Chapter 8
Problem Solving Through Cooperative Learning in the Chemistry Classroom

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The best answer to the question, "What is the most effective method of teaching?" is that it depends on the goal, the student, the content, and the teacher. But the next best answer is, "Students teaching other students".

Wilbert McKeachie

Introduction

Many chemistry instructors complain about their students' lack of interest in the subject and their low motivation to learn it. Students often enter my class without being able to solve simple stoichiometric problems, such as "*10.00 g of* Na_2CO_3 *react with 10.00 g of HCl. One of the reagents is completely consumed. Calculate the grams obtained of every product, explain the reasoning you used to do it, and outline a method to verify your results*." Some remember a rote-learned algorithm and can solve the first part of the problem, but few can explain their logic or verify their results. They do not seem to believe that this activity deserves much effort, reflecting an attitude that arriving at the answer is more important than understanding the solution process.

Like learning itself, problem solving is an important and complex enterprise involving many cognitive processes, including knowledge retrieval from procedural and declarative memory, selection among alternative solution procedures, and validation or refutation of obtained solutions. As instructors of general chemistry at the university level, we routinely teach our students procedures for basic stoichiometric and reaction equilibrium calculations. We should also feel obliged to foster in them an appreciation for chemistry and learning that will motivate them to develop the capacity for independent high-level problem solving, and to teach them in a manner that promotes such development. The traditional

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I. Devetak and S. A. Glažar (eds.), *Learning with Understanding in the Chemistry Classroom*, DOI: 10.1007/978-94-007-4366-3_8,

lecture-based instructional approach has been frequently shown by research to be deficient in achieving these goals.

What can be done to improve the interest of students and the standard of their learning? *Cooperative learning* is a well-tested and validated response to this question. I have had considerable success in my classes putting students participating in the general chemistry course to work on high-level problems in teams under conditions such that each member is held individually accountable for all the work done by his or her team. Cooperative learning has the potential of promoting the development of both cognitive and interpersonal skills, and it is one of the few instructional approaches that offer didactic advantages in large enrollment courses (Cooper 1995; Felder and Brent 2007). “When science students are given tasks that demand high levels of cognitive skills and/or personal characteristics such as perseverance and positive attitudes toward science, cooperative learning has the potential to contribute significantly to cognitive and affective development” (Lazarowitz et al. 1994).

Cooperative learning is probably the most exhaustively researched instructional method in all of education (Ledlow 2001). The widespread support for peer learning (Mazur 1997) has been stimulated by the success of cooperative learning. A robust and rapidly growing body of research, included some meta-analysis, confirms the effectiveness of cooperative learning in higher education (Slavin 1980; Johnson et al. 1981; Ziegler1981; Okebukola and Ogunniyi 1984; Lazarowitz et al. 1988; Felder 1996; Springer et al. 1997; Johnson et al. 1998, 2000; Prince 2004; Chiappetta and Koballa 2006; Felder and Brent 2007; Johnson and Johnson 2009).

Learning meaningfully requires the construction of new knowledge. The construction of new knowledge happens through the consideration of new ideas and the reasoned observation of events, interpreted and mediated through concepts that we already own. It can be seen as a dynamic process open to intellectual competition; a collection of progressive transitions between models having a different grade of explicative capacity, which encourage conceptual reorganization through cognitive disputes (Smith et al. 1981).

According to, cognitive development is a social process and the skill to reason increases through interaction with peers and experts (Vygotsky 1962). Working in groups also promotes the development of skills in critical reasoning. Students working cooperatively can engage in discussions with their peers in which they construct and extend conceptual understanding of what is being learned and develop shared mental models. “Cognitively it provides an opportunity for elaboration—putting material into one’s own words” (McKeachie 1994).

What is Cooperative Learning?

Cooperative learning is an instructional approach to group work that involves students working in teams toward a common goal. Beyond developing cognitive skills, cooperative learning helps students develop important skills of teamwork, conflict management, and leadership, skills they need to be successful as professionals and in their personal lives. The most widely accepted cooperative learning model in higher education is probably that of David and Roger Johnson of the University of Minnesota. According to the Johnson and Johnson model (Johnson et al. 2006), a learning exercise can be classified as cooperative learning if the following elements are present: positive interdependence, individual accountability, face-to-face promotive interaction, appropriate use of collaborative skills, group processing.

Positive interdependence Team members are obliged to rely on one another to achieve the common goal. If any team members fail to do their part of work, everyone suffers consequences. Students take responsibility for their own learning and for the learning of their teammates. In problem solving, the instructor creates positive interdependence by giving students different roles and requiring group members to agree on the answer and on the strategies for solving each problem. In group problem solving, "communication will be greater where interdependence is highest" (Raven and Shaw 1970). It is considered by some to be the most important element for the success of cooperative learning (Gillies and Boyle 2009). Positive interdependence is successfully structured when group members perceive that they are linked with each other in a way that one cannot succeed unless everyone succeeds: group members have to know that they sink or swim together (Johnson et al. 1998).

Individual accountability All students in a group are held accountable for doing their share of the work and for the mastery of all the material to be learned. Individual accountability can be achieved by giving individual examinations covering the complete content of the assignment or project, and also using a variety of other techniques to be discussed.

Face-to-face promotive interaction Although some of the group work may be parceled out and done individually, some must be done interactively, with group members providing one another with feedback, challenging reasoning and conclusions, and perhaps most importantly, teaching and encouraging one another. One of the Ten Educational Commandments of Alex Johnstone is to give students the opportunity to teach because you don't really learn until you teach (Johnstone 1997). (See also, the McKeachie quotation that begins this chapter.)

Appropriate use of collaborative skills Students are encouraged and helped to develop and practice trust-building, leadership, decision-making, communication, and conflict management skills.

Group processing Team members set group goals, periodically assess what they are doing well as a team, and identify changes they will make to function more effectively in the future. Towns (1998) provides a series of statements that can facilitate group processing.

Criteria for Team Formation

Experts in cooperative learning distinguish between *informal cooperative learning* (often also referred to as *active learning*)—short exercises presented in class to non-fixed groups of two or more students—and *formal cooperative learning*—longer and more complex exercises presented to groups of students that work together through a significant part of the course (Johnson et al. 2006; Smith et al. 2005). Excellent learning outcomes result from both approaches (Prince 2004). Felder and Brent (2009b) discuss active learning structures and offer implementation suggestions; the remainder of this chapter concerns only formal cooperative learning.

In formal cooperative learning, students work in groups on problems, projects, laboratory reports, or on anything else the teacher deems suitable. The work may be done all or partially in class or outside. Techniques to meet the five defining criteria of cooperative learning can be found in the literature (Felder and Brent 1994; Nurrenbern 1995; Felder 1996; Slavin 1995; Millis and Cottell 1998; Johnson et al. 2006; Felder and Brent 2007).

Formal cooperative learning groups should be made of students with different levels of skills (Felder and Brent 2007). In well-functioning diverse groups, all the students benefit from such organization: weaker students have the benefit of being helped by their more gifted colleagues, and the stronger students (who generally are initially most resistant to working in groups) have the benefit of learning by teaching. As any professor knows, even when we understand an argument, the act of formulating explanations and thinking of examples and answering questions leads to an in-depth understanding that might not be reachable otherwise. Groups formed entirely of the best students tend to split the work and complete their parts separately instead of working as a real team, and as they do not have the need to explain to others, they do not achieve the in-depth learning that derives from teaching.

Another rule for group formation is to avoid isolating members of under-represented minorities at risk for dropping out (Oakley et al. 2004). Such students tend to take relatively passive roles within groups, either by their choice or because they are forced into such roles by their teammates. If, for example, women are a minority of the students in a chemistry curriculum, groups formed of all men, all women, equal numbers of each sex, or a majority of women are acceptable, but groups with only one woman should be avoided (Felder and Brent 2007).

Both of these rules of thumb—mixed skill levels and avoiding isolating members of at-risk minorities—are only achievable if the instructor forms the teams instead of leaving to students the task of organizing themselves. Research sustains this conclusion (Obaya 1999). When students form their own teams, friends tend to cluster together and better students seek each other. One way to form teams is to randomly form temporary training groups for the first 3 weeks of a course; give a written test during this period; and use the results to form the permanent teams. If the students object that they want to choose their own teammates, an effective response is that when they are in the working world they will not have that option and they might as well get used to assigned teams now.

In the literature there is no consensus on the optimal team size: it depends on the subject and the scope of the assignment. A team of two is obviously optimal in a physical or computer laboratory with two-person workstations. For assignments and projects, teams of three or four are generally considered optimal (Felder and Brent 2007): groups of two do not offer adequate diversity of ideas and approaches and they have no clear mechanism for conflict resolution, and in groups of five or more it is easy for one or more team members to be less than fully engaged.

Teams of three are considered ideal by several authors (Heller and Hollabaugh 1992; Robinson 1995; Laughlin et al. 2006), but not every class has a number of students exactly divisible by three, and so having teams of both three and four is ideal. If students often drop a course early in the semester, forming mostly teams of four decreases the chances that many teams will fall below critical mass.

In the first lesson of the course, after announcing the group work requirement and the advantages of working in teams, I ask the students to complete the Motivated Strategies for Learning Questionnaire (see later) and I also ask for their college entrance examination grades. Using such information I form teams of three using the criteria previously mentioned. The few students who do not provide their grades are distributed randomly among the teams. Before I announce the makeup of the teams, the students work on assignments with classmates seated next to them.

It is important to explain the reasons for using cooperative learning when the students are first told they will be working in teams. I describe the interpersonal skills developed by working in groups, and tell them that those skills will be vital in their professional careers where they will certainly have to work in teams. I then tell them that less class time will be spent on lectures and more will be devoted to solving problems in their teams, promising them that I will correct *every* problem they solve and give each of them suggestions for improvement.

Cooperative learning requires careful preparation and implementation because instructors must ensure that the five defining criteria are met. As teachers, we need to reinforce appropriate social behaviors and discourage inappropriate ones, as personalities clearly influence the way in which students interact when they work in teams (Bertucci et al. 2005). Instructors must also be prepared to deal with problematic situations such as hitchhikers, dominant students, and non-cooperative team members (Oakley et al. 2004). It is important to deal with relational conflicts, because they are not only unfavorable for learning but also have detrimental social effects (Damon et al. 2002). “The best way to prevent school violence is to replace disparagement with respect, exclusion with inclusion, and lonely isolation with collaborative community” (Kagan 2001).

It is important for instructors to remember that most students have never been taught how to work in groups, and teams sometimes do not work as well one would hope (O’Donnell and O’Kelly 1994). “Unfortunately, successful cooperative group does not just happen according to the formula. The ability, maturity, and discipline of the students are big factors regarding how well the strategy will work" (Chiappetta and Koballa 2006). "The most important advice I could give a teacher who is planning to use cooperative learning is *be prepared*" (Slavin 1995). Guides to managing teams and helping them cope with difficulties can be found in the literature (Open Teaching Toolkit 1999; Oakley et al. 2004; Felder and Brent 2007).

It is not always easy to develop social cohesion between group members. Participating students need to develop social skills and tolerance for peers when working in teams. To minimize the potential difficulties mentioned above, I give the students participating in the general chemistry course handouts about how to work successfully in teams in which I stress the necessity of genuinely respecting and valuing each other's contributions, resolving disagreements amicably, and fulfilling their responsibilities in different team roles (Millis and Cottell 1998; Sleet et al. 1996; Cardellini and Felder 1999).

The formation of teams can be problematic, because the teacher does not know the students' motivations toward learning the subject (Bertucci et al. 2006), and if motivations are too diverse team dysfunctionalities can result. This problem can be addressed by forming new teams midway through the course unless every member of a team requests to stay together (Oakley et al. 2004).

Cooperative Problem Solving

It is well known that chemistry is for many students difficult, not well liked, and sometimes boring (Herron 1986; Nakhleh 1992; Johnstone 1993; Herron 1996; Childs and Sheehan 2009). According to Johnstone, the difficulties may lie in the both the intrinsic nature of the subject and the quality of its instruction. "The more I have studied chemistry, chemical education and the psychology of learning, the more I have become aware that we are trying to share our beautiful subject with young people in an apparently 'logical' way and, at the same time conflicting with what we know about the way people learn ('psychological')" (Johnstone 2000).

In the usual approach to chemistry instruction, the solution of problems is reduced to rote execution of some procedure, without any real cognitive gain for the students. Cooperative learning has been shown to have positive impact on students' problem-solving skills (Johnson et al. 1980; Qin et al. 1995; Millis and Cottell 1998). My teaching experiences support that conclusion. When I used the method for the first time, I started with a few questions and very short exercises in a lesson (I still use them) and then I increased the exercises and the time spent on them as I gained confidence with the method. At this point, about half of my class time is spent on group problem solving. The approach I use was developed by Johnson et al. (2006). The goal is to solve the problem correctly in a cooperative framework. The students have to develop and agree on one solution, and every team member must be able to explain the strategy used to solve the problem and to verify their solution. Positive interdependence is promoted by asking students to write their name on the solution sheet and the role they assumed, with the roles rotating in each new exercise. The students know that one of them will be randomly called to the blackboard to present and explain the solution, which assures individual accountability. I inform the students that many of the problems they will solve in teams or as homework will be included in the tests, which provides a high level of motivation to solve the problems.

Students participating in the general chemistry course are asked to solve problems related to every stoichiometric topic without explaining beforehand how the problems should be attacked, so sometimes teams go wrong. For example, the students participating in the general chemistry course solve the problem of Na_2CO_3 reacting with hydrochloric acid in the very first lesson, working in pairs. Several groups solve the problem correctly, but normally few or none of them can verify the correctness of the result. My goal in this task is to make them aware that they do not know how to approach and solve problems systematically. “Textbook solutions to problems and solutions presented by instructors on the blackboard are always efficient, well-organized paths to correct answers” (Herron 1986), that “provide no indication of the false starts, dead ends, illogical attempts, and wrong solutions that characterize the efforts of students when they work in problem solving” (Herron 1990).

After that initial experience, I can easily convince the students of the necessity of a different approach to problem solving. After some instruction, I present them with the same stoichiometric calculation. While the groups solve the problem, I wander around and look over the shoulders of some teams, making comments or suggestions, and also control the time spent on the task. As the course unfolds, more and more students ask for explanations. I never explain how to solve the problem, but I give clues for helping them reason and continue to cooperate. Then I collect the solutions and call someone to the blackboard to solve the problem and explain the solution. At times I ask the class how to determine whether a solution step is right or wrong. After the class agrees with a solution, I ask if there are more questions, and then proceed with the lecture or give another exercise.

Before starting each lecture, I collect the students’ homework problem solutions. I subsequently correct each solution, noting the solution times and whether the students explained their steps, used proper units and the correct number of significant digits, and verified the results. The correctness of the calculations and the numeric result are important: in my General Chemistry course, the relative error allowed is 1 %. I give feedback on the students’ performance and never miss an occasion to praise students by e-mail or in class who excel in something related to learning or problem solving.

An important issue is how to deal with the errors made by students while solving problems, particularly problems on new topics. The key is not the error in itself but understanding what went wrong. “When students make what the teacher considers to be an error, the teacher should try to find out what train of thought led the student to make that statement” (Cardellini 2006a). “Everyone has to learn starting from his/her own actual repertoire. This is why errors are not bad, but good in the educational enterprise: They tell every learner about the biases in his/her own repertoire of schemes. For this reason teachers should avoid associating learners' errors with negative feelings, emotions, or punishments" (Cardellini and Pascual-Leone 2004). Dealing in this way with errors is productive: as the course proceeds, I find fewer and fewer errors in the homework problem solutions, and when I examine the solutions I find increasing evidence of students correcting themselves.

One final consideration is about the use of extrinsic rewards as part of the cooperative learning method (Slavin 1995). Significantly positive effects of rewards on achievement were found in elementary and secondary schools (Slavin 1996). I choose not to give rewards because I want all students to contribute to the solution of problems and to maximize their participation in the group's discussion. It may be true that if there is a reward every member will make their best effort to contribute to the success of the group, but there is also a risk that the better students will do the work, discounting the contributions of less able group members. The only indirect reward for working in teams is the assurance that they will learn more and more meaningfully; in this way they will get something useful also for subsequent courses, and better scores on the exams. Students participating in the general chemistry course can get a bonus if they are able to solve problems in a way that are judged appropriate, original or new (Cardellini 2006b).

Reflection on the Practice

Students' motivation in academic tasks is influenced by their personal beliefs and by the learning environment (Ames 1992). The nature of the environment can be critical. "In supportive environments teachers expressed enthusiasm for learning, were respectful, used humor, and voiced expectations that all students would learn" (Patrick et al. 2003). The first days of a class are important for establishing a supportive environment. Our enthusiasm for the subject and our interest in the students' learning it can make chemistry interesting and relevant for them. If we are able to motivate some of them early in the course, they will lead and make more probable the engagement of their classmates. A number of authors offer suggestions for establishing a supportive learning environment early in a course (Hardy and Kirkwood 1994; Felder and Brent 2008, 2009a).

Motivation is more a process than a product: every class session should involve a variety of stimulating activities in class. A positive learning environment "…engages students in some higher-order intellectual activity: encouraging them to compare, apply, evaluate, analyze, and synthesize, but never only to listen and remember" (Bain 2004). A study investigated how students' level of motivation and use of specific cognitive and self-regulatory strategies changed over time in a course. It was found that their confidence that they would do well in class decreased over time, and they were decreasingly likely to believe that chemistry was important or useful to them (Zusho and Pintrich 2003). According to Richard Shavelson, in order to *engage* the students and making them *exert effort* in their learning, "they must relate new information to existing ideas. To this end, the content of education must be conceptually rich and challenging. Engaged and effortful learning occurs when students, confronted with challenging-but-within-reach-material *choose* to cognitively reorganize that material by modifying their prior knowledge to accommodate the new knowledge" (Novak 2010, Foreword).

Student motivation has to do with students' desire to participate in the learning process. Scholars distinguish between intrinsic and extrinsic motivation (Ryan and Deci 2000). A student who is intrinsically motivated undertakes an activity for its own sake, for the enjoyment it provides, the learning it permits, or the feelings of accomplishment it evokes. Research has shown that intrinsically motivated students tend to use strategies that require more effort and that allow them to process information more deeply than their extrinsically motivated colleagues (Lepper 1988). An extrinsically motivated student undertakes activities with the goal of obtain some reward or avoid some punishment external to the activity itself, such as grades or parents and teacher approval. An instructor may do the difference in motivating students to learn, because "stimulating students' motivation to learn includes encouraging them to use thoughtful information-processing and skill-building strategies when they are learning. This is quite different from merely offering them incentives for good performance later" (Brophy 2004).

Such an active learning environment is certainly very favorable for students because they have a variety of learning styles, according to the Index of Learning Style (Soloman and Felder 1988). This environment can also be very suitable for the development of self-regulated learning (Boekaerts 1997). The majority of students participating in the general chemistry course arrive at the university with great confidence in their capacities and very motivated toward the study, according to the Motivated Strategies for Learning Questionnaire (MSLQ), (Pintrich and De Groot 1990; Pintrich et al. 1993). But in such a learning environment, the individual response of students is also different (Vermetten et al. 2002): as with other pedagogical interventions, not all students like it.

This study examined a group of engineering students (9 females and 145 males, aged 19–22) in the second term of their first year at university. Three psychological measurements were applied to the group to see if there was any relationship between the results and the quality of the creative problem solving resulting from this approach. These were Formal Operational Reasoning, measured using the Group Assessment of Logical Thinking (GALT) test (Roadrangka et al. 1983). For $N = 54$ students, the scores ranged from 10 to 24 (out of 24) with a mean of 20.6 and standard deviation of 2.6. Disembedding ability, was measured using the Field Dependence/Field Independence test devised and calibrated by El-Banna (1987) based upon the original work of Witkin (Witkin 1974; Witkin et al. 1977; Witkin and Goodenough 1981). Out of a possible score of 20, for $N = 54$ students, the range achieved was 2–18, with a mean value of 12.8 and a standard deviation of 3.8. MSLQ: for $N = 148$ students, the scores ranged from 134 to 249 (out of 280), mean value of 200.8 and a standard deviation of 21.0.

The number of solutions of problems was about 13,000 from 89 students (mean value: 144.7; standard deviation 75.5); 20 students solved one or more problems in a creative way (Cardellini 2006b). After 6 months, 71 students passed the exam (mean mark: 25.7; standard deviation 4.6) and the majority of them handed over the material used for studying the general chemistry exam: 321 concept maps and 637 résumés were collected. The number of solutions of problems solved by the best students (final mark equal or greater than 27 out of 30) was about 5,500: mean value, 166.2; standard deviation 74.3 (from 37 to 335).

I set the stage for cooperative learning on the first day of class, when I explain to the students that we will be spending relatively little time on lectures and considerable time on problem solving in teams, and I briefly summarize the research showing that this approach will lead to more learning and better grades for most of them (Towns 1998). I also emphasize that we have a mutual goal, for all students to get interested in chemistry and to pass the exam, and that we should work cooperatively to achieve it. I then form teams of three and assign distinct roles to each team member that will rotate over the course of the semester, and I give them some challenging non-technical problems to get them accustomed to the way the class will be run (Cardellini 2006b).

As the course proceeds, the problems call for an increasing range of knowledge and problem-solving skills. While some students are initially resistant, their continuing success helps most of them develop growing confidence in their abilities, and by the midpoint of the course almost all of them express satisfaction with the class and in some cases strong enthusiasm. Most importantly, their problem-solving skills and interest in the course subject are significantly greater than they ever were when I taught more traditionally.

At the end of the course I ask the students to evaluate my teaching and to offer suggestions for improving the course. With the aim of improving my teaching, I use an action research approach, because "The fundamental aim of action research is to improve the practice rather then to produce knowledge. The production and utilization of knowledge is subordinate to, and conditioned by, this fundamental aim" (Elliott 1991). From the students' suggestions and from my observations I reflect about the improvements I can use in the next course: if my knowledge grows in teaching, the students will benefit (Shulman 2004). The teacher can know about the right direction of her/his teaching considering some indicators: students' attitudes and interest toward the subject must increase (Goldman et al. 1998).

A modification I plan to make in the future is to incorporate peer ratings into my evaluation of the students' performance. Some students may be able to cheat a teacher, but they cannot hide from their peers. A well-constructed peer rating protocol can promote individual accountability and can also give students valuable feedback on what they are doing well in their teams and which areas might need improvement (Brown 1995; Millis and Cottell 1998; Kaufman et al. 2000). In performing the latter function, peer ratings help address the fourth criterion of cooperative learning, which requires that the students be helped to develop the interpersonal skills required for high-performance teamwork, and the fifth criterion, which calls for teams to reflect on how well they are performing and to contemplate changes that will lead to improved performance. A free, powerful, and well-validated online peer rating system called CATME (Comprehensive Assessment of Team Member Effectiveness, http://www.catme.org) makes collecting peer ratings easy for instructors, uses the ratings to adjust team project grades for individual team members, gives the students feedback on their performance without compromising the confidentiality of the ratings, and gives instructors information about teams and individual students whose performance might require instructor intervention.

Conclusions

Teaching cannot be reduced to formulaic methods because many variables affect learning (Herron 1996; Bransford et al. 2000), including self-efficacy, utility and relevance of the material, and goal orientation (Ames 1992; Zusho and Pintrich 2003). Psychological factors and previous knowledge also play a role (Ausubel et al. 1978; Reid and Yang 2002). According to Shulman (2002), learning begins with students engagement and motivation. Because motivation to learn has affective components, we have to embody what we believe or preach: we need to show to our students the values we hope to see in our students' behavior. Students want professors who are knowledgeable and excited about the material and who care about their learning (Richlin 2006). Conversely, teachers who lack passion for the subject matter of their courses, are unable to connect students' interest to that subject matter, and convey indifference or hostility toward students, are likely to be ineffective (Carson 1999; Felder and Brent 2009a).

For learning chemistry with understanding we might need to take into account the human element. Learning is a human endeavor, so teachers can make a difference in the perception, motivation, and maybe in the lives of many students if we are able to interest them in our subject. We take learning seriously if we take their learning seriously, which can require a considerable effort. In my last course, about 100 of the 154 students enrolled attended the lectures regularly, and I received hundreds of e-mails and sent just as many. Students participating in the general chemistry course were quite happy to work in this engaged way and to be fully involved.

Cooperative learning refers to work done by student teams under conditions that assure positive interdependence, individual accountability, face-to-face interaction, development of team skills, and self-assessment of team functioning. Extensive research has shown that relative to the traditional instructional approach that emphasizes individual and competitive work, properly implemented cooperative learning leads to greater learning, greater confidence and self-esteem as problem solvers, higher student retention, and superior development of communication and social skills, such as leadership, project management, and conflict resolution skills (Dougherty et al. 1995; Johnson et al. 2000; Felder and Brent 2007). The technique has been widely used with considerable success in chemistry (Felder and Brent 2007). However, the benefits of cooperative learning are not automatic, and if not properly implemented, the method can create more difficulties for teachers than benefits for students. Instructors who undertake it should make sure they have read the literature on the method, understand the potential pitfalls (including student resistance to the method and possible team disfunctionalities), and know proven strategies for minimizing or eliminating those pitfalls.

Acknowledgments I am grateful to Richard Felder of North Carolina State University, who like a father helped me with advice and encouragement in my first hesitating steps in using cooperative learning, and who also offered suggestions for improving an early draft of this chapter.

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