloud. Students were instructed to work together with their entire

table group and come up with one correct answer. The group was to write the answer on a sheet of paper and bring it up to me. The class was told that these would be added up for points and added to their class grades. Generally students would start to hand in their paper slips within 30 seconds to one minute after the question was read, but if a harder question was used it could take longer. After all slips were turned in and recorded I would then go over the question and the correct answer. By narrowing down the answer possibilities, students would help one another decipher the incorrect from the correct answers.

Questions were selected based on their cognitive ability. Questions that required students to recall information were seldom added to the lecture, with the understanding that answers to those types of questions could be easily found in their notes. Instead, questions requiring students to think about the previous material and use the concept to formulate an answer were favored. Many types of questions were used. One type of questioning required students to order steps of a process, which is a technique requiring a level of material comprehension. An example of this type of question, where students are required to order the flow of blood in the body after it was discussed and modeled in class, is shown in Table 1.

Table 1

Ordering steps in a process

Order the flow of deoxygenated blood to oxygenated blood through the body:

1. Aorta
 2. Systemic circuit
 3. Pulmonary circuit
 4. Left atria to left ventricle
 5. Right atria to right ventricle
-

Additionally, questions that tested application of mathematical concepts

through the solving of problems were used. Table 2 shows an example of this type of question, where students are required to solve a sample Hardy-Weinberg population equation, an important part of the Evolution unit.

Table 2

Application of mathematical concepts

Scientists studying a population of 1600 individuals found that 245 of the individuals show the recessive trait of widows' peaks. Assuming the population is in Hardy-Weinberg equilibrium, what percent of the alleles in the population are dominant?

1. 15%
 2. 39%
 3. 50%
 4. 61%
 5. 88%
-

Questions were chosen to test the ability of students to analyze ideas by understanding and identifying the components of specific systems and concepts.

Table 3 asks students to identify the component that is not part of the gas exchange system for organisms.

Table 3

Analysis of ideas

In a typical multicellular animal, the circulatory system interacts with various specialized surfaces in order to exchange materials with the exterior environment. Which of the following is *not* an example of such an exchange surface?

1. lung
 2. muscle
 3. skin
 4. intestine
 5. kidney
-

Questions that asked students to synthesize answers based on knowledge recently presented and knowledge they previously had learned were also important.

These types of questions were favored because I felt they were problems that would best assist students in learning and retaining concepts from previous lectures and integrating them with newer concepts. In addition, these types of questions required the most input from all members of the table and seemed to spark the best group discussions. An example of a question that required students to synthesize an idea is shown in Table 4.

Table 4

Synthesis

Why must multicellular organisms keep their cells awash in an "internal pond"?

1. Negative feedback will only operate in interstitial fluids.
 2. Cells need an aqueous medium for the exchange of nutrients, gases, and wastes.
 3. Cells of multicellular organisms tend to lose water because of osmosis.
 4. Cells of multicellular organisms tend to accumulate wastes, a consequence of diffusion.
 5. This phenomenon occurs only in aquatic organisms because terrestrial organisms have adapted to life in dry environments.
-

The action research project is an analysis of the use of questions as a method of active learning in the classroom. By utilizing higher order thinking questions I am preventing the students from simply finding the information in their notes and regurgitating information back to me. Instead they are actively utilizing the concepts from lecture and applying them to questions that are similar to those that will be found on the cumulative exam. These questions have been designed to stimulate critical thinking with the hope that students will then internalize the information. As the individual contemplates the answer they use concepts from class to apply their understanding of the material and then compare it to other students' understanding.

Through social interaction students will look at the concept from a different perspective, which will challenge their ideas and help reformulate incomplete perspectives into more complete ones.

Instruments for Study

Data collection occurred over the course of the class year, beginning when the first questions were embedded in lectures in late September 2005 and culminating in April 2006. Various methods were employed to determine the affects and success of this technique. These methods include a tally sheet to record correct answers for each group, informal interviews of students, instructor observation during discussion periods, and a culminating survey.

Initial data collection consisted of a simple tally sheet to record the number of times each table group answered the questions correctly during one class period. Each time a group was correct a slash was made in their group box for the day and the slashes were then totaled for the day. The daily numbers were compared to the total number of questions asked during the lecture to correlate the number of questions asked with the number of questions each group answered correct. This allowed for a quick assessment of how well students understood the material and provided data indicating which groups needed additional help with the material. Over the course of the year approximately 178 questions were asked and a class average of 119 questions was answered correctly.

Informal interviews of students over the course of the year consisted mainly of asking various students, and the class as a whole, what they thought of the questions. The results of these informal interviews were often applied to the set of questions that

were under construction for the next lecture. The comments themselves were seldom written down in the beginning of the year, but they were often written down later in the year.

Immediately after the questions were asked students would try to determine what the correct answer was and then discuss individual answers amongst their tablemates in order to reach a consensus. During this time I would often listen to discussions as students argued the validity of their personal answer compared to that of their tablemates. Data collected during this time was informal and was not recorded in any written form, due to time constraints. When I listened to student discussions I noticed students working through the questions in a logical order. Additionally it was important that the answer the group turned in was one all students had helped to determine, and was not from one student consistently answering all the questions for the table.

The final data collection technique consisted of a survey I designed to assess the students' ideas regarding the use of the questioning techniques during lectures. The survey also provided feedback as to the students' thoughts on the use of questions in remembering the class concepts. By strongly agreeing or disagreeing with a statement the students assessed whether they felt that the questioning technique helped them to understand and retain course concepts. The survey consisted of 14 statements that students responded to using a 5 point Likert scale (see Appendix 1). An answer of 5 indicated the student strongly agreed with the statement, while an answer of 1 indicated that they strongly disagreed with the statement. To insure the reliability of the survey six teachers independent of my class but knowledgeable of

the action research project, scrutinized the statements for their validity and reliability to test the guiding questions of the project. After proposed changes were made the survey was administered and, of the 20 students in the class, 17 completed the survey.

Chapter Four: Results

Data collection was qualitative and quantitative. Both types of information provided important feedback as to the veracity of adding questions to lecture to increase active learning. Informal interviews and instructor observation provide qualitative means of assessing the use of this strategy, while tally sheets and student responses to surveys provide quantitative results.

The number of correct answers for each group was averaged and the mean calculated for the entire class. The mean score for the entire group shows 67% of questions were answered correctly over the duration of the course. One can infer from this data that students were actively engaged in answering the questions and understood the material moderately well.

Informal interviews suggest that students felt these strategies did assist with the goal of increasing active learning in the class, but does not provide a gauge of an increase in critical thinking by the individuals. Student responses were often of the idea that “the questions were better when they were more difficult” because they “made me think more” about the concept and helped to focus more on the harder synthesis questions. In addition, when asked, students often commented that they liked answering the questions because it caused them to pay more attention in class. My own observations support this comment, as I noticed very little nodding off and students were actively engaged in answering the questions.

In addition to observing the attention level of the students I also noticed a variety of discussion and thinking levels going into each answer. Some groups were better at discussing the questions and working together while others would allow one

person to say what they thought the answer was and the rest of the group would just agree. The latter strategy of answering the questions was seen more in the groups where one or more students dropped out of the class over the course of the year. In one particular group one member consistently worked out the answers while another helped sporadically and two additional members contributed very little. The mean tally sheet averages indicate that this group answered the questions correctly the lowest percentage of the time, only 55% of the time. Without this lower performing group the class average rises four percent to 70% correct, showing the improvement when most members contribute to discovering the correct answer. In groups where all students generally contributed to discovering the answer I noticed that the depth of discussion increased over the course of the year. Towards the end of the year students were questioning why answers were incorrect as well correct.

The most potentially important data comes from the anonymous survey given to the class on their thoughts and feelings of the addition of questions to lectures. Student statement scores were entered into Microsoft Excel; mean scores and the standard deviation were determined for each statement. Figure 1 lists the means for each response, where a score of 5 indicates the student strongly agreed with the statement and 1 indicates they strongly disagreed with it.

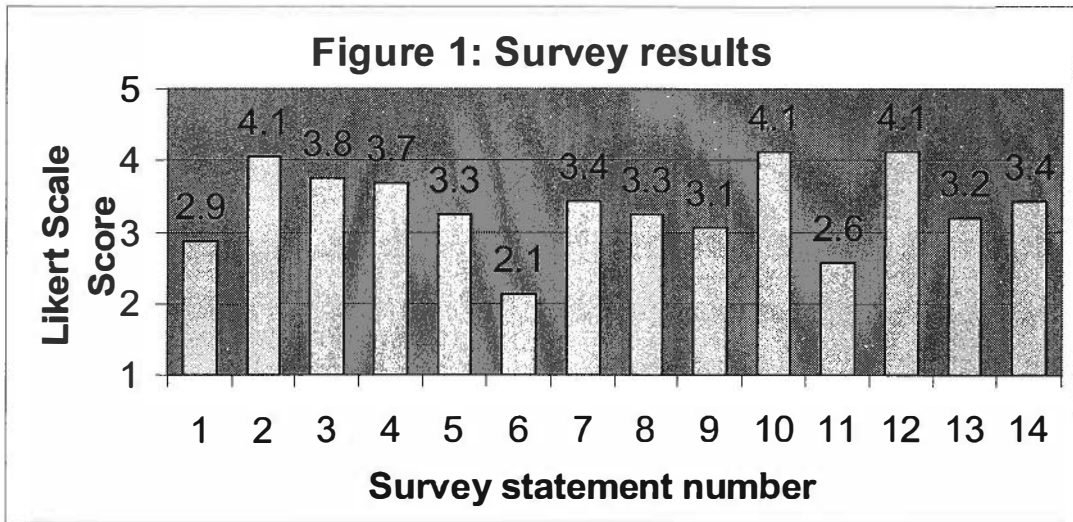
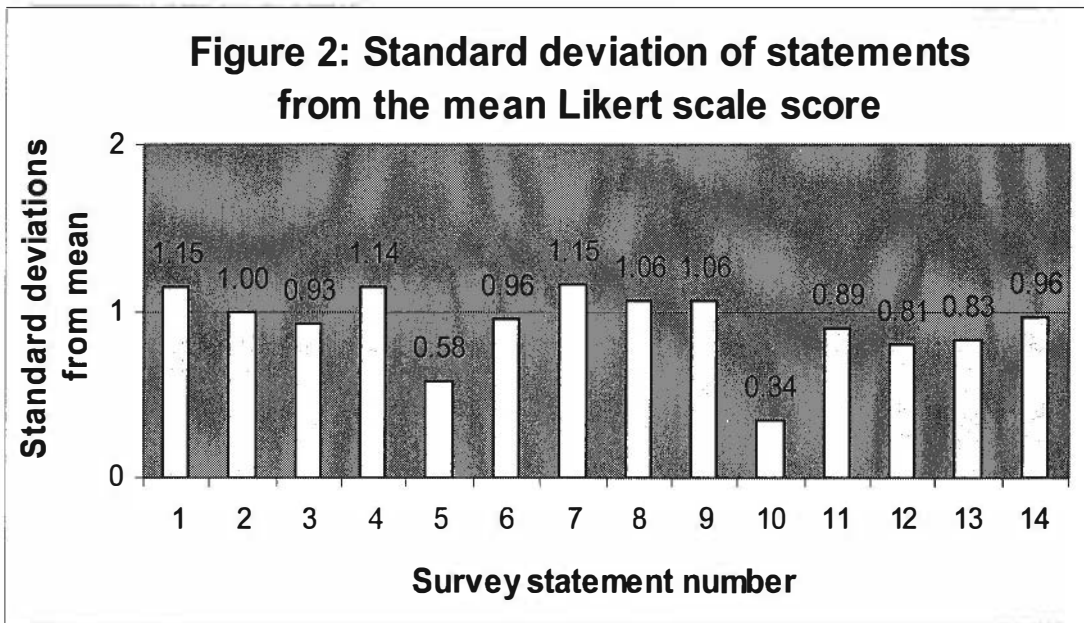


Figure 2 shows the standard deviation, an indication of the differences in the scores for each statement between the students.



How can lecture promote active learning in the student? Specific survey statements best reflect the attempt to answer whether or not this strategy is effective from the student point of view. Table 5 shows those questions most related to answering this guiding question.

Survey statements designed to measure likelihood of active learning		
Statement	Mean Score	Standard deviation
1. During lectures I have a difficult time listening and hearing what the instructor is asking.	2.9	1.2
2. Lectures with Multiple Choice questions after a major concept <i>encourage me</i> to listen in class.	4.1	1.0
3. Lectures with Multiple Choice questions after a major concept help me to <i>understand</i> the material.	3.8	0.9
4. Partial notes from the teacher <i>help me to pay attention</i> during lectures.	3.7	1.1
6. During lecture I pretend to listen, but I am really daydreaming.	2.1	0.9

Examination of this data provides evidence that students felt they were actively involved in the class and the lectures. Statement 1 indicates students did not have a difficult time paying attention in lecture, which could be attributed to the academic level of the students. However, this statement had a high amount of deviation, 1.2, indicating responses varied from those who strongly disagreed with this statement to those who agreed with it. Statement 2 had a very high mean score, 4.1, signifying that students often listened in class specifically because of the multiple choice questions. While there is a moderate amount of deviation of the mean score, 1.0, it shows that students felt it either helped sometimes or most of the time. Students also agreed that the lecture questions helped them to grasp the material at least most of the time, based on the standard deviation range. Additionally, the use of partial

notes had a mean score of 3.7, showing that students felt the notes helped sometimes, with a standard deviation of 1.1 saying very few felt it was not useful at all. The best indication that the lecture note strategy was a positive way to increase active learning is that students reported they daydreamed only rarely to sometimes, but never often.

Does inclusion of higher-order questions into lecture PowerPoint's cause students to think critically about the information? Certain survey statements were designed to probe the effectiveness of this strategy in light of desired outcomes. Table 6 shows those statements most related to this guiding question.

Statement	Mean Score	Standard deviation
5. When I do an activity I try to take what we did in class and apply it.	3.3	0.6
7. I can see the real world applications of what we are learning in AP Biology.	3.4	1.2
9. The questions that we answer during lecture help me to see the real world applications of what we are learning.	3.1	1.1
10. When I answer a question I try to think through it to find the answer.	4.1	0.3
14. The questions that we answer during lecture help me to answer questions on tests.	3.4	0.9

When this data is examined, it shows a lower percentage of mean scores than the previous data. Statement 5 mean score of 3.3 indicates students could apply what I lectured on in class sometimes, but not always, to activities that were designed to reinforce the lecture. In addition, statement 7's median mean score of 3.4, combined

with the large standard deviation of 1.1, shows that students do not see the real world applications of what we were discussing. That information, combined with the replies to statement 9, indicate the questions did not assist the students in seeing how the lecture information and questions applied to real life and they were not, therefore, critically thinking about the material. Students reported, however, that they tried to think through answers to questions most of the time. Since this statement had the lowest standard deviation, 1.1, this would indicate that perhaps students did think critically about the information regardless of the questions presented. Students also indicated they felt the use of questions sometimes or usually assisted them to answer questions on tests, but rarely did they feel the questions did not help.

Will the inclusion of Think-Share strategies during lecture promote internalization of information? Table 7 shows those survey statements that address this question.

Statement	Mean Score	Standard deviation
12. Working with my tablemates to answer the lecture questions helps me to <i>understand</i> the material.	4.1	0.8
13. When I take a test I <i>remember</i> the information that we talked about during lecture.	3.2	0.8
14. The questions that we answer during lecture help me to answer questions on tests.	3.4	0.9

When looking at this data it readily becomes apparent that students felt working with their tablemates helped them to understand the material most of the

time. While the mean score of 4.1 for statement 12 indicates that students agree with the information, the standard deviation of 0.8 does not take the mean into the negative aspects of the ranking. Unfortunately, based on the means of statements 13 and 14, 3.2 and 3.4, it does not appear students felt the use of the group discussion technique helped them to recall the information. Both of the statements have similar means and deviations, indicating students felt that when they took a test mainly the class discussions helped them remember the information occasionally. While these means and standard deviations are not as positive as could be hoped, they are still positive rankings. This indicates that students felt answering lecture questions and the use of discussions as tools to build the understanding of the material was a helpful way for them to learn it.

Two statements have not been discussed because of their bearing on the rest of the statements. Statement 11 asked students to rank their feeling of Biology as boring, where a score of one indicated they strongly disagreed with the statement. The mean rank was a 2.1 with a standard deviation of 0.9 from the mean. This indicates students did not feel biology was normally boring, which could be taken as a statement of support for the use of lecture questions. Unfortunately statement 8 asked them to rank the statement “I enjoy answering questions during lecture.” The mean student rank for this statement, 3.3, indicates that sometimes they enjoyed answering questions, but with a standard deviation of 1.1 a large difference of opinions exists within the class. While student’s reaction on how they felt about answering the questions has great merit, it is overshadowed by the mean student ranks when specific statements are looked at in light of the guiding questions.

Chapter 5: Conclusions and Recommendations

Discussion and conclusion

I used multiple choice questions, embedded into lecture PPT's in an attempt to increase student attendance and participation in the class. The focus of this technique was to have more class involvement, use this as a method of instant feedback of their understanding of the material, and have students who understood the material explain it to students who might not have. Different types of questions were used; each designed to stimulate different thinking levels and abilities. A review of the related literature shows that the use of any technique that changes lecture from straight delivery to one that increases student involvement will help to build student retention of the material. In addition, using the embedded question technique has been shown to improve student scores on exams when used in large lecture (Mazur, 2000) and small lecture settings (Wimpfheimer, 2002), so the use of this technique in the AP Biology classroom should prove effective. As an added bonus, this method also allows for an instant assessment of the level of student understanding displayed for each topic.

A survey was given to measure the amount of active learning students felt they had experienced during lectures with multiple choice questions. They were asked to rank their feelings on specific statements so as to gauge the effectiveness of this strategy as a way of increasing student active involvement, critical thinking, and class interest. In analyzing the data collected from the survey I looked for information that provided clear connections to the three guiding questions of the project. Those questions are: how can lecture promote active learning in the student, does inclusion

of higher-order questions into lecture PPT's cause students to think critically about the information, and will the inclusion of Think-Share strategies during lecture promote internalization of information?

When analyzing data from Table 5, student ranks, comments, and the low standard deviations all clearly indicate that use of questions during lecture does increase the amount of active learning that is occurring. Student responses express strong support for the addition of questions during lecture as a tool to increase achievement in class. Very rarely did student scores present negative views regarding the use of lecture questions. One student commented, "The questions presented are definitely good, having the extra incentive of points and keeping you alert. You can assess yourself on whether you're getting the material or realize that you need to stop dozing off and pay attention." This reply, along with means and standard deviations, indicate the usefulness of this type of strategy as a method of active learning in the classroom. Students are involved in thinking about the material and determining how previous learning interconnects with current information. The fact that students report they agree to strongly agree that questions encourage them to listen to lecture and they usually feel the lecture questions help them to understand the material speaks highly of its merit as an instructional tool. Another student commented that "lectures get old really fast," which is information that is very important to keep in mind. While data indicates this strategy is effective at causing students to be more involved in the notes and lecture, overuse of any one tool will have side effects that could cause it to become ineffective. The use of other strategies to prevent the overuse and accompanying drop in effectiveness of lecture is important to be aware of.

Additionally, a student comment indicates the use of wordy, or confusing, questions was a problem when trying to learn new material. While the use of these types of questions cannot be avoided at times it is important to remember we are attempting to get the students to enjoy these questions, a fact that an average 3.3 (+/-1.1) stated they did not enjoy. Therefore, it is important to take time to design or find quality questions that will further the students understanding of the material.

When analyzing Table 6 the scores for the use of questions as a way to increase critical thinking indicates it was not completely successful. However, the fact that responses were not negative and did not highly fluctuate around the mean is very important. This identifies the possibility of using this technique as a way to build critical thinking skills. One student commented that “I ... liked that some of the questions reflected on concepts from the past chapters.” Problems of this nature more fully challenge a student and should be used more often to build those critical thinking skills so necessary to achieving a high score on the AP exam. One student commented that “I liked the fact that the multiple choice questions were a reflection of the different sections and that they were a preview to similar questions on our tests and quizzes.” This helps to narrow down whether or not the use of the questions should continue, or if they were not useful. With some changes to the question types and addition of other activities designed to stimulate critical thinking the questioning technique can become far more useful. In addition, the mean score for statement 12, working with my tablemates to answer the lecture questions helps me to *understand* the material, indicates students felt learning and understanding did increase with the use of questions and discussion at the individual tables. The mere fact that students

felt they understood more makes the use of this technique very successful because it adds a layer of self-confidence that is very important to any large undertaking, such as AP Biology.

Recommended Actions and Individuals Responsible

The recommended actions for this research are to continue with the use of questions embedded into lecture. The use of questions has clearly been shown to increase the amount of involvement students' exhibit during lecture. This increased amount of involvement also indicates they are better able to retain information that had been presented during the lecture. In the future it is suggested students read and focus on the easy to understand information before coming to class so lecture time can focus on the more difficult concepts. This will free up more class time for the use of increasingly complex and involved questions. These questions should encompass larger amounts of base information, covering a wider amount of topics, so that students have to rely more on past experiences and obtained knowledge to answer them. I also recommend that back-up questions are kept handy, perhaps added as a hyperlink to the end of the PPT, for questions that a wide range of students missed. This would allow for a discussion of ideas, and a re-assessment of their achievement.

This type of active learning strategy can be used in other classes besides AP Biology. In the Living Environment (LE) it would be a beneficial strategy to increase student participation in note-taking sessions that are sometimes necessary, but difficult with ninth and tenth graders who are unaccustomed to lecture. Continued use of this strategy is recommended with the above changes made. This is not a strategy that will only be effective for a science class, or even for classes with a culminating

standardized test. This method of increasing active involvement in the class can be used in any setting and in any curriculum where questions can be applied to the material being presented or learned. It is suggested that a survey be given at the beginning and end of the course to provide more feedback as to the efficacy of the addition of lecture questions. All these actions, changes, and suggestions fall to the implementing instructor and do not require outside assistance, but should require minimal time to implement.

Limitations of Study

The use of tally sheets clearly shows the class answered questions correctly 67% over the course of the year. However, there are several problems that exist with this data. I did not record what type of question was asked (application, analysis, etc) to determine the number of groups that missed the question. I am unable to determine the difficulty level or the questions that students missed. Therefore, this does not provide a clear understanding of whether or not these questions improved students understanding of the material and if the students' ability to answer these questions improved as time went on. In the future it is recommended that this information is recorded so as to effectively estimate the level of learning that has taken place.

A different concern dealt with the table groups and their lack of consistency over the course of the year due to student attrition and seat changes. Since I did not assign seats, students sat wherever they wanted. Most stayed in or near the same seats over the course of the year, but several tables changed significantly from the beginning to the end of the academic year. Table numbers fluctuated from two to six people per table. This altered the group dynamics as different students were regarded

as more, and sometimes less, worthy of suggesting correct answers. One particular group started out with six students at the beginning of the year. This group was very important to class dynamics because it consisted of seniors with overall class ranks of first, third, sixth, seventh, eleventh, and fifteenth. When these students discussed lecture questions their answers held more weight with their classmates and when some of them changed seats, it altered the dynamics of both the new and old groups.

An early issue that arose with the student grouping at this table was eavesdropping by students at other tables. During the first lecture question I was watching the class and observed the way students were attempting to answer it. I noticed three different groups listening in on the group of six high performing students. As they listened each group wrote down the same answer the student group of six had written down. The large group of students answered the question wrong, as did the three groups that had written down the answer they overheard. This fortuitous episode allowed me to discuss with the class the importance of determining their own answers. Although the individual tables did eavesdrop on occasion after the abovementioned incident, I noticed groups were much more hesitant to commit to that answer without further discussion. Instead they often worked through the problem and then decided if they liked the other groups' answer or not. This outcome seemed to cause an increase in critical thinking about the questions and the concepts.

Whom to Consult or Inform

The key people to inform of the success of this program of involvement and participation are other teachers. This is an excellent strategy that should be shared

among teachers so that it can be refined and studied in other settings. A good way to do this would be during departmental professional development meetings to introduce the idea slowly to immediate colleagues. Other teachers might hear of the program and inquire as to its effectiveness and strategies for implementation. A choice driven school-wide professional development day might then provide an opportunity to meet with more teachers. Beyond that, there are no other individuals that require special notice of the purpose and affect of this strategy. It can even be considered as a method of classroom management and therefore falls to the teacher to implement as they see fit.

Who is responsible for collection and when will it occur?

The monitoring of the answers given and implementation of this technique fall on the individual teacher. However, the monitoring of the number of correct answers could be given to specific students or to the entire class each day. This information can then be collected by the teacher for combination with past scores on a tally sheet or a grade book. The times for collection may vary. Collection can occur after every question, every day, or weekly. The implementation should start at the beginning of the year so as to build a consistent pattern from the beginning to the end of the year.

Required resources

Resources can be anything from pen and paper to a whiteboard or a projector and computer. A test bank of questions is helpful as it is difficult to consistently build good questions for class and the test bank eases the stress of design. The AP Biology multiple choice questions are designed to require more synthesis of ideas and have 5 possible answers. Questions for LE could be directed towards recall and application

of ideas and have 4 possible multiple choice answers. Therefore, it is suggested the implementing teacher design questions that simulate, or use a test bank of questions, similar to the standardized test questions students are required to take. The only other resources required are students and a previously designed question aimed at reinforcing a concept that has just been presented or an activity recently conducted.

Concluding Remarks

It is evident from the data provided by this action research project that the use of MC questions during lecture can be an effective strategy for active learning. The use of extensive lecture is not an ideal situation, however, and as one student remarked, "I simply have a hard time trying to learn by power point. It just doesn't click very well." To be completely effective it should be balanced with the use of active learning elements that cause the students to utilize hands-on strategies. These two techniques combined can cause students to understand and internalize information for any class at a higher rate than either strategy alone.

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Appendix

Anonymous Survey: Action Research

Mr. Newman

Below are a list of statements and numbers. Circle the number that most applies to you in regards to that statement.

5= strongly agree 4 = agree 3 = sometimes 2= disagree 1=strongly disagree

Statements	Circle a Score				
1. During lectures I have a difficult time listening and hearing what the instructor is asking.	5	4	3	2	1
2. Lectures with Multiple Choice questions after a major concept <i>encourage me</i> to listen in class.	5	4	3	2	1
3. Lectures with Multiple Choice questions after a major concept helps me to <i>understand</i> the material.	5	4	3	2	1
4. Partial notes from the teacher <i>help me to pay attention</i> during lectures.	5	4	3	2	1
5. When I do an activity I try to take what we did in class and apply it.	5	4	3	2	1
6. During lecture I pretend to listen, but I am really daydreaming	5	4	3	2	1
7. I can see the real world applications of what we are learning in AP Biology.	5	4	3	2	1
8. I enjoy answering questions during lecture.	5	4	3	2	1
9. The questions that we answer during lecture help me to see the real world applications of what we are learning.	5	4	3	2	1
10. When I answer a question I try to think through it to find the answer.	5	4	3	2	1
11. Biology is boring.	5	4	3	2	1
12. Working with my tablemates to answer the lecture questions helps me to <i>understand</i> the material.	5	4	3	2	1
13. When I take a test I <i>remember</i> the information that we talked about during lecture.	5	4	3	2	1
14. The questions that we answer during lecture help me to answer questions on tests.	5	4	3	2	1

Comments: