Positive Interdependence, Individual Accountability, Promotive Interaction: Three Pillars of Cooperative Learning

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Introduction

In the Johnson and Johnson model of cooperative learning, there are five essential elements: positive interdependence, promotive interaction, individual accountability, group processing, and social skills [1]. In this minidocument, the first three of these essential elements are examined in detail, while the other two elements, helping students develop their teamwork skills and promoting reflection on team interactions, are addressed in another minidocument in the Foundation Coalition series on active/cooperative learning. This document is intended to help faculty members better understand what positive interdependence, individual accountability, and promotive interaction are, why the three elements are important in cooperative learning activities, and how these elements might be incorporated into a wide range of learning activities.

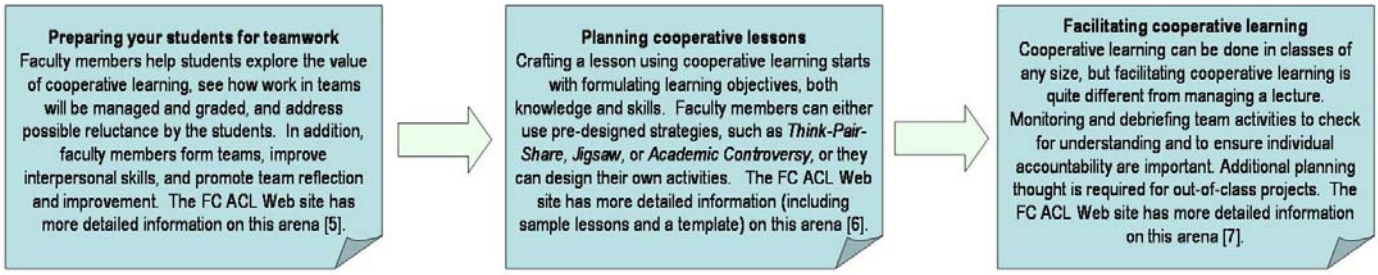
- Section 1 addresses questions about what is cooperative learning.
- Section 2 addresses questions about what are positive Interdependence, promotive interaction, and individual accountability.
- Section 3 addresses questions about why positive interdependence, promotive interaction, and individual accountability are required for effective cooperative learning activities.
- Section 4 addresses questions about how faculty members might incorporate positive interdependence, promotive interaction, and individual accountability into their classroom activities.

Section 1 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 [2]."

Although the preceding brief definition of cooperative learning may provide an intriguing starting point, faculty members might require more depth to think about how they might introduce cooperative learning into their classes. Two descriptions may help readers form more complete pictures of cooperative learning in their classrooms. The first description, shown in the figure below, is a structural model drawn from Johnson and Johnson [3], with five pillars of cooperative learning. In this document, discussions focus on the three pillars on the left of the figure below: positive interdependence, promotive interaction, and individual accountability.

Another description of cooperative learning focuses on the process. Kagan [4] emphasizes three arenas for action [5].



Section 2 What are Positive Interdependence, Promotive Interaction, and Individual Accountability?

Starting with the five-pillar structural model, this section is intended to help faculty members understand the nature of three of the five pillars: positive interdependence, promotive interaction, and individual accountability. The importance of these pillars is the subject of Section 3. Positive interdependence and individual accountability are beliefs/attitudes/philosophies that both the teacher and students hold about the classroom environment. Promotive interaction is a critical attribute of how the task is accomplished. More detailed descriptions of each of the three elements should help readers see how they might design cooperative learning activities that incorporate these elements.

Section 2.1 Positive Interdependence

Positive interdependence is the belief by each individual that there is value in working with other students and that both individual learning and work products will be better as a result of collaboration. The following quotes illustrate different perspectives on positive interdependence:

> "Positive interdependence is linking students together so one cannot succeed unless all group members succeed. Group members have to know that they sink or swim together" [6].
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> "When students clearly understand positive interdependence, they understand that each group member's efforts are required and indispensable for group success and each group member has a unique contribution to make to the joint effort because of his or her resources and/or role and task responsibilities" [6].
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> "Positive goal interdependence ensures that the group is united around a common goal, a concrete reason for being, such as 'learn the assigned material and make sure that all members of your group learn the assigned material'" [6].
>
> "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 goals and tasks, therefore, must be designed and communicated to students in ways that make them believe they sink or swim together. When positive interdependence is solidly structured, it highlights that (a) each group member's efforts are required and indispensable for group success and (b) each group member has a unique contribution to make to the joint effort because of his or her resources and/or role and task responsibilities. Doing so creates a commitment to the success of group members as well as one's own and is the heart of cooperative learning. If there is no positive interdependence, there is no cooperation" [7].

Concise examples of how positive interdependence might be incorporated into course activities may also provide a better understanding of this important element. For other ideas, see a *summary* compiled by Karl Smith [8] or "*An Overview of Cooperative Learning*" by Roger T. and David W. Johnson [9].

- Product goal interdependence uses a product that requires contributions from each member. An *example* is asking a group of students to reach a consensus answer, turn in one problem-solving assignment at the end of a class, or produce a single graph. Further *examples* and reading material on positive interdependence are available on line [10,11].
- Reward interdependence can be designed into a task using some form of shared grades. For *example*, besides their individual scores on an exam, students may receive a certain number of points if *all* group members score at or above a certain grade. Further *examples* are provided in reading material on positive interdependence on line [10,11].
- Resource interdependence exists when individuals each possess specific resources needed for the group as a whole to succeed. Teachers may *promote resource interdependence* by giving specific resources to different individuals in the group [10].
- Role interdependence exists when specific roles are assigned to team members (for example, recorder or time keeper). These roles need to be performed in order for the team to function; however, assigning the roles highlights their importance and assigns accountability to individuals. Roles *can be rotated regularly* to give all team members experience [10].
- Task or sequence interdependence occurs when one group member must first complete his/her task before the next task can be completed. For *example*, collecting water samples might be assigned to two group members, while research on how to collect samples is done by two other group members [10].

More in-depth examples of how positive interdependence has been built into course activities can be found by investigating cooperative learning structures, including *Think-Pair-Share* [12], *Jigsaw* [13,14], or *Thinking Aloud Pair Problem Solving* (TAPPS) [15].

- Barbara Millis, U.S. Air Force Academy, has presented short *descriptions* of several cooperative learning structures [16].
- Joe Cuseo has compiled "*Cooperative/Collaborative Structures Explicitly Designed to Promote Positive Interdependence among Group Members*" [17].
- The cooperative learning group at the University of Wisconsin has compiled *descriptions* of many cooperative learning structures [18].
- In several cooperative learning structures mentioned in the previous bullets students generate ideas for open-ended questions or problems. The instructor poses an open-ended question and asks groups of students to generate multiple responses. Groups then summarize their responses and report in one of several ways: in writing, random calling, groups reporting to each other, etc. A faculty member might apply one of these structures at the beginning of a new topic by briefly describing the topic and then asking groups to generate ideas for real-life applications of it. Such activities motivate students to learn the upcoming topic, tap their prior knowledge about the topic, recognize their knowledge about the topic, and realize the different knowledge that other students have about the topic and how their combined knowledge is much larger than the knowledge of any single member of the group.

Section 2.2 Promotive Interaction

Although it is an important element of cooperative learning, positive interdependence alone does not generate the degree and intensity of interaction required in cooperative learning activities. First, team members need to think that success of the team depends on the contributions by each member. Next, they need to think that ongoing interactions, particularly face-to-face interactions, are required for success. Some tasks are positively interdependent, such as report preparation or programming assignments, because they result in a single team product, but they may not require ongoing interactions. Trytten *writes* about the lack of interaction that occurred in team programming assignments.

> "The result of this analysis [examining the four models for group writing given by Schultz and Ludlow] is that group writing assignments, whether they [are] term papers or programming projects, do not result in cooperative learning. This does not mean that these assignments should not be given. In fact, the industrial need for engineers who have experience with group writing and group programming may justify the inclusion of this assignment whether it results in cooperative learning or not. An instructor who uses this assignment should not be surprised, however, when significant problems with social loafing [and] transaction costs occur, and the well publicized benefits of cooperative learning disappear [19]."

Group writing assignments—term papers and programming projects—have positive interdependence because the final products depend on contributions from all group members. However, they lack another element that is required for cooperative learning activities, promotive interaction. Promotive interaction is set of characteristics in the task or learning activity that requires ongoing conversation, dialogue, exchange, and support. As described on the *Cooperative Learning Web site*:

> "Students need to do real work together in which they promote each other's success by sharing resources and helping, supporting, encouraging, and applauding each other's efforts to achieve. There are important cognitive activities and interpersonal dynamics that can only occur when students promote each other's learning. This includes orally explaining how to solve problems, teaching one's knowledge to others, checking for understanding, discussing concepts being learned, and connecting present with past learning. Each of those activities can be structured into group task directions and procedures. Doing so helps ensure that cooperative learning groups are both an academic support system (every student has someone who is committed to helping him or her learn) and a personal support system (every student has someone who is committed to him or her as a person). It is through promoting each other's learning face-to-face that members become personally committed to each other as well as to their mutual goals [7]."

Concise examples of how learning activities, or parts of learning activities, might be structured to encourage face-to-face promotive interaction are provided in order to provide greater understanding of this important pillar in cooperative learning.

- Ask students to work on a problem, or a part of a problem (to limit the amount of time spent on the exercise), in class. The problem should be challenging enough to require contributions from multiple team members but not so challenging that teams are unable to succeed. For example, see the description of a "ChemDo" used by Frank Dinan in teaching organic chemistry [20].
- Ask students to form individual responses to a multiple-choice question focused on a particular concept and then reach consensus on an answer as a team. Eric Mazur has used *peer instruction*, which is a systematic variation of this approach, in teaching physics [21].
- Ask teams to generate possible applications of a concept introduced in class.
- With a complex concept or task, divide it into parts and post different parts on the tops of flip charts. Have groups move from chart to chart and spend a couple of minutes generating lists, including what they know about the part, what they need to know about it, and applications related to it. Allow all groups to move around the room until they return to their starting points. Have them analyze and summarize the information and report it to the class [22].
- Follow up successful team activities by asking students to reflect on how the team helped individual learning.
- Form heterogeneous groups so that different individuals have more to learn from each other than in homogeneous groups.

More in-depth study of how promotive interaction is encouraged in various cooperative learning structures may also spur ideas about how you might incorporate promotive interaction into your classes.

- A jigsaw is a cooperative learning structure in which material to be learned is divided into separate components [13,14]. Groups of students are assigned responsibility for each component and learn together how to teach that component. Then, teams with one individual responsible for each component come together to teach each other the entire set of material. First, students work together to learn how to best teach the material for which they are responsible. Second, students interact in their final teams to teach each other what they have learned. So a *jigsaw* is constructed to provide multiple opportunities for promotive interaction.
- In structured academic controversy pairs of students take opposite sides of controversial issues and prepare positions for one of two sides [23,24]. Then, pairs present their positions to each other and talk about what they have learned. Pairs may be asked to switch positions and make presentations for the opposite side. Here, interaction is encouraged in preparing the positions, presenting and listening to the positions, talking about what has been learned through the presentations, and then switching positions. Again, multiple opportunities for interaction are built into the cooperative learning structure.

Although positive interdependence is often called the most important element of cooperative learning activities, positive interdependence and promotive interaction appear to be required for successful cooperative learning activities.

Section 2.3 Individual Accountability

Individual accountability is the belief by each individual that she/he will be accountable for her/his performance and learning. Phrased negatively, an individual believes that she/he cannot receive a satisfactory rating by riding on the coattails of other members of the group. On the Cooperative Learning Web site, Johnson and Johnson *describe* the need for both group and individual accountability:

> "Two levels of accountability must be structured into cooperative lessons. The group must be accountable for achieving its goals and each member must be accountable for contributing his or her share of the work. Individual accountability exists when the performance of each individual is assessed and the results are given back to the group and the individual in order to ascertain who needs more assistance, support, and encouragement in learning. The purpose of cooperative learning groups is to make each member a stronger individual in his or her right. Students learn together so that they subsequently can gain greater individual competency [7]."

After participating in a cooperative lesson, group members should accomplish the same kinds of tasks by themselves. They learn to do something together so that they can do it more easily when they are alone. Individual accountability is the structural element required to discourage and lower the likelihood of free riders or social loafing.

Concise examples: Individual accountability is promoted by providing opportunities for the performance of individuals to be observed and evaluated by others. For example, *individual quizzes or examinations* promote individual accountability. However, in many college courses, examinations occur relatively infrequently during the semester, so other mechanisms to promote individual accountability might be considered.

- *Random checking* is posing a question or a problem and randomly calling on specific individuals to give an explanation after talking about the question or problem in a group. Some faculty members use a random-number generator, even generating the numbers of the team and the member within the team, while other faculty members just call on students.
- *Signatures on team assignment* Faculty members ask that students who have contributed to a teamwork product sign the paper or report to indicate that they have contributed. Some faculty members ask individual students to sign the parts of the work product that they have contributed.
- *Individual contributions to team report* If a team has worked to assemble an oral report, individual members might be asked at random to present a part of the report. Another approach would be to ask that each team member present at least a portion of the oral report. For example, individual accountability was ensured by having each person give his/her own oral report. The grade on the project was based partially on the group effort, and partially on the individual oral presentation [25].
- *Individual skill demonstration* Individual team members might be asked to demonstrate a skill that the team was assigned to practice. On a laboratory practicum, team members might be asked to demonstrate competency with specific experimental skills.
- *Checker* On a team, the role of a checker is to ask each member individually whether they understand the design, solution, or explanation that the team has just constructed. The checker may ask for some demonstration of understanding.
- *Individual explanations* Within many cooperative learning activities, individuals have opportunities to explain their thinking, their solutions, their approach, etc., to the other members of their team. Constructing explanations helps improve understanding of the material [27].
- *Teach it to someone else* Giving students opportunities to teach material to their peers is another way to promote individual accountability and learning. One cooperative learning structure in which this occurs is a *jigsaw* [13].

More in-depth study of how individual accountability is encouraged in various cooperative learning structures may also spur ideas about how you might incorporate individual accountability into your classes.

- In peer instruction [21] the instructor prepares a concept question that students first answer individually and then in pairs or teams. Peer instruction promotes individual accountability by first asking for individual answers and then providing a conversation environment in which individuals may describe their answers, listening to other answers, and then reaching decisions about the best consensus answer. In some respects, peer instruction resembles structured academic controversy [23,24] by promoting conversation about possibly different positions.
- In structured problem solving [27] groups with assigned roles (that are rotated) work on a problem or a portion of a problem together, but a designated member or a member at random presents the solution. Individual accountability is encouraged because the instructor selects the member who will be asked to explain the group's result.
- In Dyadic Essay Confrontations [27] individuals read an outside assignment, prepare an essay question, and prepare a model essay in response to their question. In class, they receive a different question and model essay from another individual. They write a spontaneous essay in response to the received question and critique the received model answer. Individual accountability is encouraged through out-of-class preparation that is reviewed by another student (as well as the teacher) in connection with the reading assignment and through in-class preparation of the spontaneous essay and critique that are returned to another student.

Section 3 Why are positive interdependence, promotive interaction, and individual accountability required for effective cooperative learning activities?

This section describes why each of the three pillars of the cooperative learning that are the focus of this minidocument—positive interdependence, individual accountability, and promotive interaction—are essential for effective cooperative learning activities.

Positive Interdependence Deutsch [28] describes three types of interdependence in a class: positive interdependence, neutral interdependence, and negative interdependence. With positive interdependence, students value collaborating productively, which follows from the conviction that the learning environment permits everyone in the class to succeed. Positive interdependence is promoted by a grading system in which everyone in the class could earn an *A*. On the other hand, grading on a bell curve that requires set percentages in the class to receive *C*s, *D*s, and *F*s does not promote positive interdependence. In neutral interdependence, students believe that there is no value in working together and that the efforts of the other students in the class will not affect their grades. It is an "I can't help anybody, nobody can help me, and nobody can hurt me" attitude. In negative interdependence, students believe that the activities of other students have the potential for lowering their grades. Negative interdependence occurs when students believe they are competing with other students for the desirable grades and that success by some requires failure by others. Although many people believe that competitive environments bring out the best in individual learning performances, many studies show that cooperative learning environments promote superior results [29,30,31].

As the studies that compare performance in cooperative (positive interdependence) and competitive (negative interdependence) classrooms suggest, the type of interdependence that is created in the classroom affects student performance. Students in every class are interdependent since, as Darwin Linder, a psychologist at Arizona State University, summarizes the situation, "Group dynamics happen." Each faculty member plays a significant role in helping to determine the type of interdependence. If you do nothing, then students will assume that they are competing with one another (negative interdependence) or that they are not dependent on one another (neutral interdependence). Efforts by faculty members are required to develop positive interdependence.

> "Positive interdependence (cooperation) results in promotive interaction as individuals encourage and facilitate each other's efforts to learn. Negative interdependence (competition) typically results in opposition interaction as individuals discourage and obstruct each other's efforts to achieve. In the absence of functional interdependence (that is, individualism [neutral interdependence]) there is no interaction as individuals work independently without interchange with each other [32]."

Without positive interdependence, most students will see themselves in competition with other students for good grades. With positive interdependence, most students work to help others succeed. However, as students work together, there may be opportunities in which students see the potential for success by riding on the efforts of others. Free riders, slackers, or social loafers are roles that appear in the mind of every faculty member when she/he hears about cooperative learning activities. Therefore, positive interdependence alone is insufficient for effective cooperative learning activities. Individual accountability is also required.

Individual Accountability The case for individual accountability is clear for almost every faculty member. Faculty members understand that students must believe that their individual contributions, learning, and performance will affect the grades that they receive. Section 2.3 should help faculty members think about how they might include elements in cooperative learning activities that promote individual accountability. With cases for positive interdependence and individual accountability presented, one important element still remains: Why is promotive interaction so important for effective cooperative learning activities?

Promotive Interaction Group writing assignments and group programming assignments are examples of learning structures in which the members of each group are positively interdependent. Their final work product, and perhaps the grade that they receive, depend on the work product constructed by the group. Research on group writing [4] and experiences with group programming assignments [19] show that these learning activities may not produce the desired results. Group members may simply delegate portions of work to each person in the group and cobble the individual products together to produce the final product. Michaelsen, Fink, and Knight write about tasks in which team members are positively interdependent, but the tasks promote little interaction beyond delegation.

> "When the rational way to complete a task is to 'delegate' the work to individual members, that is exactly what will happen. Delegating commonly occurs in two situations. One situation is when the assignments are too easy (i.e., group interaction isn't needed). In this case, one member will simply act on behalf of the group. The other situation occurs when the task requires a great deal of writing. Since writing is *inherently* an individual activity, the only real group activity will be deciding how to divide up the work. When group members work independently, cohesiveness is reduced for at least two reasons. The first reason is that some members always feel like they are having to do more than their fair share (and in most cases, they probably are correct). The other reason is that, depending on the group's performance, the top students are likely to resent having to choose between carrying their less able or less motivated peers or risk getting a low grade [33]."

Problems arise when one or more group members default on their assignments. Effective cooperative learning activities enable more interaction, more conversations, more constructive debates regarding the merit of various plans, and more opportunities for students to learn from each other. So positive interdependence and individual accountability are insufficient; effective cooperative learning activities must also be designed to promotive substantial interaction in which students facilitate learning and contributions by each other.

Learning in courses with other students is a social activity. Interactions between students inside and outside the classroom influence how everyone learns. Many people have glowing, positive stories about how they studied with other students in study groups. Many people also have negative stories about competing with other students for grades. Each faculty member plays a crucial role in constructing the learning environment for her/his class. Characteristics of the learning environment have a major effect on the quality and quantity of learning that occurs. Cooperative learning environments built upon positive interdependence, promotive interaction, and individual accountability can increase learning. The next challenge is to design learning activities that simultaneously incorporate all three elements to a considerable degree.

Section 4 How might faculty members design classroom practices that promote positive interdependence, promotive interaction, and individual accountability?

At this point, the reader may be thinking, "I accept the importance of these three elements, but can you help me design learning activities that incorporate all three elements that work for the material that I'm teaching?" This is a design challenge in which the three elements are part of the design specifications. Other objectives or constraints are the time available for the learning activity, the complexity of the learning activity, and the learning objectives for the activity. Ideas may be prompted by reading the description of how the jigsaw structure was created [35]. Once the nature of the design situation is understood and the specifications have been prepared, the next step is to generate options for the learning activity.

Section 4.1 Generating Options

Use Existing Cooperative Learning Structures: One source of ideas for potential learning activities is cooperative learning structures that have already been developed and used in other classes. Section 2.1 mentioned three sources of existing structures. Another source is *Cooperative Learning for Higher Education Faculty* [27]. Yet another source of innovative ideas is *On Becoming an Innovative University Teacher: Reflection in Action* [35]. Pimmel provides ideas for constructing team projects from assignments [36]. Felder [37] provides some in-class structures that take very little class time. Existing cooperative learning structures are a rich source of examples that can either be used without alteration or adapted as necessary for the particular classroom environment and learning objectives.

Building from Small-scale Examples: A third source of ideas is to look for examples in which cooperative learning activities are working on a small scale. For example, consider a group of students studying electrical engineering. An engineering professor begins a unit on an engineering topic—for example, frequency response. The principal assessment tool will be an examination in two weeks. Four students agree to meet together regularly, talk about the text and the lectures, and work problems. They meet, converse, critique each other's ideas, and tackle the homework problems together, but each submits a unique homework assignment. Finally, they take the exam individually, and all four receive high grades. The scenario demonstrates all three elements. The question is not whether a learning activity can be crafted with all three elements but whether the learning activity can be extended to the entire class or at least a very large majority. Cooperative learning activities with all three elements might be crafted for an entire class by extracting important elements from the preceding scenario and generalizing them.

The first crucial element of the scenario is reflected in the phrase "they take the exam individually and all four receive high grades." The phrase illustrates two incredibly important elements. First, it illustrates individual accountability (that is, the four students took the exam individually). Each student knew that she/he would be accountable for her/his individual learning. Each student would have to demonstrate mastery of the material individually. Second, each student knew that if she/he performed well on the test, then she/he would receive a high grade. The grading system would allow all four students to receive high grades. If extrapolated to the entire class, a learning activity must convince students that they will be individually accountable, and it must convince students that they could all earn high grades. Grading on a curve in which specific, predetermined percentages of students will receive different grades would penalize and discourage students because they know that the percentages of grades are predetermined and some students receiving high grades implies that others will receive lower grades. Summarizing responses from several faculty members who use cooperative learning in their classes, Cooper et al. described connections between grading on a curve and positive interdependence [38].

The second crucial element in the scenario above was the face-to-face interaction in which the study group members talked about the homework problems. What factors contributed to the productive conversations and how might these same factors be used to encourage similar behavior across an entire class? First, these individuals believed that they would benefit from listening to others talk about how they understood the material being presented and how they would approach homework problems. Second, they also believed that trying to explain how they were thinking about the problem would help them improve their ability to solve homework problems. Third, they were trying to learn how to master and apply the material and learn how to solve problems as well as finishing the homework assignments. Fourth, they were developing some capabilities to solve problems collaboratively. As faculty members think about how to enhance promotive interaction, positive interdependence, and individual accountability, keeping these four factors in mind may improve the learning activities. Frank Dinan has constructed sets of learning activities, which he called ChemDos, for organic chemistry that generalize many of the elements from an informal study group.

> "A typical problem set, which I call a 'ChemDo,' consists of three or four problems dealing with the more difficult or problematic material assigned in the learning guide for that class. Although the problems are designed to be challenging for the teams, care must be taken to insure that they are not overwhelmingly difficult. The problems in a ChemDo are also designed to increase in difficulty as the students move through them. For example, a ChemDo might begin by asking the teams to clarify and explain some of the major concepts dealt with in the learning guide. The next question might require application of these concepts to specific problems, and the ChemDo might conclude with a problem that requires the teams to integrate the material in the current learning guide with previously covered course material [39]."

Focusing on Learning Objectives: Another source of ideas can be generated by focusing on the learning objectives for the proposed learning activities. What do you want learners to be able to do? Then, envision an activity in which learners perform the activity while other learners provide constructive feedback based on what the learner has produced. For example, in many engineering and science courses, a typical answer is, "Work problems at the end of the chapter." So an initial activity might have the instructor choose a problem at the end of the chapter and ask learners to work the problem, exchange solutions in pairs or teams, and, finally, receive a critique of their solutions from other members of the group. However, this initial design may consume too much class time or generate insufficient discussion. In addition, instead of working problems at the end of the chapter, a more accurate statement of the learning objective may be stated as, "Learn to think about how to work the problems at the end of the chapter so that you can work problems on a test or quiz." Now, the focus is less on working a specific problem and more on the process of thinking about setting up and solving problems similar to the ones at the end of the chapter.

As Nancy Simpson, Director of the Center for Teaching Excellence at Texas A&M University, suggests, instructors might use focused questions only for the first (or next, or last) step—e.g., "What is this problem asking you to do, and how do you know that?" or "What picture would you draw to help you figure out what to do?" Show a partial solution path and ask, "What would you do next?" or "Would you have started the problem in this way? Why or why not?" Show a final solution (either correct or incorrect) and ask, "How could this problem-solver check his/her solution?" Work on the refocused questions might take less time, and conversations might be richer and more interactive. If a complete solution is desired, Simpson suggests that instructors might ask for a written solution that would make an ideal "solution manual" solution. Since students understand the frustration of a solution manual that does not tell them why or how to go from one step to the next, they will often respond well to such an assignment. One way to structure this is a two-column approach: one column has the steps of the solution, while the other column has the thought process. To further promote individual accountability, an instructor might randomly call on teams and individuals within teams to describe their work after conversations within teams.

Since the goal of solving several problems is not to obtain the answers to the individual problems but to develop the process of solving the assigned and similar problems, Cowan [35] suggests asking students to develop a script for how to solve a particular class of problems instead of asking student teams to solve a specific problem. Asking for a script or procedure to solve problems instead of asking for an answer to a particular problem may reinforce the idea that the emphasis should be on learning how to solve problems rather than on obtaining the answer to an assigned problem. Focusing on learning objectives for an individual learning activity may generate an initial pattern for interaction. Then, asking how the initial pattern might be refined to further promote interaction, interdependence, and individual and team accountability might generate a usable learning activity. For more ideas on promoting focus on problem-solving processes, see *Beyond Problem Solving and Comprehension* and "Improving Thinking and Learning Skills: An Analysis of Three Approaches [40,41]."

Section 4.2 Evaluating Alternatives

After generating potential alternatives for a learning structure, evaluate each potential alternative using the design criteria and consider possible ways to improve an alternative.

- Does it promote the learning objectives for the activity?
- Does it satisfy the time constraints?
- How does it promote constructive interaction? How might interaction be improved?
- How does it promote positive interdependence? In what ways might interdependence be improved?
- How does it promote individual and team accountability? In what ways might accountability be improved?

Section 4.3 Anticipating Student Resistance

Faculty members should anticipate resistance from students if they incorporate active/cooperative learning activities in their classrooms, initially only because everybody resists doing something different. Approaches to anticipating and addressing student resistance are provided in a description of active/cooperative learning in a digital logic course [42], a widely referenced paper by Felder and Brent [44], and in Cooper et al. [38]. Although excellent details are provided in these references, faculty members are encouraged to describe their reasons for the change, particularly in regard to benefits for students; to ask students for input regarding potential problems; to ask students for input on addressing potential problems; and to incorporate some of their input.

Two potential challenges might be mentioned. If groups of students will be working on learning activities outside of class, plan to provide some support for them by using schedules and residential locations in forming teams and providing forms to help teams identify meeting times early in the term. Details are offered in "Getting Student Engineering Teams Off to a Good Start" [44]. Also, students usually need support in developing a level of interpersonal and team skills necessary for high-performance details. Suggestions for working with students to develop these skills are provided in "Understanding Conflict and Conflict Management," "Effective Interpersonal/Intrateam Communication," and "Effective Decision Making in Teams" [45,46,47]. Employers indicate that these same skills are also valuable after graduation.

The following activities assist with adjustment of student expectations of their role from passive recipients of knowledge to active/collaborative participants in the learning process [48].

- *Why am I taking this course?* The classic answer is because it is required and does not promote buy-in to course activities. Students benefit from the opportunity to think more deeply about this question. Writing and talking about this issue motivates thinking beyond the semester to their choices of major, career goals, etc. This can increase their sense of commitment to the course and the learning process. Steve Krause, Professor and Associate Chair of the Department of Chemical and Materials Engineering at Arizona State University, asks his students at the very beginning of a class to write down what they want to know and be able to do by the time the class ends and how they might use those skills in the future. He summarizes their responses and brings the summary to the next class. He notes that "it usually works out that the responses end up being pretty much the same as are the class objectives and outcomes, but there are sometimes some interesting twists or areas of emphasis." He also may take those items on the last day of class, stand in front of class, and have the students grade the course on how well each item was accomplished.
- *What are the strengths/challenges I bring to the course?* This makes students think about what they have to offer and what their needs are within the context of the course. It helps the instructor and the student to identify and focus on learning needs. When this information is shared with peers, reflection in this area can pay off in group activities by increasing awareness of and appreciation for diversity in thought and contribution.

- *Why did we study this? or Why is this important?* Asking students to reflect on their learning enhances the learning experience by encouraging metacognition and promoting self-assessment. It also provides perspective as students hear multiple perspectives on particular issues.

Section 4.4 Avoiding Pitfalls

Several patterns that lead to problems in cooperative learning activities have been observed. Here are a few.

Avoid grading on a curve. Grading on a curve destroys positive interdependence and builds negative interdependence.

> "A number of informants stressed the important of using a criterion-referenced grading procedure based on actual performance of individual mastery of course content and understanding. Traditional norm-referenced grading (that is, grading on a curve), they noted, defeats the purpose of cooperative strategies and focuses on having students compete against one another for scarce commodities (As and Bs) [40]."

In summary, individual exams are one way to encourage individual accountability and grading criteria that depend only on individual performance, allow every student to earn a high grade, and encourage positive interdependence.

Avoid tasks that are easily decomposed by delegating responsibility. Examples include assigning a team to write and submit a term paper or programming assignment. Michaelsen, Fink, and Knight have written about tasks in which team members are positively interdependent, but the tasks require little interaction beyond delegation.

> "When the rational way to complete a task is to 'delegate' the work to individual members, that is exactly what will happen. Delegating commonly occurs in two situations. One situation is when the assignments are too easy (i.e., group interaction isn't needed). In this case, one member will simply act on behalf of the group. The other situation occurs when the task requires a great deal of writing. Since writing is *inherently* an individual activity, the only real group activity will be deciding how to divide up the work. When group members work independently, cohesiveness is reduced for at least two reasons. The first reason is that some members always feel like they are having to do more than their fair share (and in most cases, they probably are correct). The other reason is that, depending on the group's performance, the top students are likely to resent having to choose between carrying their less able or less motivated peers or risk getting a low grade [33]."

Avoid group grades. Although giving everyone on a team the same grade for a team project, report, or presentation may promote positive interdependence, the practice decreases individual accountability and may reward an individual who contributes very little, i.e. a freeloader. Susan Ledlow at Arizona State University has prepared *Group Grades in Cooperative Learning Classes* [49], a summary of research and experience from several contributors in cooperative learning. To emphasize all three elements of cooperative learning—positive interdependence, individual accountability, and promotive interaction—evaluation of a team project must be arranged so that individuals might receive different grades, depending on their individual contributions. Different grades might be based on observations by the teacher, *peer assessment* [50], or a combination of the two. If peer assessment is used, then research [51,52,53] has indicated that students may unconsciously discount contributions from underrepresented groups such as white women or minorities, so training in peer assessment may be required.

Avoid long-term projects with no intermediate milestones and progress checks. Students need to learn project management skills [54]; providing models of project management is one vehicle through which they can learn. Intermediate milestones, *team process checks* [55], and regular monitoring are requirements for successful long-term student projects. Guidelines and suggestions are provided in a *minidocument* [56] assembled by the *Foundation Coalition*.

Avoid starting major active/cooperative learning activities in the middle of a term. By the middle of a term (e.g., semester or quarter) students have formed expectations about how the course is supposed to operate. Perceived changes to the "rules of the game" in the middle of a term are likely to provoke more resistance than can be effectively addressed.

Avoid relying on a team project to provide positive interdependence. A faculty member might think about the three elements of cooperative learning and design a course using the following mode of thinking: Individual exams provide individual accountability. To provide positive interdependence, she/he introduces a team programming or writing project in which every team member will receive the same grade on the project. The design violates several principles that have been described in the minidocument. First, the three elements of cooperative learning should be included in every cooperative learning activity, not just in the overall course. Second, assigning the same grade to every individual violates individual accountability as described in the pitfall "Avoid group grades" listed above. Third, programming or writing projects, if not very carefully structured, can be easily decomposed by delegating responsibility. If decomposed, the team project will not provide promotive interaction that is essential to an effective cooperative learning activity.

Richard Felder and Rebecca Brent have described other possible *pitfalls* [43].

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Whether you're just getting started or looking for some additional ideas, the Foundation Coalition staff would like to help you incorporate active/cooperative learning into your engineering classes through workshops, Web sites, lesson plans, and reading materials. For suggestions on how to start, see our Web site at

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