

The Trials and Errors of Collaborative Learning: A New Faculty Perspective

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ABSTRACT

There are a number of teaching techniques that have proven very useful in involving the students and increasing their learning. As a new faculty member, I have chosen to improve my teaching by first implementing collaborative learning exercises into my classes. The exercises I have used include in-class group problem solving, informal study groups, and group term projects. In this paper, I will detail the published benefits of collaborative learning that led me to use this in my classes. The introduction of collaborative learning exercises into my lectures has also brought a number of problems and fears including time constraints, the practical issues of forming groups in large classes, and the barrier students have towards working together. From the perspective of a new faculty, I will discuss the problems I have had implementing collaborative work into my classes and tips for avoiding and overcoming the problems I have encountered.

INTRODUCTION

Collaborative learning is when students work together in groups to improve the overall learning of the group. Collaborative learning by definition involves positive interdependence (all members must cooperate to complete the task) and individual and group accountability. Collaborative learning exercises (CLEs) could include in-class or out of class assignments and groups that are assigned for just one class or for the whole term. Many detailed publications exist defining collaborative learning and assessing its role in the classroom [1-4].

The effectiveness of collaborative learning has been extensively documented (over 700 studies during the past 90 years). More is known about the quantitative benefits of collaborative learning than is known about the effectiveness of traditional lecturing! (The highlights of these studies are explained in Johnson, Johnson, and Smith [1].) Even without performing a formal study of the effects of collaborative learning, the biggest benefit can be seen by acknowledging what professors experience. Teachers learn an incredible amount by preparing their lectures and explaining the material. Collaborative learning exercises give students the chance to be teachers. They can explain what they know and in the process define what they still don't understand.

In-class collaborative learning exercises also introduce variations in the lecture format that appeal to alternative learning styles. The four main ways of classifying learning styles (Myers-Briggs type Indicator, Kolb's Learning Style Model, Herrmann Brain Dominance Instrument, and Felder-Silverman Learning Style Model) all classify learners as either introverted/ reflective or extroverted/ active [5,6]. Traditional classroom lectures are tailored towards reflective learners. Actively engaging students through CLES allows every student time to learn in a mode they are most comfortable with and time in a mode that challenges them to expand their learning styles. Also, based on the fact that the average attention span of an adult is 15-20 minutes [7], switching between active and passive modes of lecturing will improve the attention of the student during both parts of the class.

Working on problems in class also gives a means of assessing the learning that is taking place and adapting the material covered and the teaching style [2,8]. This immediate feedback allows for the gaps in the student's understanding to be addressed before a homework or exam. Also, using group problem solving as an in-class assessment may show that the students understand the material and the pace of the lecture can be accelerated.

Both in-class and out of class group assignments provide flexibility in designing the project. The groups can be expected to handle harder problems and larger projects. Mourtos found that students in his Aerospace Engineering course were 80-90% successful at solving complicated test problems when working in groups as compared to a 50% individual success rate [9]. In interdisciplinary classes, groups can be made up of differing majors allowing a group to view and solve a problem from several perspectives.

Student retention throughout engineering can be improved by strengthening students' interactions with their peers and faculty, thus increasing their sense of belonging to the academic community [10,11]. All collaborative learning exercises should have a component built in to them that allows students time to get to know one another. This is particularly useful at commuter schools such as San Jose State University where a common practice of students is to come to campus only for classes and leave immediately following their class. This group experience not only makes their college experience more enjoyable but also teaches them teamwork skills that will be very useful in their later careers.

IN-CLASS COLLABORATIVE LEARNING

Based on these many benefits, I have used CLEs where groups of students work on problems during the class time. This involves splitting the lecture time, in a manner similar to that shown in Table I, between passive and active learning. My main objectives are to get the students actively involved in the lecture and to assess what they are learning (though all of the benefits addressed above apply to the in-class CLEs). The CLEs are graded (in terms of participation, not technical content). This increases participation in the CLE and class attendance.

The CLE starts by dividing the students into groups. I use group sizes of three to four students. I have found that participation goes down (for certain students) with bigger group sizes. With large classes, having small groups mean there will be a lot of groups needing attention. CLEs with large classes can be difficult but they can also be quite successful (and critically important in building the community atmosphere of a large class) [12,13]. In my class of 80 students, I use a classroom assistant to help answer questions from the groups during the CLE time.

In terms of the mechanics of forming the groups, there are many different ways this can be established. Formal groups can be assigned for the entire term [4]. These groups are typically assigned by the professor based on students' academic background and grades. The goal is to

Table I. Sample scheduling of a collaborative learning exercise (CLE) in a 50 minute class period.

Time (in minutes)	Activity
5	Q&A Review of Last Class
20	Lecture
15	CLE
10	Lecture

make the groups as academically diverse as possible. For the in-class CLEs, I do not use permanent, formal groups. I use informal groups that are formed randomly each week. This increases the number of other people in the class students will meet. The quickest way to form groups is to have students work with those around them. While this maximizes time, it results in relatively the same groups every week due to the fact that students usually sit in the same seat. This does not maximize student interaction. It also generates groups that may not be as academically strong so they are repeatedly unsuccessful at the assignments. Another method I use is to place numbers on the tables at the beginning of class and randomly assign students to numbered groups. The group assignments vary weekly. To expedite the forming of the groups, I have an overhead with the students' names and group numbers. Another important logistic I have found in forming groups is the classroom setting. It is necessary to use a classroom that has moveable seating (such as chairs and tables). CLEs do not work well in auditorium style rooms.

The exercise is broken up into two parts: an introduction question and the technical assignment. The introduction is an ice-breaker question geared at helping the students to get to know one another. This is meant to emphasize the group nature of the work and build community in the classroom. Some typical questions may be: "How many classes are you taking?", "Do you work part time?", "How long is your commute?". The technical part of the question is directly targeted at material just covered in lecture. I decide when designing my lecture what the key learning objective(s) are for that day and focus my CLE on that. While the students are working on the problem, I circulate and answer their questions. Following the exercise, I collect the worksheets (for their participation grade) and post the solutions on the class website.

The biggest problem I have had with CLEs is that they take lecture time, something I feel I don't have enough of as it is. To minimize my fear of this, I use one CLE exercise a week for a class that meets twice a week (the second day is pure lecture and Q&A). (Some professors have been quite successful teaching courses using complete CLEs!) I think the time used in lectures for CLEs is justified. Students are learning the material covered in a thorough manner and the in-class assessment allows me to make better use of the time by adjusting the lecture content to their needs. However, the reality is less lecture time usually means less material is lectured on. I use learning objectives to emphasize the key components of the course and identify topics that may be removed or downplayed to ensure the important material is learned more thoroughly. Another option is to insist that the students learn some of the material on their own, outside of class, using the textbook. In my classes, I have chosen to remove from the lectures the basic definitions and simple background material that is given in the textbook. This requires students to have done the assigned reading before coming to class in order to fully understand the lecture and be able to contribute significantly to the CLE. To encourage reading before coming to class, I have preparation notes on the course website. The preparation notes are questions the students should be able to answer after doing the assigned reading. It helps insure they obtain the important points from the reading. I also give short reading quizzes at the beginning of some classes. These are typically one multiple choice or short answer question and only take a few minutes.

Another difficulty I have had with CLEs is getting all the students to participate. Typical problems I have seen are students working on the problem alone, students doing other classes' work during the time, and students asking me or other students about material not related to the CLE. As discussed above, the group size influences participation. Students interact more in the smaller groups. Another proven method is "material interdependency", to give each group only

one copy of the assignment and any charts or figures they'll need [4]. This makes it difficult for the group members to work individually. Also, teamwork is enhanced by making the problems open ended. As a group, the students are required to choose certain variables such as material or thickness or make certain assumptions.

Giving them instruction on how to work together is a critical part of the definition of collaborative learning [1-4]. Assigning a role to each group member helps the students see how they can participate in the activity. Some roles are: group leader (who organizes the group's approach to the problem and make sure everyone has a chance to be heard), recorder (who writes and submits the group's solution), public affairs person (who asks the group's questions and gives answers to the professor or class assistant), reflector (who evaluates the dynamics of the group), and time keeper (who keeps the group on the time schedule and prevents them from devoting too much time to any one part of the problem).

The other aspect that is hard to get accustomed to when designing the CLEs is to write the questions so that they fit in the time period. The extremes, some groups finishing quickly and some barely getting started seem to always exist in my classes. To minimize this, I have the students come fully prepared with what they'll need (textbook and calculator) and I provide (or give the textbook page number) of any data, constants, or figures needed in the problem. As I circulate the room, I identify the groups that are having difficulty and give them hints to aid in their progress. For the quicker groups, I add an optional part at the end with advanced calculations or discussions. I also encourage faster groups to help the groups around them when they are finished.

FORMAL STUDY GROUPS

Considering that students learn from each other and from the act of teaching others, I encourage students to work together on their homework and to study together for tests. Many students do this already informally. In my classes, I try to organize "formal" study groups for those students in the class that don't have an informal group in place. I organize the groups based on schedules, when during the week they will be on campus and have time to work with the group. At the beginning of the term, I create the groups, give the group members' email addresses to each other, and suggest places on campus where the groups can meet. To encourage continued involvement in the group, I offer extra credit homework problems (that must be passed in as a group, one answer per group) and special group office hours. Having homework assigned to a group also offers the advantage that the homework can be more challenging than individual assignments with the thought that the collective group of minds will be able to work through it.

The downfall of these study groups is that, when working on homeworks in a group, some students don't actively participate in the work. However, the reality is students working together (or outright copying the homework of others) exist without the professor organizing formal study groups. I do think the assigned groups reduce cheating in that students are less likely to copy from students they don't know that well. I have each student sign an honor code attesting to the fact that they actively participated in the homework. I also use midterm questions very similar to content on the homework. In the solutions, I indicate from which homework problem they should have learned the material. Hopefully, students who cheat on the homework realize after the first midterm that they need to actively participate to learn the material.

COLLABORATIVE TERM PROJECTS

I have used collaborative term projects where a group of three to four people research a topic and generate a group oral and written report. Having the term project as a group project addresses all of the benefits outlined in the introduction section of this paper. In particular, group projects mimic workplace situations students will be facing in the future. Most engineering students will go into an industry setting where they are part of a team and as a group are expected to organize their work, solve problems, and report their findings. The group term projects also allow for a more challenging, multi-faceted topic to be addressed. In the case of multi-disciplinary classes, researching a topic as a group allows each student to contribute a unique perspective. For example, chemical, materials, manufacturing, and electrical engineers would have different contributions to a paper on chemical vapor deposition. In terms of group formation, I have assigned the groups based on students with consistent time schedules and a mixture of academic background and major. I use a survey at the beginning of the term to determine this information. If the topic of the assignment is flexible, I let students choose their own groups based on projects that interest them.

The biggest fear that I have in assigning collaborative projects is individual accountability in terms of grading (and student learning). There is a chance that some students will under perform and benefit unfairly from the work of the group (or vice versa, some students grades will be reduced by the lack of effort of their group members). Group accountability exists in the real world, an individual is judged by the outcome of its' team, and a company is judged by the overall performance of its' groups. However, individual accountability in terms of performance evaluations and special recognition also exists in industry. With this thought in mind, I structure the grading of collaborative term projects in my classes with about a 50% group grade and a 50% individual grade. I require them to indicate who prepared what sections of both the oral and written reports. In their group grade, they are marked down for evidence that they did not work together (the report did not have a standard format, some sections of the report were not properly proofread, they ran out of time in the oral report indicating the sections did not practice together, etc...).

Students also have the same fears with group term projects. They do not want to work with students who are under performing. Oftentimes, students do not know how to manage a group. In order to make group projects more effective, I give guidance in terms of group dynamics and effective meetings. I have the project divided into smaller sub-projects so that the groups start meeting early in the term and their meetings have clear purposes. Some examples of this are to have assigned deadlines for a proposal, a literature review, a detailed outline, a draft of the report, and a final report. (I don't grade all these assignments. They are mainly to keep the groups on schedule and working effectively together.)

The group should also clearly assign to each member technical and non-technical roles. I have students state in their proposal what sections each student will be investigating. Using the chemical vapor deposition example, students may divide the project up into kinetics theory, equipment issues, materials problems, and current research topics in industry. The students are also required to divide up the peripheral tasks of running a group project by assigning roles to each team member. I suggest roles such as leader (who keeps track of the participation of all members and helps to motivate students), scheduler (who plans the meetings and sets the agendas), time keeper (who keeps the meetings and the overall project on schedule), and coordinator (who sets the format for the reports and coordinates the individual sections). I use a

mid-semester survey that the group fills out together to encourage dialogue on the group's dynamics. I also have them generate a chart of what each member has contributed as a subtle way to confront students who are under performing.

CONCLUSIONS

Collaborative learning exercises allow students to become actively involved in the lecture, improving student learning and overall student retention. The exercises, coupled with the proper guidance on teamwork, give students experience that will be critical in their future engineering careers. I have used in-class problem solving, informal study groups, and group term projects in my classes. The main concerns I have dealt with in introducing these exercises into my teaching are time taken away from traditional lecturing, the logistics of forming groups and helping them to work together effectively, and individual accountability in both grading and learning. I have developed means of addressing all these concerns including reducing the material covered in lecture and assisting students to learn more from their textbooks, assigning roles to each group member to increase participation, and having individual and group components to the project grades.

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