

This interview with Eric Guilbeau and Vincent Pizziconi, Professors of Bioengineering at Arizona State University, took place on the campus of Arizona State University on February 23, 2001.

**Ledlow:** How long have you used cooperative learning, and why did you start using the techniques?

**Eric Guilbeau:** The person responsible for me getting involved in cooperative learning was Lynn Bellamy, a faculty member in the department of chemical and biomaterials engineering, who was very interested in total quality learning and applying the principles of Demming to improve the educational processes. He . . . encouraged a group of faculty within my department to attend a workshop at Rio Salado College. Then, following that, Lynn arranged a number of workshops with experts who came to the college to give us ideas about how to apply it and made us aware of some basic resources on cooperative learning.

**Vincent Pizziconi:** I was the “second wave,” introduced to cooperative learning through Professor Guilbeau and people in the engineering college who provided workshops on introducing those new concepts into the classroom.

**Ledlow:** Could you compare your experience using cooperative learning versus more traditional learning strategies—such as lecture—in terms of how your students have responded or just what the differences are for you as a teacher and students as learners?

**Pizziconi:** It is much more normal to have an interactive environment where students are working cooperatively on a project or a concept in the classroom than it is to lecture to them. That’s not how they will work after graduation. For cooperative learning you don’t necessarily have to prepare lecture notes in the traditional way, but you do have to plan for different activities. The real-time, active engagement of students in a cooperative way is a much more effective learning—it is not a one-way conversation.

**Guilbeau:** I agree with everything Vince said. Cooperative learning, more than the traditional lecture format, immediately builds a sense that the student is responsible for learning within the classroom environment. The side benefit, which I didn’t really appreciate as much until years after I started doing cooperative learning, is that it helps you deliver . . . skills [to the student] that otherwise would be totally lost in a lecture environment. For example, the students inherently work in teams, so they learn how to socially interact; and for engineering students that is particularly important, because many of them are not as extroverted as in some of the other disciplines. It also teaches them better oral communication skills. The courses that Vince and I worked together on had a public speaking component, and those skills come more naturally, I believe, in the cooperative learning environment than in a traditional lecture classroom environment.

**Pizziconi:** I agree with that.

**Ledlow:** You have already talked a little bit about how you learned to do cooperative learning, but can you say a little more about the skills that you needed to develop as a teacher? This is a different way of teaching, so what skills did you need to learn that you didn't or hadn't needed when you were lecturing?

**Pizziconi:** For the traditional lecture you basically plan out a set of concepts you want to teach the students. In cooperative learning you introduce a concept and then engage students in some kind of team activity. I have found the instructor skills are more [those] of planning the classroom versus having a set of lecture notes to get through by the end of the period. In cooperative learning you have to have timed events that take place, in order to achieve the objectives by the time we get to the end of the class.

**Guilbeau:** I will add to that, in my own personal case, when I prepared for traditional lectures, I was more concerned about being an expert on what I was going to teach. Most of my time would be spent making sure that I thoroughly understood the material and that I could communicate it in an effective way. In the cooperative learning environment you pay less attention to that, because you are kind of part of the team with the student, where you are going to be learning this material together. In the lecture environment I was far less willing to take risks and to talk about things that were kind of at the limits of my knowledge; whereas, in the cooperative learning classroom, I wouldn't hesitate to go into the class with something I had never done before, or I had no experience in doing, and offer up, "Okay, we are going to do this as a group and see if we can figure out how to make it."

**Pizziconi:** I would like to add that, once you allow yourself to be a little bit more vulnerable to the class, you narrow that gap of teacher versus student. You engage in open-ended kinds of activities, telling the student "I don't know the answer, but together we can map this out." It becomes like the real world, where you are really trying to achieve things that haven't been done before. They can learn and memorize, but now they can actually process information to achieve an objective. But when you can work with them to get an answer, that process is probably far more valuable than whether they know the raw material in a rote way.

**Guilbeau:** I believe it is also important that it lowers the barriers that prevent specific faculty members from teaching together. In the lecture format, where you are kind of the expert, the greatest fear would be to have a peer come in and hear you say something that is just absolutely wrong. In the cooperative learning environment the opposite happens. You are less concerned about the material you are delivering, because you are actually developing it in the classroom. It was not unusual, for example, when Vince and I were team-teaching a course using cooperative learning, for us to get into a disagreement within the class. That would have been heresy within the normal lecture environment.

**Pizziconi:** In fact, that happened about two weeks ago. We were in a bioengineering introduction course, and Dr. Guilbeau asked me to come in to work with him on a lecture. During the class lecture, we got into this area that was controversial. I said, "I

am not sure I agree.” The students look at you and say, “What are they doing?” But it is not necessarily true that professionals always agree, and that they all know everything, and everything is black and white.

**Guilbeau:** They also learn that the problem-solving process is not as straightforward as it appears in the lecture process. In the lecture environment, if you are working an engineering problem, you have worked it out in advance. It might have taken you three hours to do it, but when you walk in the classroom, you present in forty minutes, as if anybody could do this in forty minutes. In the cooperative learning classroom it is a three-hour experience in front of the class. And the students then realize, “The problems I am struggling with present problems for others. It is not because I am inherently not intelligent—because apparently the faculty are intelligent—but it is simply because it is difficult material that requires a lot of analysis to get through.”

**Ledlow:** Do you explain why you are using cooperative learning to your students, or do you just start doing it?

**Pizziconi:** In general we tell the students [that] cooperative learning is a process to help them build a set of skills that the industry expects them to use. We work closely with Boeing Corporation that requires their engineers to be able to work in teams. We tell them that this is an important way of learning and it is a lot of fun—it is much more natural. We have now incorporated this into the classrooms in our college, because our industries tell us that this is the kind of way they want them to work on the job.

**Guilbeau:** Seven years ago, when I first started using cooperative learning, it was rare that a student had ever been in a cooperative learning classroom. We spent a lot of time explaining the philosophy, and explaining what they could expect as they started to work in teams, and how to actually improve their skills as a team member. Now in the college of engineering this is covered in the introduction to bioengineering class. This is a little bit more efficient, since we don’t have to teach it every time, but we do still remind students of what the philosophies were.

**Ledlow:** How do you set up teams in the classroom? What methods do you use to set up your teams?

**Guilbeau:** We used to spend a lot of time discussing how to do that. We looked at the GPAs of the students as a first pass at teambuilding, ensuring that every team had what we would consider a student who had achieved “A’s” overall in their studies to date. We would always include a student who was at the lower end of the GPA scale, and then we would try to add people in the middle range of the GPA scale. You can argue whether that is good or bad, but what we were trying to do was prevent an environment where all of the “A” students got together and all of the “C” students got together and, instead, create an environment where the “A” students could help us teach the poorer students, or those who might not have sufficient background. Once we had that process worked out, we began to try to maintain diversity within the groups by making sure that the groups were not all female or all male or all international students, etc.

**Ledlow:** Have you incorporated any sort of teambuilding activities into your teaching, and, if so, could you give some examples or explain what kind of teambuilding activities you have used?

**Pizziconi:** In 201 we did a lot of teambuilding activities. . . [We got] into issues in bioengineering that allowed the teams to come together on concepts that were not easily translatable—"in-black-and-white" kinds of things—but very gray areas. . . We were able to then implement or integrate tools of consensus building, brainstorming, consensus, how to resolve controversies.

**Guilbeau:** We tried to use. . . total quality management tools to show students that if they utilize these techniques, they could work efficiently in a team and accomplish more than they would expect to accomplish as individuals, in a shorter amount of time. That's the challenge, because the bright students of the team often reacted by saying, "Gee, I could do all of this by myself. Why am I being burdened with this team?" But using total quality management tools, they quickly realized that there were many things that the team came up with that they would not have come up with on their own.

**Pizziconi:** We used to set the stage with this notion that, if you are good, you can solve all the problems of the world, versus there are some, and many, issues and problems that simply cannot be solved by an individual—at least not efficiently. We usually go through team forming . . . relative to an individual performance—on forming, storming, performing. And at some point in time, the team that operates correctly with the right leadership and facilitation can easily exceed the parts, or the individuals—or the sum of the parts become synergistic. It is not automatic; there is a process. And we try to implement this in their training programs so they are able to do this in industry as well.

**Ledlow:** What skills in particular do you think are important to developing teams of engineers? So you are trying to prepare them to go out and work in an actual team, as an actual engineer—what sort of skills are you thinking that you are trying to emphasize in your teaching that would translate into their future workplace?

**Guilbeau:** Engineers are attracted to engineering because they have skills and talents in math, science. They tend to think quantitatively and analytically. So it is not hard to get them to do those things. What is harder for those students, often, are the communication skills and the social skills. Many engineering students are not as extroverted as other students, so getting them into an environment where they have to be like that is very important. It would be great if you knew, going into a class, who the introverted and extroverted student were, because that would help you form teams more easily. But when you are picking a group of four people, usually there is at least one extrovert in an engineering classroom.

**Pizziconi:** There are a lot of experiences involving how the leadership evolves, but eventually they understand that somebody has to take charge. But they are all responsible for the aggregate objective. And the interpersonal skills that Professor

Guilbeau mentioned are critical in working together, giving constructive criticism, being effective listeners—willing to step back and listen to any and all ideas—promoting other people’s capabilities, etc.

**Guilbeau:** We try to structure it where everybody had to act like a leader at some point, and everyone had to act like a recorder and be more focused on paying attention and listening to what was going on. In that type of team environment students learn to appreciate, more that sometimes, that being the brightest and knowing how to solve the problem is not as important as getting the work done. The student who actually puts the effort into the creating the report and submitting the materials on time may be just as important as the creative person who comes up with the idea but hasn't got the foggiest idea how to implement it. That never happens in the lecture classroom.

**Ledlow:** When, or under what circumstances, do you choose to use cooperative learning rather than another teaching strategy, such as lecture or case teaching or modeling and demonstration or lab . . . ?

**Pizziconi:** I use it in every class but don't do it all the time. I mix cooperative learning with traditional lecture and hands-on case studies. If I have a specific concept I want them to work collectively on, because it is a complex issue, I can build on what I've said in lecturates and see if they remember how teambuilding works. If they get stuck on something, I will say, "Remember the tool we used?" or, "What kind of tools would you use as a group to work through this?"—whether it is a brainstorming or some other activity. I do this in little parts, sprinkled through the semester, in other courses in upper division. I usually start off with individual projects [and] then set the stage for a group project. I ask them and remind them, "What was it about cooperative learning that you felt was worthwhile?" and see if they can choose, themselves, what other techniques they would like to use to approach that problem in a cooperative way. After a while, it becomes pretty automatic: "Let's go ahead and try to do this," and I usually have them decide on what kinds of team members they would like to work with.

Sometimes it works and sometimes it doesn't, but at some point in time they have to do this. We can't pick the teams when they leave the university. I have found this useful in upper-division classes, particularly in design classes, because in projects that are of large scale, the process requires design review— it requires input from many people in the process. These kinds of skills are very important in how consensus building occurs on a design of a product that takes years and much effort and lots of money. They seem to work pretty well through their process.

I actually took it to another level with a multiple, multi-district training program in which we bring students in from different disciplines—engineering, life sciences, physical sciences. . . . I introduced this concept of cooperative learning, and how to build a consensus on very complex areas that transcend disciplines, which really represents, at least in the technical world, much more what goes on in product development. The students have not seen these kinds of concepts as we do in engineering, or, if they have, it was from different kinds of venues. I have found that when we did, when we

mixed students from these different disciplines, the students were able to accomplish a fairly complex objective. This was group training on a high-level kind of graduate research project. At the graduate level I think it is a powerful technique, particularly as we get into multi-disciplinary training programs. It goes way beyond even individual degree training programs.

**Ledlow:** I think both of you mentioned earlier [that] preparing for cooperative learning is a little different than preparing for a lecture. Could you talk a little bit more about that? Is there more prep time, or how is it different than getting ready for a lecture?

**Guilbeau:** 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. I think it does require a little less preparation once you have learned how to master the cooperative learning process. But if you don't do it well, it doesn't work well. You learn very quickly that you do have to spend a reasonable amount of time [preparing for cooperative learning], but, I think, less time than [for] the lecture format.

**Pizziconi:** I agree. I think the issue is that . . . the timing is critical, particularly in limited class periods. You need to . . . incorporate that active learning process in a very timed way. If you keep it too loose, you will run out of time and not achieve the objectives of the class. . . . Once you have got it down, it actually becomes. . . easy to implement. In fact, it is much more normal. I find this to be a much more conversational kind of way to be able to instruct students in ways that are much more interactive—even for the instructor.

**Guilbeau:** I think Vince and I also found, when we were making this transition, that in the lecture format, the fifty-minute class is almost ideal in the engineering world. It doesn't work as well for the cooperative learning class. The longer, twice-a-week format, I think, gives you more time in the class for the kind of interaction you are looking for.

**Ledlow:** To help you get proficient did you guys start out [using], or do you still use, any pre-designed cooperative learning activities like Academic Controversy , Jigsaw , Formulate-Share-Listen-Create?

**Guilbeau:** When we decided to develop this new course together, we used a book that was written specifically on Creative Controversy and then used those strategies to design the course.

**Pizziconi:** We tailored it to controversies in bioengineering, and we picked global kinds of controversies that were complex enough that a team activity was clearly evident, as far as an approach. Many things that came up in these controversies reinforced the whole idea about consensus building and that not everything is that simple. It takes teamwork and communication [and] effective listening to get through different kinds of barriers. We used Force Field Analysis tools and these kinds of things that are very simple but [are needed] or the team gets stuck. In my experience working with the standards agencies for the federal government, I have watched how medical device standards get pummeled through the national level; and it takes years; and lots of people with vested interests, very different things that they want to get out of this standard, have to, somehow, agree upon the standard. You get the sense that this isn't easy and does not happen overnight. That is the real world we try to demonstrate with the students.

**Guilbeau:** Within the engineering curriculum, one of the things we have to do is build an awareness in students of social, legal, ethical, and economic issues that arise in the design of medical devices. And that is typically challenging to do. We have found that this Creative Controversy method was just excellent for that. So, as an example, if we were teaching the class today, we might throw out as a controversy, "Should stem cells be used," or, "Should research on stem cells be funded by the National Institutes of Health?" Vince and I would prepare an advocacy statement and a proponent's statement that gives a little background, but then it was up to the class to thoroughly research the topic and come into the classroom prepared to debate both sides. Following those debates, the students write a sophisticated case study analysis of the issue. Then we would force them to change their roles and promote the opposite side, using any techniques they wanted. It was incredibly rewarding to see what they came up with. In many cases they would tape interviews with people hundreds of miles away who were experts in the field and surprise their opponents by having this taped video. In one case a state legislator was brought into the classroom to take sides, and it was really a very, very fun experience to do in the classroom.

**Ledlow:** When you are planning these activities, how do you ensure that students are prepared and they are participating fairly equitably? Are you using any techniques like assigning homework to ensure preparation, assigning roles, giving particular written instructions as to how to proceed? What are some of your tips for planning an activity that really works successfully in the class?

**Pizziconi:** We remind them again of the basic tenets of cooperative learning and teambuilding. We remind them that there should be some kind of team leader, some facilitator. They should be able to decide on the roles that they can most effectively work to contribute to the goals. Sometimes I have them actually develop what we call a Gantt Chart—an activity-effort chart—of a team and its roles, including outside interactions—one of the biggest problems with cooperative learning—how they get together as groups outside of the classroom.

**Guilbeau:** We also tried to explain to students that communicating what special challenges each one of them has in managing the affairs of their life is a very important part of the team process. The worst mistake they can make is to let the team down by not participating. Even though they might have a perfectly legitimate reason for not participating, the team will hold them accountable for that in a very serious way. This is [to try] to convince them that, even with strangers, to have this free flow of communication regarding what their limitations are, and working to figure a way to compensate for that, so that they are perceived by the rest of the team members to be a contributing member.

**Ledlow:** I remember visiting your class once and [students were given] the objectives for the day and a real tight agenda—"We are going to spend x minutes on this and x minutes on that." That seems like a really wonderful classroom management tool. Could each of you talk about how you organized your classes, kept students on track, and made sure that the time was being used productively?

**Guilbeau:** Vince and I spent a lot of time outside of class preparing for each lecture, making sure there was a lot of structure to the class and that things were going to be achievable within the appropriate time frame. We prepared a very detailed initial list of topics and schedule for the entire class, showing the students from the very beginning everything that was going to happen in the class. Then we went through a series of four Creative Controversies that repeated the same process. After the first one the students knew what to expect, and it was very natural for them. Because we were also teaching them these quality learning tools, we had a lot of structure in terms of how they should use those tools—how much time they would have available to use those tools. For example, if we were doing a brainstorming affinity diagram, we would have PowerPoint slides that told them, "You have five minutes to do your brainstorming exercise, two minutes to do the affinity grouping of that exercise, and two minutes to report out." The students then learned that, if they structured things correctly within their teamwork, they could get things done in a fairly tight schedule in a given amount of time. It tended to work very well.

**Ledlow:** What were you guys doing while the students were doing their group work? That is always a common question.

**Pizziconi:** When we did this team type course, we were trying to see exactly how the groups were interacting, and sometimes we would talk about how the previous event occurred and whether we made the kind of impact we wanted. Then we would mingle with the groups and see how they were doing brainstorming. We would split ourselves up, and go to the different group tables, and see what they were doing, and interact with them.

**Guilbeau:** Interestingly enough, sometimes we were seated with groups trying to solve controversies that had arisen within the group as they were trying to these exercises—especially during the storming periods when groups weren't necessarily getting along well. Most of the time, however, we were carefully listening to what the group was

saying, then trying to interject helpful things that moved them along a little bit if they seemed to be stuck. If they were just going along great, we would interject something that made them stop and think a little bit about what was happening, to get even more creative.

**Ledlow:** A lot of faculty worry that when students are working in groups they are going to be teaching each other the wrong information. So can you talk a little bit about how you debrief teamwork, and make sure that the time has been productive, and [make sure] students got the right thing that you wanted them to get?

**Guilbeau:** In the class that Vince and I taught together there really was not anything that was the wrong information, because the types of issues that we were asking them to work on had no answer. There was no single right answer or wrong answer. In a more structured engineering class, where you are asking them to apply some principal of physics to solve a real problem, that is a much more challenging problem. In those types of environments I have always required the students to do their homework independently, rather than as a group, to ensure that each student really does understand what they are doing, and to make sure they haven't been misled by somebody else in the group.

**Pizziconi:** After I had this experience with Eric in introduction to bioengineering, I actually tried to implement this in a design course, with a project that came out of a local medical device company. They were doing an activity where they could actually listen to the engineers in the company on what was right or wrong, but the stakes were higher. It was not just a homework problem anymore; they were [working on] a project that was submitted by this company—actually a list of ten [problems]—and they decided which one they wanted to attack. I asked them to use cooperative learning tools, and we had the company project engineer come into the classroom and interact with them. What they were doing . . . was actually being supervised by those practicing engineers, and they got the real sense that those engineers didn't necessarily know the answer but they knew kind of what it should be. I think that was probably the best experience that I had in trying to integrate cooperative learning with a real-world situation. The stakes were high on both sides in this case—I think it was the epitome of what we wanted to accomplish in active learning.

**Guilbeau:** One advantage of the cooperative learning classroom is that it does give you the opportunity to not tell the student whether what they have come up with is right or wrong; whereas, in the lecture format, traditional engineering classroom, student work problems have answers in the back of the book. The faculty member double checks and makes sure the answer looks pretty good; then they do their homework or they do their exercise in class, and you tell them this is either right or wrong, right? It is really never right or wrong—just simply an answer that you get based upon what assumptions you make. The assumptions you make dramatically affect the actual outcome of the exercise. In the real world the experience is very different. The students' work may be in a team [or it] may be independently to come up with an answer to a real-world problem. Then they reach a consensus about whether or not this is right or wrong, then

decide to implement it or not implement it. Sometimes that implementation is catastrophic; most of the time it is not. But the first time they learn that, in fact, nobody is going to tell them whether what they do is right or wrong, [used to happen] when they went to work. Now, in the cooperative learning classroom it can happen. It is possible to have four groups working on a problem, come up with four answers, and then let the class reach a consensus about whether it is right or wrong. As long as the faculty member is fairly comfortable that they are using appropriate techniques, that is a good experience.

**Ledlow:** What are some tips that you have for ensuring individual accountability? How do you know that one student didn't do all of the work?

**Pizziconi:** We came up with a strategy that assured the individual accountability as well and the group accountability. We created a matrix that we gave to the students—each student—to evaluate each other in the team. When we graded their work, it was a project grade. And then, based on the team's evaluation of themselves, in a confidential way, we had basically a correction factor that could be greater than one or less than one. Whatever the grade was, say it was a ninety, if you were really doing above and beyond, or at least met expectations, you would get the same factor:  $1 \times 90$ . If you were much better than, the team really thought you pulled your weight, maybe you got a  $1.2 \times 90$ . If you weren't pulling your weight, you might have gotten a  $0.6 \times 90$ . I was surprised at how critical they were of each other, and how willing they were to say exactly what happened in that group if it was done in a confidential way. That really gave us a pretty good evaluation of what happened, and it also reminded the group that if they weren't going to work in a cooperative way, they were going to be accountable.

**Guilbeau:** We also kind of tried to depersonalize that process by posing a hypothetical situation. We would tell each member of the group that they were now a project leader, and they had worked with this team on the past exercise, and they now had from management a budget of \$100,000. They could spend this \$100,000 to pay the salary of anybody on their team to help them over the next project. They were to allocate what portion of that \$100,000 they thought should be spent on each of their team members, with expectation that those people they gave the most money to would be the ones they expected would participate the most. That was a very, very effective way of getting the students to quickly criticize or compliment their team members. A real high achiever who had done a great job on the past exercise might get \$30,000, and a low achiever might get \$10,000. It was very easy then to show that, if you got \$80,000, you were performing at about eighty percent. And it was also easy to see who was trying to manipulate the groups, because what would often happen was somebody who was slacking off would give themselves more money than they deserved, in anticipation that the rest of the group members would give them less. And, in fact, the rest did give them less. We could easily see what was going on.

**Ledlow:** Let's talk a little more about grading then. In your classroom what are you grading? Are you grading every time you do an in-class, problem-solving assignment?

Are you still doing individual tasks and combining that? How do you weight how much of a student's grade is individual and how much is team oriented?

**Pizziconi:** I have used it in different ways. I still do individual grading to see individual accountability; I do an in-class cooperative learning where I don't grade. I go to independent projects, and then I go to group projects. So in the aggregate of the course, the grading of the cooperative learning or the active learning part may be based mainly on a larger group project that has been built up over the semester and may be twenty to thirty percent of the grade on the large group project. And we usually have five to seven groups in our classes now.

**Guilbeau:** I think it does vary by the topic of the class. I tend to use the cooperative learning activities and group grading for those activities that are what I would refer to as open ended—that don't really have an easy single answer but could have many answers, depending upon what you choose to assume. A design project within the context of the class—a more structured heat-and-mass transfer class—works well with cooperative learning. That is balanced by having students individually accountable for shorter types of problem-solving exercises that they can do in a reasonable amount of time individually—that are what would be normally scheduled homework exercises in a lecture type class—recognizing that students outside of the classroom have been way ahead of us in cooperative learning for many years. This is especially true for engineering students, who, for years, have worked in groups to solve their homework problems.

**Ledlow:** Do you ever get feedback, from students or colleagues or anyone else, on whether or not a lesson that you have designed and implemented is successful? Do you every say, "Hey, how did this go?" or do you ever invite people in to look? How do you reflect on your success using this technique?

**Guilbeau:** This is formalized within the college of engineering; every class is evaluated. My experience has been that the students always provide very positive feedback about the cooperative learning experience, saying they liked it, then enjoyed it, and then found it helpful. We designed specific survey instruments to try to get feedback from the students. In that particular class, at the end of each class, the students were asked to write on a Post-it note what they liked most about the class, what they got out of the exercise, and what they would change about the class exercise.

**Pizziconi:** Plus/Delta.

**Guilbeau:** Plus/Delta worked very effectively, because we would look at those immediately after class and get feedback from the students regarding what we did well, what we did poorly.

**Pizziconi:** That worked very well because they realized that we were willing to work with them and that we don't have everything set—that we are in that process as well.

**Guilbeau:** It was done in a way that was confidential: we did not know which student was writing what on the Post-it note.

**Ledlow:** You have already said that you do have students do out-of-class projects and those are very often group graded with feedback. If you do get complaints though, do you go in and intervene? Do you talk to individual students who are supposedly “the ones causing the problem”? How do you deal with team conflict?

**Pizziconi:** I think all of the above—at least with an earlier experience in the introduction course, we had all that happen. We had some team members that were just not pulling their weight, and we would talk to the group at first about what the issue was. And then, if there was an individual that simply wasn't pulling their weight—if they weren't able to work with the team—they may have to do the project by themselves. That was usually a good wake-up call. In the worst case, I don't know if we have ever had that happen . . . somebody wound up actually working by themselves; but we clearly had that notion that they were going to be reprimanded, and eventually they may be expelled out of the group. They may be expelled out of a company if they do not pull their weight. I think we have had circumstances where we talked to the groups as a group, and as individuals, and we try to work with them, but there are issues that are unsolvable. Somehow that group just isn't coalescing, and that is not necessarily a bad result to have them see that.

**Guilbeau:** The most challenging experience was in this group where we were using the strategies we explained. And it turned out that one of the group members was a graduate student—high achiever—who really got into what was happening in the class. There was another student in the group who was kind of a senior-level student and equally talented and equally interested. The third member of the group was a young female student, who was a freshman or sophomore, who was a single mother trying to go to school part time. The fourth was a fraternity rat who just really had a totally different expectation of what he wanted out of the class. His goal, and the goal of the single mom, was just to get out with a “C.” The other two wanted to write papers that would be published in journals. After the first exercise the two high achievers just decided that they would just work on [their] own because they were really loving this—they just completely segregated themselves from the other two. We finally got the group together. We got the group to communicate effectively on what everybody's goals were, and the single mom felt really badly that she hadn't been able to participate properly and that she had been getting graded down by her teammates. She and the fraternity guy got together and said, “We will carry the load on the last project.” And the two high achievers said, “Oh, we can't jeopardize our grade that way,” and they said, “Don't worry, you won't lose your grade.” I remember they wrote this splendid report for the group. All of them had this learning experience, and I think it was a pretty profound learning experience that not everyone's life is [as] quiet and clean and orderly as yours.

**Ledlow:** Large classes are an issue for some programs. Is cooperative learning appropriate for different sized classes, or do the methods or strategies change

depending upon class size? Could you do some form of cooperative learning in any size class? . . .

**Pizziconi:** Our classes, to date, are not all that big. I think our average class size is maybe forty-five to fifty. But around there we have sensed that if you try to do cooperative learning in that level, you might have six groups or more, and the groups have four to six people. With so many groups going [that] you are trying to coordinate, there are issues as far as logistics in class size. A very large class size gets to the point of where it's stretching it.

**Guilbeau:** I have done it with as many as thirty-six students, and I think that is too many. In my opinion, six groups of four—twenty-four students total with two teachers—is the optimum way to [do] cooperative learning.

**Pizziconi:** It is just the opposite of a lecture class where you can, whether you are talking to one person or 500 people, you control the stage. Nobody is talking to you. It is really a different experience.

**Ledlow:** As you have gotten more skilled with cooperative learning strategies, what has changed? In other words, are you still doing the same thing at this point that you were doing seven years ago when you started? . . . Have you evolved as a teacher in the way that you do cooperative learning?

**Pizziconi:** I believe I have gone a lot more free form with cooperative learning. I try to build on the basic skills that [the students] may have picked up, in either the engineering design class or the introduction to bioengineering, and then I try to implement it in very different ways to combine cooperative learning with hands-on learning. The Millikin Foundation issued a report on hands-on learning that declared it by far the most effective way—at least in K-12 study. Our curriculum provides a perfect opportunity to bring hands-on and cooperative learning together, so it really reflects more real-world kinds of activity, where they get a project [and] go into either laboratories or computer environments where they are working on a real project.

**Guilbeau:** Vince has raised that to a higher level than a lot of people, mainly because he teaches the senior-level courses. When he is interacting with the seniors, by the time they leave his class they are thinking, "Okay, when I go out to industry and I have to form teams, who is going to be on the team, and how is this going to impact what I achieve as an industrial employee." This is really the end goal. The changes that I have made are that I have spent far less time teaching students the philosophy of cooperative learning, because I think they come into the classroom having already had an experience. I spend less time telling them how to work in teams, because they have learned that in lower-division courses. I am more concerned about individual accountability than I was when I first started teaching classes, and I worry a lot more about structuring-in individual accountability.

**Ledlow:** You guys are lucky in a way that there are other people in the college doing this. Students are arriving in your upper-division classes with some team skills. What about the person who is trying this in another college or university that is not as far along in implementing teaming as CEAS [College of Engineering and Applied Sciences] at ASU? Could you be doing what you are doing in your upper-division course if the students had not had that prep from their freshman classes and other classes?

**Pizziconi:** Clearly it would be re-inventing the wheel if they didn't have the prior introduction. ASU has been very progressive in implementing a very powerful tool in how we train people. Our experiences in upper division is we don't necessarily remind them, or go through the didactics of what this process is about, but . . . remind them of how this is useful and how we might use this process—not all the time, but is it useful for this particular thing. Now we work from a base now that is much higher and much more efficient.

**Guilbeau:** I have an administrative perspective from which I would like to answer that question. I think when someone starts using cooperative learning techniques in a department that has historically been using routine lecture, there is the possibility that some tremendous controversies can arise between individual faculty members. The first day that I was an administrator, for example, I had a group of thirty students walk into the class complaining about a faculty member who had been teaching in the department for almost twenty years—telling me he was a terrible teacher, that they were terribly bored in his class, and asking me what I was going to do about it. This is someone whose teaching evaluations had always been very [good]. This group of students had left a series of cooperative learning classrooms that were changing the paradigm. Coming into this teacher's classroom, immediately there was a conflict for the students between the more traditional faculty and the faculty who were doing more innovation. The senior faculty, doing the traditional things, feared that, in fact, standards were not being adhered to and the reason the students liked those cooperative learning courses was because they weren't as demanding; and, in fact, they started blaming every inadequacy that the students had on the fact that they had had these cooperative learning classes. It took almost five years in my department for those types of controversies to go away. In fact, it wasn't until a group of faculty retired that they disappeared entirely.

**Ledlow:** If another engineering faculty member came to you and said, "I am considering starting to use this cooperative learning stuff," what advice would you give them? And here we want the good, the bad, and the ugly. What is your advice?

**Pizziconi:** Eric and I are both enthusiastic about this tool, and that it is very important. If you do this right, it works well; but you have to be prepared. Once you have that paradigm in place, then you can be a lot more fluid in your instruction; you can be a lot more interactive. I think you have a better relationship with your students. You can keep building, building, building every year. If they talk to the relevant industries, the industries would tell them that this is what they want to see in the students. It is clear that companies are working on very complex areas; they need people who can go

across boundaries, that can listen, that can build consensus, and have the skills to push that company forward in a very competitive, complex world. These are the kinds of things that a faculty member is looking for in tools; tools that can help them better train students would be very [well received]. The college has lots of resources—they have workshops, there are trained faculty that have done this that they can talk with. They should talk to the students that have been in other classes and see how they liked it. If they do that kind of fact finding, they will be reinforced that this is a very good thing to get involved with.

**Guilbeau:** I would advise them, don't embark upon this exercise without going to the trouble of observing other people who do it well, and attending some workshops, and really understanding how to do it. Read some books that discuss the overall philosophy; then decide what works best within your class. Be prepared for your role as a teacher to completely change from being the expert in class to perhaps being the mother for the class, solving all of the social problems and interaction problems. What you will find is a tremendously rewarding experience where students regularly exceed your expectations in what they produce. Then again, be prepared to be challenged by whether the entire grading system that we use is an appropriate way of evaluating students, because one of the outcomes of cooperative learning is that faculty begin to realize, "Gee, these grades that we give stand in the way of a lot of things that we are trying to achieve."

**Ledlow:** A unique question for you, since you are our first team-teaching faculty, [will you] talk about that experience? What are the advantages of truly teaching a class collaboratively with another faculty member? Also, what are some of the barriers?

**Guilbeau:** From an administrative point of view, having a way of people getting credit for what they are doing is important. My experience in team-teaching a class, the way Vince and I team-taught the class, was both of us deserved 100 percent credit for the class because we were physically present in the classroom every time—for every lecture or experience. We would prepare for each class jointly. As an administrator, if a class is being structured where four people are team-teaching it—and faculty member A has the first four weeks, faculty member B has the second four weeks—I am much less likely to feel that they deserve full credit for the class. The allocation of load is a problem that has to be overcome. In some of the liberal arts classes it must certainly be a bigger problem than it is in engineering, where the class sizes tend to be smaller and faculty are a little less concerned about their overall teaching loads relative to other people.

**Pizziconi:** The advantages of having different faculty within the same course—at least in bioengineering because it is such a multi-disciplinary program—is we have virtually a mini engineering faculty that represent all the major disciplines. It is wonderful to bring together two people that might be bioengineers, but come from very different perspectives, to bring different things to the table. The class can work very well from the standpoint of how information is exchanged in an interdisciplinary way within a

program. If you can add to that a cooperative, active learning process, the team-taught faculty members are engaged in that process. This is very powerful.

**Guilbeau:** The other advantage is, at least within our department, that there are always times when things are pulling you away from preparing for that lecture or that class. When I was traveling, or pulled away for administrative reasons, Vince was always there to maintain the continuity in the class and vice versa. If he had something going on in his life, like an impending grant proposal deadline that was looming the next day, then I could step in and make sure that things got done. I think less possible to quantify were those times we were struggling with what the experience should be in the next class. Vince came up with creative things that I would have never have thought of, and they worked extraordinarily well. I hope there were times when I did the same thing. But clearly, we are different people. I tend to be a very organized, very structured person. Vince tends to be much more creative and—

**Pizziconi:** —and disorganized.

**Guilbeau:** I wouldn't say that. I mean it obviously gets done. But let's say Vince lives on the edge more than I do, and so the combination of that for the class was fabulous, right, because they got the best of both personalities.

**Ledlow:** Final question—could you share some of your best experiences using this method?

**Pizziconi:** The whole 201 class was a tremendous experience, because Eric asked me to do a few workshops to see what the basic concepts were, because I was not at all aware of this technique. It was like a whole new world for me. To implement it in real time in our program, with students that were literally just asking for information on how to learn, and watch these tools work in real time, was fabulous. We repeated this four times, and the student evaluations came out very high. We were able to solve some fairly complex intersocial problems of teams. This was an activity that makes the education experience be very different—from "I have to go to class," to, "I want to go to class." We saw a lot of those things. The absenteeism, I think, went way down. Lots of subtle things happened. On an individual class level [one thing] was when I tried to watch this activity with a company where there were a lot of things on the line. The company is obviously looking at our students; our students are looking for jobs. We let this activity go real time and implemented a few of those tools while they were trying to work on a real, hands-on problem. The project engineer came in, interacted with these students and teams, and the aggregate experience was about as best as we can deliver education. And from an industry viewpoint, this is as best as they can influence the process of students coming out.

**Guilbeau:** I think for me it has to be the debates that happened in that 201 class. Vince and I had this book on Creative Controversy, trying to decide whether to use it or not. The idea of having groups of students engaged in debates in an engineering classroom was about as far as you could get from the traditional engineering paradigm. We kind of

reluctantly said, “OK, we will give it a shot,” and we created this first Creative Controversy. The students gave these debates, and I walked out of that class saying, “Boy, that was good.”

**Pizziconi:** They exceeded our expectations, way beyond, because it was real-time competition.

**Guilbeau:** This was a good thing to do. When we had the second Creative Controversy, the quality of what happened in those debates increased probably two orders of magnitude. I can vividly recall walking out of that classroom thinking, “Boy, they are really into this.” That was a very, very different thing; that had never happened.

**Pizziconi:** It is very different from a lecture class where there they may be interested but not engaged—you are not really asking them to participate. They may be able to solve whatever you are doing, but in active learning, they are empowered. On the very subject matter that they are being trained for professionally, they are taken, in a very proactive way, to their limits. Yet, it is still in the training ground; it is not out there yet. It is within our bounds, and we can mold, and shape, and learn, and evolve. What comes out is a far superior product than we ever could do by lecture only.

**Guilbeau:** I went to a group workshop that the university had with all the best teachers, and the question was, “What do all of these people have in common?” This group of outstanding teachers eventually decided it was really the passion for what they did that separates them away from the average teachers—that is was the passion with which they were engaged in their own learning experience.

**Pizziconi:** You are not necessarily the teacher [but] the facilitator. We’re certainly there to correct or give input [for] the aspects that are technical, but it is much more give and take.

**Guilbeau:** Students see the dynamic ebb and flow of how real world works.

**Ledlow:** Thank you.