

## **Active/Cooperative Learning: A Discipline-Specific Resource for Engineering Education**

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### **Introduction**

While general information on the use of active/cooperative learning (A/CL) in higher education is increasing, discipline-specific resources, especially materials for science, technology, engineering and mathematics education, are still relatively rare. A frequent comment from engineering faculty who don't use active/cooperative learning is that they don't understand how this form of pedagogy and classroom management strategies can apply to their subject or to their classroom. Too often these strategies are brushed off with comments about them only applying to the "softer" subjects taught on the "other side of campus" – but certainly not to the rigorous and complex technical subjects of engineering.

Reported in this paper is information on *Active/Cooperative Learning: Best Practices in Engineering Education*, an online repository of engineering-specific ideas, testimonials, and teaching strategies to stimulate and aid faculty in trying and adopting a different look, feel and performance for the classroom. While the project does contain some general information on A/CL, the bulk of the content is specific to engineering education, and was derived from interviews with engineering faculty on multiple campuses. Materials are organized so that they will serve as a useful guide to faculty who have never used cooperative learning, but will also provide sufficient depth that more experienced faculty and faculty developers may benefit from them as well. The CD contains essentially the same content as the website, but will be provided to those whose Internet connections will not easily access large video or audio files.

*Active/Cooperative Learning* was developed by the Foundation Coalition<sup>a</sup> through the Center for Research on Education in Science, Math, Engineering, and Technology (CRESMET) and The Center for Learning and Teaching Excellence (CLTE) at Arizona State University. The project was funded by the National Science Foundation<sup>b</sup> and highlights the success of Foundation Coalition engineering education reform activities on multiple campuses. The participating faculty represent the disciplines of Chemical and Materials, Environmental and Geodetic Science, Computer Science, Bioengineering, Mechanical, Industrial, Civil, and Electrical Engineering, and come from the campuses of Arizona State University, Ohio State University,

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<sup>a</sup> Foundation Coalition members are: Arizona State University; Rose-Hulman Institute of Technology; Texas A&M University; University of Alabama; University of Massachusetts, Dartmouth; University of Wisconsin, Madison

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North Carolina State University, Purdue University, Rose-Hulman Institute of Technology, Texas A&M University, University of Alabama, University of Minnesota, and University of Oklahoma.

The website is organized into six sections. The first section presents an overview of the differences between A/CL and traditional group work, and the rationale for its use in engineering classrooms. Sections two through four provide faculty insights and recommendations preparing students for teamwork, planning lessons and activities, and implementing and assessing active/cooperative learning. Section five presents actual lessons and activities developed by participating faculty. The final section includes faculty profiles and interview transcripts. This paper loosely follows the organization of the website: we provide an overview of the use of active/cooperative learning in engineering education and then summarize and annotate the Foundation Coalition faculty members' suggestions for preparing students, planning lessons, and implementing active/cooperative learning in diverse settings.

### **Overview of Active/Cooperative Learning**

Reform in engineering education has been of concern to programs across the country for over a decade. An important goal of reform is closely aligned with the more general goal of improving the performance of American college graduates in mathematics and the sciences. Don Evans<sup>c</sup> summarized the issue in these terms:

... U.S. students are not doing very well compared to other countries. We could argue about how far we are behind everybody else, but it turns out that our students really don't learn the things that we think we are teaching. So, there is a big movement, especially in science and mathematics education, to do what is called inquiry-based learning. This lets the student generate the question, become curious about things, lets them deal with some topic before you do a lecture on it. Part of that is to get the students to work together and talk to one another.<sup>1</sup>

Methods for getting students to work together to solve problems are growing in popularity, but undoubtedly, the most common instructional strategy used in higher education is still the traditional lecture. A traditional lecture is a highly efficient means of presenting a large amount of information to a large number of people. However, simple presentation of information guarantees neither that the ideas and concepts transmitted can be meaningfully integrated into students' existing knowledge, nor that they can be generalized to new problem. Thorndike long ago recognized the limitation of the lecture model: "The commonest error of the gifted scholar, inexperienced in teaching, is to expect pupils to know what they have been told. But telling is not teaching."<sup>2</sup>

A number of instructional strategies are currently being practiced and promoted in higher education as a means of overcoming this limitation. They include (but are not limited to) cooperative learning,<sup>3,4,5</sup> case teaching,<sup>6,7</sup> classroom assessment,<sup>8</sup> and writing across the

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<sup>c</sup> Throughout the paper, we use faculty participants' full names followed by the reference number for the website (<sup>1</sup>) when quoting directly from their interview transcripts. All of the full transcripts are available on the website at <http://clte.asu.edu/active> under the "Participant Profiles" link.

curriculum/writing to learn.<sup>9</sup> These strategies fall under the general rubric of active learning. While many faculty use the terms active learning and cooperative learning interchangeably, Richard Felder draws an important distinction between the two:

Active learning is anything in which students do anything in the classroom but watch me and listen to me—if I am the lecturer. They're talking to each other. They're writing things, reflecting, trying to solve problems.... they may be doing it individually, and they may be doing it together.... Cooperative learning is a much more formal kind of activity. I use that for exercises—usually homework, or projects—where students are working in teams that stay together for extended periods of time.<sup>1</sup>

Cooperative learning, as we define it for the *Active/Cooperative Learning* website, is a formal instructional approach in which students work together in small teams to accomplish a common learning goal. It is important to understand that cooperative learning is fundamentally different than simply asking students to work together to complete a task. The first difference is that, in cooperative learning, students are working in teams, not groups. A team is "a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable."<sup>10</sup> In the cooperative learning classroom, the instructor is responsible for forming teams and providing those teambuilding activities that are needed to ensure that the teams have the skills to work together effectively.

The second is that the task they are assigned is a learning task (which may or may not involve a formal product), and that task has been carefully designed by the faculty member to be suitable for teamwork. At the heart of this design are positive interdependence and individual accountability. Positive interdependence means that the successes of team members are linked: if one succeeds, all succeed, and if one fails, all fail. Unfortunately, many faculty develop interdependence only by the use of a common grade for a single team product, whereas experienced practitioners of CL focus more on learning goals. They stress that all team members are responsible for helping each other learn.

Positive interdependence must be balanced by individual accountability. In a cooperative learning activity, the faculty member puts in place mechanisms by which individual team members may be held accountable for contributing and for learning. These may include simple strategies like calling randomly on students to explain their team's answer to a problem, or more complex strategies involving peer assessment and feedback.

Whether using more informal active learning strategies or more formal cooperative learning strategies, a course that includes active learning requires different preparation, implementation and assessment than a course that relies primarily on lecture.

### **Preparing Students for Teamwork**

It is important to prepare students for teamwork by setting the climate, forming teams and conducting teambuilding activities. Some faculty are initially reluctant to undertake these activities; those we interviewed told us that the time involved is well spent.

*Setting the climate.* While many students are enthused about the opportunity to learn with and from their peers, it is not uncommon to encounter students who are reluctant to participate in any sort of group activities. This reluctance could be due to a preference for working independently or due to prior bad experiences with poorly designed group projects. Many engineering students have previously been highly successful working independently in a traditional classroom; “changing the rules” may be particularly threatening to these students. Providing students with a positive experience with and explicit information about active/cooperative learning right away helps to overcome reluctance and start the class with clear expectations.

Karl Smith<sup>1</sup> stressed that demonstrating the power of active learning on the first day of class is far more effective than talking about it. He recommends having students to come up with ideas for solving a problem individually, and then giving them a similar task in which they solve a problem in groups of two or three. They quickly come to the realization that “When we interact with one another, we build on one another’s ideas; we come up with more ideas and better ideas.”

Susan Urban starts her class with a slightly different activity:

At the beginning of the semester, I always do an exercise when I first put them into groups.... where they identify why they don’t like working in groups.... they’ve all had bad experiences.... We identify and list those on the board, and then we do another cooperative exercise on what’s good about working together in groups. It helps them at that point to identify the good things about learning from other people, and about making use of the strengths of different people in the group. <sup>1</sup>

Whatever the strategy for introducing A/CL, all faculty involved in the project agreed that the rationale for using active learning shouldn’t be a mystery to students.

*Forming teams.* Teams in the cooperative learning classroom are best formed by the faculty member. Self-selected teams are usually be composed of groups of students who all have similar skills and therefore may be lacking the requisite skills to complete particular tasks or assignments. Such teams are often be composed of individuals with similar academic achievement, while a range of academic achievement would better ensure that all teams will acquire the knowledge and skills needed for success in the course. Finally, self-selected teams are almost always comprised of students of the same ethnic group or of the same national origin, when it would benefit students to learn to work with a diverse range of colleagues.

Instead, teams should be heterogeneous. Darwyn Linder, a social psychologist who has worked with the Foundation Coalition on strategies for helping students develop team skills, explained,

I think the most important thing [in forming teams] is diversity... along a lot of dimensions. You certainly want diversity in terms of academic talent and preparation. You don't want all of the ‘A’ students forming teams and leaving [out] all of the challenged or less well-prepared students. And that's easily justified, because the students who are more advanced actually learn more by helping the students who are not as far

advanced... Gender diversity, attitudes towards school, towards the course [are also important]. I just try to avoid allowing people to form together in little kinds of cliques that mutually support misperceptions or dysfunctional attitudes. Forming [teams] at random is one way to do that, but often I will look very carefully at the dimensions of diversity in the class and then try to put teams together that are structured so that we have different kinds of people working together.<sup>1</sup>

Other criteria for forming diverse teams include ethnicity, specialized technical skills, or professional experience. Faculty on commuter campuses may even use geographical location to ensure that getting together in study groups or project groups may be more easily accomplished. It is important to note that criteria for forming teams can differ greatly from class to class. For example, computer skills may be critical for accomplishing goals in many engineering courses, so in those particular courses, there should be a uniform distribution of computer talent among the teams. P.K. Imbrie shared his strategy for setting up teams in a problem-solving computer tools class:

I ask them about their computer experience, and I'm very detailed. [I use statements like], "I can get on the internet and play games. I read email. I can do spreadsheets. I write equations in spreadsheets." I take that information, I look at gender and ethnicity, and I look at the specific skill set that I want. And then I use those, initially, as the primary criteria for establishing teams.<sup>1</sup>

In some cases, faculty might want to use multidisciplinary teams; in others, mixing students with industry experience and no experience might be the most important criteria. Richard Layton commented that,

If I have a class like dynamics, where I have students from different disciplines, I'll make sure that those disciplines are evenly distributed among the teams, so that every team has an electrical engineering student or a computer engineering student on it.<sup>1</sup>

A/CL teams are composed of no more than five members. While the size of the team may be determined by a number of factors, such as the type of assignment, the layout of the room, or the equipment the team needs to use, Richard Felder noted that "Anything more than four is totally unwieldy."<sup>1</sup>

While faculty may use ad hoc groupings for very short-term, informal, active learning assignments in class, formal cooperative learning teams are more stable. Some practitioners find that changing team composition no more than twice during the semester is beneficial, or only once if working on extensive projects. Darwyn Linder summed it up as "... there's not a pat answer here. If you have a class where there's a semester-long project, then semester-long teams make sense."<sup>1</sup>

*Developing team skills.* Teambuilding may be defined as "the process needed to create, maintain, and enrich the development of a group of people into a cohesive unit."<sup>11</sup> Teambuilding exercises are very important in the development of teams that will work together for an extended period of time on a complex project or a series of activities. Minimally, teambuilding should include

structured opportunities for team members to: 1) get acquainted and become cohesive as a team; 2) become aware of their interdependence (how each team member's success is tied to the success of the other members); 3) develop roles and norms for cooperation; 4) learn to communicate and resolve conflicts effectively; and 5) reflect upon how well they work together.

Many engineering faculty are reluctant to conduct teambuilding activities in class. Few faculty in any disciplines outside of social psychology, communication, or management have been taught to conduct such activities. Faculty also fear that time spent on teambuilding is “wasted” because it takes time away from course content. Veronica Burrows pointed out that teambuilding activities can actually enhance course content when carefully designed:

In the freshman engineering class there's an activity called "the professions of engineering and construction," where students are required to go research their field of study-- what it's like to have a job in that field. Then they are put into teams and present that to each other. And that serves as a team builder in itself because they talk about why they chose the profession, what they like about the profession, and their future in the profession.<sup>1</sup>

### **Planning A/CL Lessons**

Even when teams are carefully formed and students are well prepared for working together, designing effective A/CL activities can be challenging. The Foundation Coalition faculty we interviewed offered a wealth of suggestions for getting started in this new approach, for using and adapting pre-designed cooperative learning structures, and for planning activities “from scratch.”

*Getting started with cooperative learning.* As with any instructional strategy, planning for active/cooperative learning classroom activities begins with looking at the knowledge and the skills that students should develop as a result of the lesson. If A/CL is appropriate to that development, then the task of creating effective team activities begins. Well-designed team assignments give students a specific task, such as solving a problem, creating a model, or comparing and contrasting. To a certain extent, they also provide a set of instructions or guidelines that describe how students should work together. Finally, the lesson should include some sort of class-wide debriefing or closure activity in which students are randomly called upon to present the team's work. This helps to both build in individual accountability for participation and to ensure that all students understood the material and are ready to work with it independently.

Our faculty didn't all agree on how preparing for an A/CL lesson differs from preparing a lecture. Eric Guilbeau said that he found preparing for a traditional lecture more difficult than planning for A/CL:

I always have felt that the lecture preparation was a little bit more intense, and I tend to spend more time preparing for a lecture. I live this kind of schizophrenic life of being a university administrator—trying to maintain an activity in the classroom and then [being] involved in administrative activities. When I have a lecture format class to teach, or when

I used to teach using the lecture format, it was much more challenging to find a block of time before the class to get things organized. In the cooperative learning format it is easier, because you need to know what your learning objective is, and then you work with the students to figure out how to achieve that objective.<sup>1</sup>

On the other hand, P.K. Imbrie noted that he finds it more time consuming both to prepare for and carry out A/CL activities:

The goal in my mind is always to present things in an active, cooperative, collaborative way. But when pinch comes to crunch, and I'm coming up on a test date, then I will start adjusting that, saying, "Okay, I've got to go a little bit more to lecture mode."... If I'm teaching a course for the first time, and I don't have it all planned out in its nth degree, then I find myself moving to lecture mode more often, simply because I'm afraid if I don't say it, then they're not going to get it—even though I know there's no correlation between those two things.<sup>1</sup>

*Using pre-designed structures, strategies, and procedures.* Many faculty are introduced to active/cooperative learning through the use of pre-designed strategies, such as Think-Pair-Share,<sup>11</sup> Jigsaw,<sup>12</sup> or Academic Controversy.<sup>3</sup> These strategies have been developed by researchers and practitioners of cooperative learning, and have been used successfully in a variety of courses for a number of years. They are convenient to use, in that they are content-free. For example, if using Think-Pair-Share, one could have students think about how to solve a problem related to dynamics, statistics, materials, or any other content before pairing up with a partner to discuss the relative merits of their approaches, and sharing their ideas with the class as a whole. Jim Morgan told us,

I use Think-Pair-Share a lot. In fact, if you poll my students, I think they will tell you that the only thing we do is Think-Pair-Share in class. . . . I think that's because I was a reflective learner and so the "think" part of Think-Pair-Share is very important for the students who might be like I was and [who might] need some time before they're willing to talk to their classmates.<sup>1</sup>

A number of our faculty also mentioned Jigsaw as an effective way of having students divide up the responsibility for learning new information. Teri Rhoads uses Jigsaw to introduce new topics in both her graduate and undergraduate quality engineering courses. She explained that that "I use Jigsaw whenever I would like to cover multiple topics, usually from more recent publications."<sup>1</sup> After reading the article(s) on their assigned topics, students become the team's "expert" in that topic and are responsible for teaching the other teammates what they have learned.

Both Richard Felder<sup>1</sup> and Darwyn Linder<sup>1</sup> spoke highly using pre-designed methods as particularly useful for faculty who are just beginning with A/CL. Karl Smith<sup>1</sup> also acknowledged their utility, but expressed concern about relying solely on using pre-designed strategies without acquiring a full understanding of their underlying conceptual base. For example, faculty who don't understand basic principles of A/CL may have difficulty refining an activity that does not go as planned.

*Designing activities “from scratch.”* While the use of pre-designed A/CL structures is very useful, often, there really is no pre-designed cooperative learning strategy that fits well with particular content called for in the curriculum. Think-Pair-Share, for example, would not be an appropriate strategy for having a team undertake a complex design project. When our faculty and experts talked about designing A/CL activities from scratch, they emphasized starting with goals and objectives (what students should know or be able to do at the end of the activity). The problems or questions assigned and the cooperative process for working through them should help all team members acquire this knowledge or these skills.

Terri Rhoads described how she goes through the process of designing lessons and activities:

I go backwards. I figure out where I would like them to be at the end, and I reverse engineer it. That’s how I like to think of it... I try to step back and see what technique will take the students along the path that would place them where I would like for them to be at the end. [Often] I find myself combining a couple of techniques or just coming up with something new.<sup>1</sup>

A common theme throughout all our interviews was the importance of paying careful attention to the instructions given to students. The use of specific roles within the teams was also emphasized by most of our participants. Jim Morgan told us that,

All of our teams are told that they have to have roles. We give them several required roles. . . . They have to have a “meeting coordinator.” We don’t call them “team leaders” because Aggies [students at Texas A&M] interpret the word “leader” in a disruptive way, as far as the team function is concerned. They have to have a “timekeeper” and they have to have a “recorder.” We tell the students that, during the first part of the semester, they have to rotate the roles, and some of roles have to continue to rotate, mostly because of my own biases. No one can be the recorder forever.<sup>1</sup>

It is interesting to note that most of our faculty commented that the use of A/CL isn’t incompatible with lecture. Ron Roedel’s approach is one shared by many of the faculty we interviewed:

What has worked extremely well for me is to blend a little bit of lecture with a lot of cooperative learning... I’ll usually begin—I think they call this the Bookends method—with a small lecturette—five minutes, maybe three minutes—just setting the stage so that everyone knows the direction I want them to go. Then I will assign a task that needs to be done in class by the students themselves. I’ll check for understanding to make certain they know the direction I want them to go. They will work on this for ten, fifteen, thirty minutes—whatever the appropriate period is. We’ll stop. I will call on teams at random to report what they’ve got. Then I’ll be the Greek chorus, and I’ll comment on what that team has done, and on whether I thought it was successful or unsuccessful, or if it could lead to something right, or if they are going down the wrong path. And then perhaps [I’ll] show a few more hints, some suggestions, some paths and directions to follow. Perhaps



ask for other students' comments at this point and then let them work some more. Then, finally, [I'll] wrap up the class again with another little lecturette to produce closure.<sup>1</sup>

Another common observation was that once faculty decide to start using active/cooperative learning strategies in their classes, they often find themselves using them more and more frequently. As Russ Pimmel explained,

If I'm teaching a regular course, like digital systems or computer architecture, I plan on building in [cooperative learning activities] periodically—two or three per lecture... so, when I get to the end of a topic, I'll stick an exercise in there. When I'm doing a transition, I'll put something in there to get them involved. Like I say, I'm a real believer now, and ten minutes [of lecturing] is a long time, twenty minutes is a real long time, and fifty minutes is beyond infinity.<sup>1</sup>

### **Implementing A/CL**

Just as planning A/CL lessons is different than planning for a lecture, so is the management of A/CL classes. Our faculty stressed that they had to learn classroom facilitation skills, and consider new approaches for assessing student performance. They also frankly discussed the pitfalls of managing out-of-class projects and working with large classes.

*Facilitating in the classroom.* Faculty who are new to A/CL are often uncertain about what they should be doing while their students are working in teams. Don Richards' approach is shared by many of the faculty we interviewed:

Typically... students are working the problem, and I'm walking around the room and listening to what their problems are, what their misconceptions are. Many of them will take that opportunity to ask me a question about a misconception. I can then either stop and clarify for the whole class or I can just answer that question and move on to another group. When you do cooperative learning, you don't turn the students off and walk away.<sup>1</sup>

Susan Urban added, "If I just gave them a problem and sat there and didn't do anything, I don't feel like I'd be doing my job. Part of doing cooperative learning is being actively involved in the classroom while they're working on problems."<sup>1</sup>

Opinions differed slightly as to how and why a faculty member should intervene when teams get off-track. Cesar Malave explained, "I have a tendency to intervene. Especially if I think they might be leaning towards the wrong answer. I listen first, and I intervene only if I see that the team cannot solve the problem and when... they are frustrated to the point that their learning now is going to be affected."<sup>1</sup>

On the other hand, Jim Morgan said,

I don't intervene, except occasionally. If there's someone that doesn't seem to be engaged in the process of the team, I will pull them aside and ask them how are things going with the team and where they are. That's more of what I would call [a check on] individual

accountability, where the students need to know that I want them all to be participating and I want them to believe that I'll notice whenever they aren't. <sup>1</sup>

Styles of intervention also differed. Greg Raupp told us,

If they are off task, I will remind them that they are off task. Usually though, however, when I do that, I will do it by going off task with them first. They will be talking about the Coyotes game, and I will say "Yeah, I can't believe how bad the power play was." I'll go ahead and talk about the Coyotes game for twenty seconds, but then I will say, "But we're off task," and get them back that way.... It's steering for sure, but it's not a real abrupt steer; it's a subtle steer. <sup>1</sup>

Many faculty who are new to A/CL have concerns about how much time to give students for team activities. Veronica Burrows suggested that,

You need to put very tight time constraints on them. Most cooperative learning exercises are successful, despite the fact that the students will almost never complete them—to the students' satisfaction—in the time allotted. Giving them a tight time schedule forces them to stay on topic; it forces someone to play the role—either that you designate them in the role or they choose that role—of timekeeper and resource manager. When you don't have that time pressure, they seem not to perform so well. <sup>1</sup>

Jim Richardson added:

...one thing I learned very quickly is that if you don't have a deliverable at the end of the time period—if you just say, "I want you to discuss this or brainstorm this topic or work on this problem"—then they quickly learn they can talk about football or whatever until class is over and then walk out. And so I say, "You've got ten minutes, and at the end of that ten minutes I'm going to pick a team at random to come up and present their results," or, "I'll call on a team member at random to explain what you talked about," or, "You've got to put your calculations on this sheet." . . . what I've found is that the deliverable [itself] is not really so important. It is the fact that . . . I asked them to give me something. And that comes in handy with the next exercise I have, because then they'll take it seriously, and they just won't talk about the weather. <sup>1</sup>

*Assessing student learning.* The end-of-class debriefing session is a critical means of giving students immediate feedback on their learning, but faculty are always required to provide students with more formal assessments: grades. Grading in the A/CL classroom can differ from the more traditional classroom in two ways. First, faculty in the A/CL classroom must decide whether or not to grade or assign points to in-class activities. This decision is usually relatively simple. Many of our faculty told us that they don't grade in-class activities at all; others grade a random selection of in-class assignments. More rare are those faculty (usually those with teaching assistants) who grade all in-class activities.

A second related, but more complex decision is how and if to use group grades. Group grades are one of the more controversial aspects of active/cooperative learning. As Karl Smith<sup>1</sup> noted,

group grades are *not* an essential part of the A/CL classroom. Some faculty regularly use active/cooperative strategies in class to help students process the course content and acquire problem solving skills. These in-class activities are not graded; grades for homework, exams, or papers are given to individuals just as they would be in a lecture-based class. On the other hand, engineering students are regularly expected to work in teams on design projects. In such a class, it would be difficult to use a purely individual grading scheme. Cesar Malave mentioned that finding an appropriate balance of groups and individual grades is something that each faculty member has to experiment with and work out for him- or herself over a period of time:

I have tried all percentages. I have gone from fifty percent teaming to ten percent teaming. I thought that the fifty percent was too much in my classes. The problem that I had was that you could have a student fail the individual part and still pass the class. Now, usually twenty to twenty-five percent is teaming. If I have a project in the class, the percentage will be a little bit higher... in my experience, twenty to twenty-five percent is enough that it will make the students be serious about the team and is not that much that the free rider [can] pass the class without passing the individual component of the class.<sup>1</sup>

P.K. Imbrie agreed that a mix of individual and team assignments is important:

In general, I always try to make my class have a large enough teaming component to the grade that they want to engage in it, but not so large that their grade would be devastated should their team be totally dysfunctional. In that vein, I don't have any team exams; I just have individual exams. Projects are always done as a team. I have both individual and teaming homework assignments and their labs are always done as teams.<sup>1</sup>

*Out-of-class projects.* The most difficult kind of active/cooperative learning activity that faculty can undertake is an out-of-class design project. When students meet (or don't meet) outside of class, it is much more difficult to monitor their progress, give them feedback about their performance, and resolve difficulties as they arise. Without careful attention to the design and management of these projects, it is sometimes possible for teams to let one student do all the work, or for teams to simply divide a project, work on the sections independently, and paste them together the night before it's due. Besides the hard feelings that can occur, students often don't learn the content or skills that the project was meant to teach them.

We asked our experts and faculty for advice on setting up out-of-class projects. They first noted that it's important to think carefully about why you want students to work together outside of class and what the major logistical problems might be. Veronica Burrows, cautioned that

Because we're a commuter school (Arizona State University), students may live very far away[from each other], and it's just unreasonable to expect them to get together for extensive out-of-class work. So when I give them a project, there's probably a lot more flexibility in terms of time and tasking, and I provide them technological tools for enhancing their ability to work together.<sup>1</sup>

Most suggestions from faculty fell into two categories: how to prevent problems and how to intervene if problems occur. Suggestions for preventing problems included having teams develop

a code of conduct and agreeing to hold each other accountable to it, establishing frequent checkpoints along the duration of the project, and setting up a peer evaluation system before the project begins.

When faculty learn that problems are occurring in one or more teams, Richard Felder<sup>1</sup> recommended that they consider intervening by having the full class brainstorm some strategies that all teams could use for resolving conflicts. Alternately, P.K. Imbrie told us that he is willing to facilitate a problem-solving session for a particular team:

I do not talk, and I advise my teaching assistants not to talk, to *individuals* on a team that is having problems. I ask them to forward their names and e-mail addresses to me, and then I ask the team as a whole to meet to talk; and I go through facilitation with them. I have really specific things that I do. The first part of it is all written, and I explain to them that they do the writing because I don't want them to change their answers as they hear what other people have to say. I ask them (1) What are their goals for the semester? (not just "coming to class"), (2) What are their goals for the class? (3) What are their Plus/Deltas toward their goals for the class and semester? And then I have them bring their Code of Cooperation. I ask them what they have individually violated on their Code of Cooperation. And then I ask them to write down the elements of their Code of Cooperation that each other member of the team has violated. And then we just start a Roundtable type of discussion, where we generally find that they've either misunderstood or misrepresented—that they didn't really hold one another accountable to their Code of Cooperation. Or that one person violated one thing, so someone else thought they could violate something else, and it just kind of started from there.<sup>1</sup>

*Working with large classes.* The Coalition faculty that we interviewed teach classes that range from 20 to 400 students. All agreed that active/cooperative learning can be done in classes of almost any size. Richard Felder commented that A/CL is especially important for large classes, where getting students engaged is usually a challenge:

The larger the class the more imperative it is to use cooperative learning and active learning. Active learning, getting students to do things in small groups in class, is the only conceivable way to get large-scale student involvement in a class. Some students will be willing, in a class of fifteen or twenty, to ask questions, or, if you ask questions, to volunteer answers. It is a very, very rare student who is willing to open their mouth in front of 299 classmates and risk looking foolish. We can make all the speeches we want about how there is no such thing as dumb questions, but forget it. They are not buying that, and they know that [with] any question they ask that there is a risk that it could be a dumb question. But there is nothing threatening about talking to two other people in a small group, and so really the only difference between a class of 200 and a class of twenty is you have ten times as many little groups working.<sup>1</sup>

Our faculty did note that sometimes adjustments have to be made for class size. For example, Cesar Malave told us that,

I think that when the class size is smaller, you can do more of the complex structures. For example, I have a hard time doing a Jigsaw with 100 students. I have an easier time doing a Jigsaw with thirty students... I can have a lot more [team] presentations when the class size is smaller, and I find myself doing a little bit more lecturing, more than I should, in large classes.<sup>1</sup>

Russ Pimmel agreed:

You can give a smaller class more obtuse, complicated problems because you can go around and help them a little bit. With a big class, if things aren't going right, you have to stop the whole thing and start over. So that's a big difference. And maybe it's the level of the students, too, because the bigger class is a lower-level class, so those students are not quite as intellectually mature and experienced.<sup>1</sup>

## Conclusion

We asked the Foundation Coalition faculty why they became practitioners and proponents of active/cooperative learning. We conclude with three of their responses that point to the many benefits of creating an active learning environment.

Jim Richardson:

[Last semester] I had the students design a model of a sports arena roof. That's where the real interesting structures occur: in long spans like the Georgia Dome. They had been working cooperatively all semester long. I was a little nervous as to what I was going to get, and we had our presentations, and I was sitting back there, and I was just on a high. [There was] so much imagination and creativity. It really was rewarding. And you know, the thing was, the students didn't really think they did that good of a job. But I've been teaching the class for twelve years, and I was amazed at the creativity and energy that I got out of that last project. It never would have happened with a traditional class.<sup>1</sup>

Jim Morgan:

The most important thing that we have to do as faculty members is helping students learn how to learn—or, another way of saying it, preparing them for this idea of lifelong learning. Through a traditional lecture class, we teach them how to be stenographers, and to go memorize whatever it is that they have to memorize, and to regurgitate that on an exam. In the active, cooperative classroom, students actually have to learn how to learn, because they have to learn how to communicate their ideas to other individuals while they're in that teaming environment. I think that's what this is all about.<sup>1</sup>

Ron Roedel:

All I can say is that I believe I am a much more effective teacher now with the cooperative learning method—and I thought I was a very effective teacher beforehand. I believe there has been a step up in my productivity and my ability to help students learn,

and it is not a technique I intend to abandon. It is probably the most worthwhile thing I've done in my twenty years of being an educator.<sup>1</sup>

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## **Biographies**

Susan Ledlow is an Instructional Professional at the Center for Learning and Teaching Excellence at Arizona State University. She has been a teacher in K-12, adult education, community college, and university settings for 22 years and has been involved in faculty and staff development for 17 years. Susan's work at ASU involves providing workshops, seminars, and one-to-one assistance to faculty in implementing active learning strategies, especially cooperative learning and case teaching. She also has expertise in team facilitation, course and curriculum design and revision, grant-writing, and classroom assessment. One of the most rewarding aspects of her job is teaching Rookie Camp, a seminar that introduces new faculty to resources and strategies for teaching and learning at the university. Susan's academic discipline is social psychology. Her current research projects include investigations of cooperation and competition in social dilemma analogs, women's status from an evolutionary perspective, and contextual influences on individualism and collectivism. She particularly enjoys combining her research with teaching each semester by involving undergraduate research assistants in her projects.

Janel White-Taylor is an Instructional Professional at the Center for Learning and Teaching Excellence at Arizona State University. She has a Ph.D. in Educational Media and Computers. Her research interests include intrinsic motivation, learning environments, and educational technology. Janel's experiences include creating educational web-based learning environments, computer-based learning materials, and educational youth programs. She received a Bachelor's of Business Administration from Loyola Marymount University in Los Angeles, California. After completing her bachelor's degree Janel worked for Kraft, Discover and Habitat for Humanity in the business sector. She returned to Arizona and completed her M.E.D. and Ph.D. in Educational Media and Computers.

D. L. Evans is the Director of Arizona State University's Center for Research on Education in Science, Mathematics, Engineering, and Technology (CRESMET), an affiliation of the Colleges of Education; Engineering and Applied Science; and Liberal Arts and Sciences. Professor Evans received a BSME degree from the University of Cincinnati and a Ph.D. degree from Northwestern University in mechanical engineering. He has been a faculty member in the College of Engineering and Applied Sciences Department of Mechanical & Aerospace Engineering since 1966, serving for many years as the departmental Vice Chair and twice as the Interim Chair. He is the author or co-author of many papers in the fields of high temperature gas dynamics and solar energy. For the last 15 years he has been interested in education-related research and has published two text books and many papers in the field of engineering education. He was the founding Director of the Center for Innovation in Engineering Education (CIEE) in ASU's College of Engineering and Applied Sciences, and became director of CRESMET when it

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