Why isn't cooperative learning used to teach science?

It is a shame that more scientists do not read the education literature. They would then be aware of the quiet revolution taking place in teaching. For the past 30 years, cognitive psychologists have made significant headway in understanding how people learn. Many of these principles have found their way into the hands of educators, and from there into some of the nation's K–12 classrooms. As usual, educators in institutions of higher learning lag behind.

The revolution I speak of is called "cooperative learning." Its message is simple: Put students into small interactive groups of perhaps four or five students; give them projects, problems, tests, or case studies to analyze; and they will learn more effectively. Unlike many fads in education, which are enthusiastically touted but poorly investigated, cooperative learning may be the most thoroughly studied educational technique ever utilized. Johnson and Johnson (1989, 1993) have performed a meta-analysis of over 1200 studies in which researchers have compared the performance of students educated using cooperative learning strategies with that of students taught by traditional methods, such as the lecture method.

The results of this meta-analysis are unequivocal and overwhelming: Cooperative learning promoted higher individual knowledge than did competitive and individualistic learning, whether the tasks required verbal, mathematical, or physical skills. Most important, the retention of knowledge was greater. Cooperative learning has striking additional benefits: Students enjoy the experience more, have a better attitude toward the subject, develop better social skills, become more articulate, and end up respecting differing viewpoints more than when they are taught by traditional modes. Clearly, these are outstanding plusses, especially for the field of science, in which educators are concerned about our failure to engage the majority of students.

by Clyde Freeman Herreid

Cooperative learning holds out the possibility of offsetting the scientific illiteracy that plagues Americans. Evidence of this illiteracy is seen in the following signs (Herreid 1995, Mullins 1993): the results of standardized tests, in which American students perform poorly compared with those of other nations; the declining fortunes and international competitiveness of American industry and business; the increasing prevalence of the occult, pseudoscience, and paranormal nonsense in the media; the high dropout rate of students from science and engineering programs (the "pipeline problem"); and the finding that adult scientific literacy in the United States is as low as 5% (e.g., Miller 1988). In addition, science as a field is not attractive for many women or members of ethnic minority groups. For example, African-Americans in 1993 received only 2% of the life sciences doctorates and 1% of the physical sciences doctorates (Macilwain 1995). In the United States, women make up 50% of the population and 45% of the workforce, but only 13% of engineers and scientists.

Small group learning is well suited for many individuals and is especially effective for the very groups that are not currently enchanted by the current pedagogy. Uri Treisman (1985), of the University of California–Berkeley, pioneered the teaching of college calculus in groups. He noticed that African-American students failed freshman calculus at a higher rate than other minorities, whereas Asian-American students outperformed all others. He found that the African-American students tended to work alone, whereas the Asian-American students tended to study in groups. When Theisman set up study groups for the African-Americans, their performance improved spectacularly. Similarly, Frederick Mostellar (Light 1990), a statistician at Harvard University, found distinct improvement in students who were placed into learning groups—and improvement was especially significant for women.

The findings of Light's (1990, 1992) Harvard Assessment Seminar Reports, which involved 100 faculty members from 24 colleges and universities, are especially noteworthy. When students were asked why they do not take science courses, they pointed to the fact that science courses have more grade competition among students than classes in other areas, a view reinforced by Tobias (1990). Light (1992) emphasized the importance of small study groups: "For some students, whether or not they work in a study group outside of class is the single best prediction of how many classes in science they take. Those who work in small groups take more" (p. 66).

What is cooperative learning?

"Cooperative learning is the instructional use of small groups so that students work together to maximize their own and each other's learning" (Johnson et al. 1993, p. 6). But instructors should beware: Cooperative learning is more than throwing students together and expecting learning to occur. This casual approach is a recipe for failure (see Feichtner and Davis 1985). Five elements are essential to successfully implement cooperative learning (Johnson and Johnson 1989).

• **Positive interdependence.** The groups must be given a clear task and

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group goal, the success of which demands that several individuals work together to complete the job. Students understand that they will either sink or swim together. In other words, they must cooperate or fail because the task is too complex or time consuming to do alone.

• **Individual and group accountability.** Not only must the group be held accountable for achieving its goals, but each person must be held accountable for his or her own contribution. There must be no "hitchhiking" on the work of others.

• **Face-to-face (promotive) interaction.** Students need to encourage and help each other by exchanging resources, providing feedback, challenging conclusions, acting in trusting and trustworthy ways; in short, they need to care about one another's success. Thus, most advocates of cooperative learning strongly recommend using class time for group work.

• **Interpersonal skills.** As Johnson et al. (1993) point out, "People must be taught how to work in groups. Leadership, decision-making, trust-building, communication and conflict-management skills have to be taught just as purposefully and precisely as academic skills" (p. 10).

• **Group processing.** Students must constantly assess how well their group is functioning and, if things are not going well, fix them. Fortunately, groups that work together over long periods tend to resolve many initial problems on their own.

Strategies for cooperative learning

Cooperative learning is quite variable in form (Johnson et al. 1993). However, all strategies are based on the knowledge that learning is enhanced when people explain their ideas to one another.

• Informal cooperative learning groups are brief groupings of students for only a few minutes or perhaps one class period. For example, a lecturer may pause and ask the students to work a genetics problem and then, moments later, ask them to turn to their neighbor and compare answers while explaining their reasoning.

• Formal cooperative learning groups are larger groupings of students, lasting from one class period to several weeks. For instance, students in a general biology class may be formed into temporary debate teams to collect information about human cloning and then argue its merits. In a physiology class, groups might design an experiment or present poster presentations on recent advances in the field.

• Cooperative base groups are groupings of students that last for months or years. For example, an ecology class might have a semester-long project to study a river, in which permanent teams of students gather data on the hydrology, water chemistry, plants, and invertebrates. For years I have taught a course titled "Science, Technology, and Society" using Michaelsen's (1992) team learning approach, which places students into permanent teams in which they take group tests and work on case projects together.

Team work is not an alien concept to scientists. After all, scientists function within research teams and departments. They know that groups often produce better results than individuals. Indeed, many science projects could never be duplicated by a single individual. However, scientists rarely consider the impact that group interactions can have on education or their obligations to provide students with opportunities (such as cooperative learning) to enhance their social skills. The need for such training is emphasized by Light (1990), who reported that 80% of the alumni from 35 liberal arts colleges said that the prime ingredient for success in their chosen field was the ability to work in groups and with people. Most alumni reported that virtually no time had been spent developing that skill in the normal classroom. Murphy and Hildebrandt (1984) make the point another way: They note the number one reason that people lose their jobs is interpersonal conflict!

Cooperative learning works extraordinarily well in science, math, and engineering courses. One of its noted practitioners, Karl Smith, of the Engineering School of the University of Minnesota, summarizes some of the reasons why cooperative learning works effectively (Smith 1993, p. 11):

> (1) Whoever organizes, summarizes, provides elaboration, justification, explanation, etc. learns. The person who does the intellectual work, especially the conceptual work, learns the most.
>
> (2) More learning occurs in an environment of peer support and encouragement because students work harder and longer.
>
> (3) Students learn more when they're doing things they enjoy.
>
> (4) Learning that is informal, social, and focused on meaningful problems helps create 'insider knowledge.' Gaining insider knowledge is a major part of becoming a member of a community of practice.

Obstacles to change

Although cooperative learning can be very successful, there are several potential problems. Johnson and Johnson (1993) point out that there is always a danger that many faculty will implement cooperative learning poorly on the basis of inadequate training and become disillusioned. Fortunately, there are numerous workshops around the country and a national newsletter (see box page 555) that will help to alleviate that problem. Also, there are increasing numbers of centers for teaching excellence on university campuses where cooperative learning strategies may be acquired.

Nevertheless, three groups of individuals will provide resistance to implementing any change in science teaching: the faculty, the students, and the administration. Each group has its own doubts, and its concerns must be addressed.

Barriers for faculty. Few scientists have implemented cooperative learning or its cousin, collaborative learning, in their classes in spite of their demonstrated superiority over traditional teaching (Bruffee 1995, Matthews et al. 1995). There are several possible explanations for this situation.

Science faculty rebel at the thought of things "educational."

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Resources for cooperative learning and alternatives to the lecture

Boot Camp for Professors
Office of Teaching Effectiveness
University of Colorado–Denver
Denver, CO 80217-3364
Tel: 303/556-4915; fax: 303/556-2678

Boot Camp for Professors
School of Business and Economics
1200 N. DuPont Highway
Dover, DE 19901
Tel: 302/739-5115; fax: 302/739-3517

Case Studies in Science Workshop
C. F. Herreid
Department of Biological Sciences
State University of New York–Buffalo
Buffalo, NY 14260
Tel: 716/645-2892; fax: 716/645-2975
e-mail: herreid@acsu.buffalo.edu

Problem-Based Learning in Science
Center for Teaching Effectiveness
University of Delaware
111 Pearson Hall
Newark, DE 19716-1106
Tel: 302/831-2027
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Journal of College Science Teaching
NSTA Membership
1840 Wilson Blvd.
Arlington, VA 22201-3000
Tel: 703/312-9232; fax: 703/522-5413
Web site: http://www.nsta.org/jcst

Kagan Cooperative Learning
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Many university science teachers have not heard of group learning techniques. In addition, they are apt to dislike what they often perceive as the jargon, "mushy" methods, and "touchy-feely" approach of "education." They believe that the field of education is for K–12 teachers and has little to say to the college instructor. Consequently, even if they have heard of the cooperative learning process, they find it easy to dismiss. Professors of education and professors of science tend to remain in their private worlds: The two groups are in different places physically, pedagogically, and philosophically; they attend different meetings; they read different journals; they do not speak the same language; and they cooperate on little or nothing. In fact, only a few scientific societies have teaching sections in their journals, and many scientists seem unaware that a rich literature exists for higher education.

Science faculty know only how to lecture. Scientists have been trained by the lecture method. They have grown up with it. Even if they have not been trained how to teach (and few have), they knew what was expected of them when they stepped into their first classroom: lecture. If they were lucky, they got better. If they tried to lead discussion in class, it was probably a failure. They asked a question and were greeted by averted eyes and silence or by a brief response from one of the braver students. Getting even brief responses was like pulling teeth—painful. Soon they were lecturing again. They simply do not know any other way to teach. Discussion leading is a skill

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most scientists do not have, and cooperative learning is something altogether foreign, even to those who might want to try it.

Science faculty do not want to spend the time retooling their teaching methods and revising their teaching materials. Cooperative learning takes time, and lots of it, because a teacher cannot rely on old lecture notes. New exercises for groups must be carefully crafted and projects graded. Standardized tests and well-known textbooks can be used, but most are clearly out of step with the higher-level thinking that cooperative learning demands of students. Hence, the instructor is soon forced to write new materials. The result is more work.

Some faculty are convinced that they are such good lecturers that they do not need other teaching methods. Some stellar lecturers are loathe to relinquish center stage. The ego satisfaction can be enormous. Why give up something you are good at, especially when your teaching evaluations say you are the best?

Faculty do not know how to handle group grades. A cooperative learning strategy demands that groups produce some evidence of their progress. Most of the time they must turn in a tangible product (a paper, proposal, model, or report). How should this product be evaluated? Some experts argue that no group grade should be given and that rewards should be given only to the individual (Johnson et al. 1991). They argue that students will work on the group project even if they are not graded on it because it promotes their individual understanding of the material. Moreover, because the instructor provides numerous opportunities for the groups to analyze their own social dynamics, looking for ways to improve their effectiveness, the group will stay motivated (Johnson et al. 1991).

There is another school of thought: that the group work needs to be graded to ensure that students will be sufficiently motivated to work together. Such assignments prepare students for the real world, which works in this way. That is, many projects cannot be done by a single individual and must be worked on, and evaluated, collectively. Another argument is that grading group work cuts down the workload of the instructor. But even if instructors buy into group grading, how can they determine if all students have contributed equally to the project? That is, how can they ensure that the grading is fair?

Faculty using cooperative learning may be seen by colleagues and administrators as flakes, kooks, or, worse (in some large universities), as too interested in teaching. Instructors, especially young nontenured individuals, run a serious risk when they teach in an unorthodox way, especially if the method takes time away from research and reduces the chance of getting tenure.

Faculty claim that they cannot cover as much material if they do not lecture. There may be some truth to this claim, depending on the cooperative learning method chosen. Nevertheless, Dinan and Frydrychowski (1995), teaching organic chemistry using team learning (Michaelsen 1992), actually covered more material than with the lecture method, and their students received higher grades, so the generalization is not universally true. In team learning, students work together in small groups for a semester. They receive reading assignments and take individual and group quizzes without any lecture. Students use the new material to solve applied problems, which are often presented in the form of case studies.

Nevertheless, most cooperative learning techniques generally do not put a premium on coverage. Rather, they emphasize higher-order learning skills—that is, analysis, synthesis, evaluation, and critical thinking skills. Facts as such have a lower priority. The use of case studies is an illustration (Herreid 1994a). Teaching by case studies puts the learning into context, yet it is difficult sometimes to put together a sequence of cases that will get in all of the facts an instructor wants to cover. Indeed, medical students at McMaster University, in Hamilton, Ontario, who are trained by the problem-based learning method, were found to have some gaps in their background (Albanese and Mitchell 1993). These gaps were readily filled in during residency because the students had learned how to learn and find information. Their great strength—problem solving—was far more important to their careers as physicians than the accumulation of a few facts whose absence was easily remedied.

Finally, as all teachers recognize, just because an instructor covers the material does not mean that students learn it. Cooperative learning stresses learning rather than coverage, which explains why it produces better retention than traditional methods, even if fewer actual facts are taught.

Faculty argue they cannot use cooperative learning in large classes. Cooperative learning has traditionally been used for small classes, perhaps 30 students or less. But much larger classes have tried cooperative learning successfully (Ebert-May et al. 1997, Eisen 1998). For example, cooperative learning has proven to be workable in dental school classes of 70 students (Scannapeico and Herreid 1994). Michaelson (1992) writes that team learning has been effective with classes containing hundreds of students. A major limitation in using cooperative learning in large lecture halls is that the seats are all fixed to the floor, which makes group work difficult. Nevertheless, students can work with their neighbors, and with the people in front of and behind them, if they are encouraged to do so. Of course, large science classes frequently have laboratory or recitation sections in which students meet in small groups, providing excellent opportunities for cooperative learning.

Barriers for students. By the time most students reach college, they have become adjusted to the lecture method used by so many of their K–12 instructors. They have become passive listeners. Anything out of the ordinary in the classroom is greeted with suspicion, especially by students who have done well in the previous mode. They have a right to question any changes.

Students can be threatened by the new approach to learning. When cooperative learning is the dominant method of teaching, students may perceive that they are doing everything whereas the teacher does nothing. Student evaluations may slump during the first couple of years that cooperative learning techniques are

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set in place. Then, after the instructor has become more skilled, evaluations soar. I have even had a student refuse to fill out a teaching evaluation form because he said it was not applicable to me because I did not teach. Students do not recognize that learning to teach themselves is one of the goals of education. However, when students are asked to evaluate cooperative learning courses they almost universally make positive remarks about working in groups, especially if the groups are permanent for the semester.

Students can be hostile to cooperative learning. Science majors, especially ones who get good grades, are survivors of the current system. The lecture method suits them just fine. If it is not ideal for their learning style, at least it is familiar and they have mastered it. Even if the lectures are disorganized and boring, science majors are attracted by the subject matter and have a long-term faith that things will get better. It should not surprise instructors that such students, when first confronted with a new technique, have a healthy skepticism about it. Such skepticism seems especially likely in professional schools, such as schools of dentistry (Scanneipco and Herreid 1994) and medicine (Albanese and Mitchell 1993), all of whose students are there by virtue of their excellence in receiving grades by the traditional route. Cooperative learning strategies, especially if only a single course is involved, are a hard sell indeed for science majors who have done well in the traditional lecture system. By contrast, as Tobias (1990) reported, nonscientists are different; they do not have an inherent love for the sciences. When the teaching is uninspired, they often give up on the sciences, even though they may be good students. Such individuals often welcome cooperative learning with open arms.

There is another danger: Students become discontented if they believe they are part of an experiment; they sense the instructor's insecurity and blame any setbacks on the teacher and the method. Moreover, discontent with their teammates, sometimes for very good reasons, is likely to lead to problems unless the faculty member is a seasoned problem solver. Beginning instructors are particularly vulnerable in trying cooperative learning. They must grapple with both the novelty of the method and the normal problems of any classroom.

Students do not have the social skills to survive the stress in small group learning. The competitive nature of our society is mirrored in the classroom, and much of a college student's early life is locked in a struggle for a rigid grading scheme in which there are few "A"s. Small group work can be a terrible experience (Feichtner and Davis 1985), particularly for good students who feel they have been taken advantage of by their classmates. To be successful, cooperative learning techniques must solve the social problems that threaten all groups: the dominant person, the shy nonparticipant, the personal conflicts over control, and so on.

Barriers for administrators. Administrators must deal with the spillover of problems faced by the students and faculty. If their problems are not dealt with adequately, the trouble lands resoundingly on the chairman's, dean's, or even president's desk.

Administrators question the use of novelty if it generates problems for students. Department chairs are usually the first administrators to hear of difficulty in the classroom. But sometimes unhappy students go to administrators at higher levels: My first experience using small group work was so clumsy that a student delegation went to the dean to appeal for relief.

Administrators in large schools may rebel if class sizes drops. Cooperative learning classes are frequently small. Consequently, if an instructor switches from the lecture method to cooperative learning, adjustments in class size may be necessary. Reducing class size may be troublesome and even impossible if large numbers of students are involved. The problem may be insoluble unless the instructor manages to incorporate cooperative learning into recitation sections or labs or can figure out how to implement cooperative exercises into the large lecture hall (Ebert-May et al. 1997).

Administrators often view teaching as interfering with research. This phenomenon is common in "publish or perish" institutions. Faculty promotions and tenure decisions hinge on the publication list and grant success of the candidate. Despite lip service to the contrary, teaching in many large public universities is often seen as getting in the way of research. Time used in creating new exercises, correcting numerous papers, and meeting with student groups—all standard demands of cooperative learning—is time taken away from the lab bench, field station, and grant writing.

Overcoming the barriers

With all of the negatives, why would anyone change his or her teaching to cooperative learning? For four reasons. First, over 1200 studies testify that the traditional mode of teaching is less effective than cooperative learning. Second, instructors have demonstrable evidence in their own classrooms that with the traditional methods, large numbers of students fail or barely pass. It is too easy to blame the students for all of the failure. The comment of cognitive psychologist Jean Piaget is telling; he says that teachers should do some animal training, "since when that training fails, the trainer is bound to accept that it is his own fault, whereas in education failures are always attributed to the pupil" (Kraft 1990, p. 69).

Third, it may be that even a "good" lecturer is no better a teacher than a "poor" lecturer. In science courses in which multiple sections were taught by different people of widely differing lecture skills and teaching evaluations, student grades on standardized tests were identical (Birk and Foster 1993). When good lecturers hear these data, they are at first disbelieving. They then immediately challenge the standardized test as an accurate method of measuring the impact of their teaching. Of course, if the standardized test is not an accurate measure, why is it so widely used in lecture courses? Something is wrong here. Fourth, attendance is dramatically improved with cooperative learning. In my institution and many others, even fine lecturers may have 30–50% absenteeism in their classes after the first few

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weeks of the semester. In cooperative learning classes, attendance is 95–100% because students do not wish to let their teammates down.

Given that there is a persuasive case for small group learning, how can the barriers outlined above be overcome? Here are several suggestions:

• **Recognize that all things "educational" are not just fluff, but are based on decades of rigorous testing by thousands of researchers.** Some studies are good, some are poor, but virtually all say cooperative learning is superior to the lecture method. Communication between scientists and educators must be improved.

• **Read the education sections of scientific discipline journals.** In addition, subscribe to the *Journal of College Science Teaching*, which has articles from teachers in all types of universities and colleges. There are frequent articles on the use of exercises for small group learning.

• **Learn how to use small group teaching methods and active learning strategies.** Read key works and attend workshops and seminars on the topic. For example, subscribe to the cooperative learning newsletter (see box page 555), and attend conferences (such as Lily Conferences) devoted to the art of teaching.

• **Start small.** Add a cooperative learning exercise now and again until you gain proficiency and are secure with the method. Few instructors have the nerve to suddenly convert a class to small group learning overnight. A slow beginning also means that it will not be necessary to devote massive amounts of time to designing new exercises. But there is a catch: group work takes practice for students, so if cooperative learning is only an occasional activity, the payoff is likely to be low. Also, I have found that it takes no more time to design a cooperative learning class than to design a new lecture. Both require thought and creativity.

• **Use peer evaluation if you use group grades.** Kegan (1995) makes strong arguments against group grading, noting that this grading method is blatantly unfair, debases report cards, undermines motivation of high achievers, and violates individual accountability. The disadvantages Kegan mentions disappear if it is possible to determine who is doing the work. Thus, the group grades can be apportioned accordingly. For instance, in problem-based learning, tutors who sit in on groups can easily assess who does the work. When tutors are not used, peer evaluation techniques will work. For example, students in a five-person group can each be given 40 points to distribute among the four other group members. People averaging 10 points receive 100% of the group grade; those with an average of 9 receive 90% of the group grade, and so on. The instructor can reserve the right to overrule the peer evaluation if he or she believes that there is an injustice in the result.

• **Encourage your colleagues to use cooperative learning.** The best solution is for several faculty in a different department or school to try out the method in different classes. Then, by meeting periodically, perhaps over a brown-bag lunch, they can talk over their experiences. The members of such a local support group can do wonders to help each other over the rough spots.

• **Beg, borrow, or steal group exercises from one another to use in the classroom.** It takes significant time to build up a supply of exercises. Why reinvent the wheel? Fortunately, in the last few years exercises and case studies are beginning to develop and to appear in publications such as the *Journal of College Science Teaching* and on Web sites, such as the University of Minnesota's cases on agriculture, food, natural resources, and environmental problems (http://www.decisioncase.edu/); the State University of New York at Buffalo's Case Studies in Science (http://ulib.buffalo.edu/libraries/projects/cases/case.html); and the University of Delaware Problem-Based Learning cases (http://www.udel.edu/ppl/).

• **Give up the idea that coverage of the material is the same as learning.** Students forget most of the lecture material as soon as the course is over. Cooperative learning and other small group methods deliver far better retention. What good is it to cover the book when few remember it?

• **Refuse to accept the fact that cooperative learning cannot be used in large classes.** Eric Mazur's "concept tests" are a case in point. This Harvard physics instructor delivers 15-minute lectures, then stops the class and asks students to privately write down the answer to a multiple-choice question. He then asks the students to turn to their neighbor, compare notes, and justify their answers. Following this two-minute pause, he asks for a show of hands on each of the multiple-choice answers. If a high percentage of students has answered wrong, he lectures further to clarify the concept. The interruption of the class period by these concept tests generates feedback and excitement.

• **Constantly give and receive feedback from the students.** Explain why you are using small-group methods, soothe their concerns about grades, and talk to them about their responsibilities to their group. Have them write and talk together in their groups about how they can improve their own effectiveness. If you are using peer evaluations, run practice sessions so that individuals will have opportunities to correct their behavior before disaster strikes. Warn them that absenteeism and tardiness are the two worst offenses in a cooperative learning setting.

• **Tell the department chair about the benefits of cooperative learning.** Jim Cooper, editor of the *Cooperative learning and College Teaching Newsletter*, has recently written the article "Ten Reasons College Administrators Should Support Cooperative Learning" (Cooper 1995). He notes that cooperative learning increases student retention, values diversity, enhances the success of technology in the classroom, develops critical thinking, fosters the goals of liberal education, prepares students for the world of work, builds a sense of community, revitalizes faculty, responds to learning styles, and promotes cooperation in university governance.

Following these suggestions will overcome most of the barriers to implementing cooperative learning. In addition, it is important to remember that students do figure out how to handle many of the difficulties themselves, especially if student groups are kept constant. It takes time to learn to work as a team; at least one-third to one-half of a semester is generally needed. Even then,

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it takes a certain maturity before students recognize that they do not have to like their teammates to work with them. Under the best of circumstances, perhaps 10–20% of groups have significant difficulty working together. Thankfully, most of these problems are fixable if the instructor intervenes by meeting with the troubled group members individually and collectively. Finally, I should note that in my experience, as many as 15% of students will still prefer the familiar lecture method even if they have had a good experience with cooperative learning.

Conclusion

Practitioners of cooperative learning must have not only skill but also patience because they are flying in the face of student expectations and tradition. They must expect challenges from students who have, for the first time, been empowered by the group process to openly voice their concerns about the educational process. They must be prepared to experience greater highs and lows than they will probably have experienced before in teaching. The lecture method allows the instructor to operate at a distance, treating students as a mass audience. He or she is the authority figure at center stage. By contrast, cooperative learning strategies force the teacher to see students as individuals. For the first time, the instructor has ample opportunity to watch student interactions, often leading to profound insights into the learning process. When one gives up being "the sage on the stage" to being a "guide on the side," teaching will never again be the same.

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