Do's and Don'ts of Introducing Active Learning Techniques

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Abstract

Each year at ASEE we hear of all sorts of wonderful active learning techniques that engineering educators are using to involve their students in the classroom. This paper relates the experiences of one new engineering educator in trying out some active learning techniques in his classroom.

As with other teaching techniques, instructors must carefully evaluate active learning techniques not only for pedagogic soundness but also for fit with their style. A technique that works well for others will do you no good if it doesn't mesh well with your course organization and plans. This paper discusses some examples of techniques that fit well with the author's style, some that have been tried and discontinued, and a few that the author has not even attempted.

Most new engineering educators pay much attention to student feedback, particularly informal feedback, about our use of new teaching techniques. However, there are many new confounding variables in these evaluations to deal with. Often, the course that we are trying to introduce active learning into is new to us, or we are extensively revamping the organization. We may be teaching a style of student that we have little experience with. We may even be learning new material as we are teaching it. It is often hard to separate out what works from what doesn't work based on formal feedback. This paper includes some ideas on evaluation of efficacy of new teaching techniques, and some tips on making this evaluation easier.

This paper discusses personal experiences and gives a practical first person perspective. It investigates the implementation aspects of some of the more abstract pedagogical techniques that new educators find so intriguing and inspiring.

1. Introduction

From Carl Smith's semester-long group projects[8] to Angelo and Cross' "one-minute quizzes,"[1] the annual meeting of the American Society for Engineering Education brings many tried-and-true techniques to engineering educators. Just as our students usually see only the polished end result of our problem solving in class, engineering educators usually only see successful experiments in active learning.

I joined the professoriate in Fall 1998: as this is being written, I have been teaching for almost three semesters as an assistant professor. As a new engineering educator, I am extremely interested not only in how well these techniques work, but also in the little implementation details that may or may not keep me from implementing them in my classroom. Unfortunately, all too often an idea that sounded interesting and immediately applicable during the summer falls to the wayside due to a combination of content tyranny and administrative overhead during the semester.

In the following pages, I will describe a few case-studies of implementations for active-learning techniques in my courses. The relevant courses are *Digital Logic Design*, an introductory course in logic design, *Microcomputer Systems*, a course in embedded systems with the Motorola 68HC11 microprocessor as the center point, and *Network Analysis*, an introductory course in circuit analysis.

2. What is Active Learning?

The term “Active learning” can mean many things, based upon context. Bonwell and Sutherland[3] discuss a continuum of active-learning activities, with the size, length, and complexity of the activity begin decided upon by course objectives and other constraints. Within a course, the length and degree of involvement in active learning can vary dramatically, based on what objectives you have for the activity.

In this paper, I will take a broad definition for active learning and include all activity in the classroom that does not fit into the passive lecture note-taking framework. Note that this definition purposefully includes most laboratory classwork: this is intentional and more will be said on this topic later.

3. Lecture Techniques

The simplest in implementation, and smallest in scale, of the active learning techniques described in this paper involve enhancing the traditional lecture format by including short active-learning activities. These techniques are included as breaks in a traditional 50-60 minute lecture, and typically involve small randomly generated groups of students.

Bonwell[2] describes five activities of this sort: The pause procedure, short writes, think-pair-share, formative quizzes, and lecture summaries. The pause procedure involves stopping the lecture every thirteen to eighteen minutes to allow the students to do something else, such as compare notes and ask each other questions. The short write (also called “one-minute papers” by Angelo and Cross[1]) are small ungraded and unevaluated writing assignments asking the student a simple question regarding the lecture portion immediately preceding the paper. Suggested questions include “What was the main idea presented in this portion of the lecture?” or “Describe the concept of ______ in your own words.” Think-pair-share is a popular technique for having students generate answers to questioned posed to the class. It involves having the students work individually on an answer or solution for a period, then share their solution with a neighbor. Finally, pairs may be asked for their solutions. Formative Quizzes are ungraded in-class quizzes where questions similar to those seen on examinations are presented to the students, and students are asked to generate solutions individually. Lecture Summaries allow students to summarize what was presented, and immediately synthesize the lecture into a cohesive unit.

I have experimented with three of the five aforementioned methods. Explicitly scheduling pauses into lectures is seldom done, and is much appreciated by students. Care must be taken with this, though. One problem I had was that over the course of several weeks the mid-class pause began as standing and stretching, moved to several students running out to get a drink of water, to (on a Friday morning), most of the class moving to the hallway to talk about an upcoming exam in another class. As the point of this mid-lecture pause is to relax and regroup, I did not want to become too stringent by, for example, requiring students to stay in the room (this is a class of about twenty students). My solution for this was to keep a close eye on my watch during the break, and to begin introducing a new topic after exactly the same amount of time each lecture. The students quickly learned how long the break was expected to be, and the problem was resolved.

Think-pair-share (TPS) is easily adaptable into many engineering analysis classes, where problem-solving skills are the main topic for the course. In this method, which is a cross between TPS and the formative quiz as I implement it, a problem is presented to the class that is related to the topic just covered in lecture. Often, a problem is split into several steps, and TPS is used for each step. First, a general solution path is generated where the sequence of calculations required is generated. A final solution path is decided upon by the class, the computations are performed individually and the results shared with a partner. Discrepancies between students are usually solved at this point. After a consensus among the majority of the students has been reached, the correct answers are shared with the class. This step is important so that anyone who has incorrect answers can correct their work after class.

This method for working through examples takes somewhat longer than that traditional style of the professor presenting and solving a problem on the board, but functions as a break and formative quiz as well. There are several pitfalls to avoid when solving problems this way. First, this method requires that students be completely up to date with the subject matter (assuming that the solution requires the use of techniques and knowledge from previous classes). If a student isn't prepared to work problems, it is easy for the instructor to spend too much time answering remedial questions and coaching these students. Second, very bright students can sometimes dominate the problem-solving session. If you are not careful to be equitable in retrieving answers from groups, students quickly learn that they can't solve problems quickly enough and don't bother. This is mostly an exercise in the amount of time given to the class to work on a given problem. This is an art: too little time and students don't have a chance to think about the problem, too much and you start getting interpersonal communications and boredom. Ellis et al.[6] suggest waiting for a rise in room volume as students discuss the problem, followed by a drop. At this point, many student have completed the task but have not moved on to other subjects. Third, you must break the problem into a simple enough size that students can quickly see the solution path, but complex enough that the students feel that it's worth their time to work through the problem to the solution.

One-minute papers are also useful in problem-solving courses. One problem I had with one-minute papers was in presenting too vague of a question to the class. For example, it's much harder for a student to know (and admit) what they don't understand than to illustrate what they do know. So a one-minute paper on "Which of the topics we discussed this week is most fuzzy" is not likely to generate much useful information, but "Which method would you solve this circuit with (and why)?" might do a better job.

4. Group Work

As Johnson et al.[7] point out, group work in the classroom can range from small clusters of students working together on homework problems before class to long-term assigned formal groups working on projects. When deciding whether to use group work as a component of a course, the course objectives and current organization must be taken into account. As new engineering educators, many of us don't have the time or the inclination to re-invent courses, but wish to incrementally change them to improve the pedagogic style and learning of students. I've described my use of short-term problem-solving group work in lecture courses above.

In a course that is (or can be) project-based, such as the embedded systems course described above, project groups are an excellent way to involve students in group work. This gives the students an opportunity to work with other students on a more ongoing basis, but without committing to a semester-long or year-long partnership. This course utilizes 3-4 projects throughout the semester.

On a practical note, the degree of structure imposed on group work bears a direct relationship to the seriousness with which the students perform that group work. If the course objectives include group dynamics, leadership skills, and teamwork more training and structure should be imposed than if group work is used as an active learning exercise.[5] My courses tend to utilize the active components of group work such as bouncing ideas off of other group members and criticism of ideas rather than explicitly concentrating on group dynamics. Therefore, even in extended projects I evaluated results based on technical content generated by the group and not on leadership or teamwork issues.

5. Laboratory Techniques

The laboratory is almost the ideal situation for active learning: this may be part of the reason why educators and students love them so much. In the laboratory, the theory and examples learned in course work is put into practice, forcing the student to organize the material conceptually and apply it to a (moderately) novel situation. In addition, there are usually other groups working toward roughly the same goal that are useful as sounding boards for ideas, and for help when stuck on a solution. Finally, this allows students working in the sensor learning style to actually see the ideas put to some useful purpose, and to measure the real-world impact of theories.

Many of the techniques described above for enhancing a lecture work well in laboratory situations. In these cases, the purpose is to cause the student to integrate and utilize the knowledge rather than to re-involve the student into the learning process after an extended period of inactive listening. For example, the process of writing abstracts is an excellent way for the student to summarize and paraphrase the results of the laboratory. Think-pair-share happens almost naturally, with interactions between teams of lab partners.

6. Evaluation of Efficacy

New engineering educators often have problems evaluating the efficacy of a particular teaching technique. There are many confounding variables: we have limited knowledge of the abilities and characteristics of the student audience, we may be developing or substantially changing the course materials as the course progresses, or we may be seeing the material for the first time as we teach it. In these situations, there are many possible barriers to learning.

In an ideal situation, the best way to evaluate the efficacy of a particular teaching technique is probably to track student performance utilizing metrics such as content mastery. This should be done both across sections and over time, varying only the application of this technique. Most new educators are not willing to wait for this collection of data before trying new techniques, and are significantly changing the course each semester, so we have to rely on other evaluation methods.

Don't underestimate the value of your feelings. An educator can certainly tell during group exercises if the students are involved with the material. One thing that I have done is to split the material into different areas, and concentrate on implementing as many active learning exercises as possible into the material that they seem appropriate for. For other material, I've relied on the traditional lecture delivery method to deliver. By actively varying the concentration of different types of exercises, you can get a feel for the exercises that help the students to learn the material. However, a few caveats apply. First, the inherent difficulty of the material confounds this evaluation. Second, Centra[4] points out that the correlation between self-evaluation of overall teaching effectiveness and external (student, colleagues, and administrator) evaluation is quite weak.

Informal student feedback gives some indication of how well the students *like* various exercises, but may not correlate with learning. The instructor's knowledge of how the students are doing with the material, as measured by one-minute quizzes, homework problem sets, and office hours, is often the most useful measure of the efficacy of these techniques. However, student enjoyment of classroom activities should not be discounted entirely. As teachers, we owe it to the students to try to involve them in the course material as much as possible. If increased enjoyment of class brings a student to class more often, that is not an insignificant benefit in itself. Angelo and Cross[1] give several assessment techniques centered around eliciting student opinions on the efficacy of various student activities.

7. Discussion

This paper has related, in an informal fashion, the experiences and ideas of one new engineering educator with respect to introducing active learning into the classroom. Once you have an established reputation for group work and active learning, and the students are accustomed to this style of learning, the problems and issues faced with regard to active learning activities will no doubt change.

The two key points that I have see suggested in many places and that I would like to echo are to evaluate the proposed active learning exercises in light of what you want to do with the course and to only implement the types of activities that you are comfortable doing. That said, I believe that some degree of active learning will help students learn simply by virtue of the increased involvement with the material. As you become more comfortable with active learning exercises and group work, you can expand their use in the classroom. Conversely, if you are not comfortable with a particular exercise, the students will pick up on that, and the exercise has a much lesser chance for success.

In summary, the introduction of active learning does not have to mean the abandonment of lectures and the formation of a large number of self-paced challenging group exercises. Not only can it be insinuated into the traditional classroom format, I believe that it has a better chance for long-term success if it is introduced in this fashion.

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