Engineering Engineering Education
A Catalyst for Change

Practical Guide to Teamwork

Version 1.1

by

Bucknell's Catalyst Team on Teamwork

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Chapter 1. Introduction

"Tough problems require teams."[1] Teams are used extensively in research, government and industry. When corporate recruiters visit campuses, they seek individuals with good team skills. We expect students to function on teams in our capstone design courses. Further, there is considerable evidence that students working in teams develop deeper understanding. Clearly, team skills are important, but how do we as engineering educators develop these skills in our students?

An important characteristic of successful teams is the power of *creative collaboration*. Michael Schrage defines creative collaboration as "the process of shared creation: two or more individuals with complementary skills interacting to create a shared understanding that none had previously possessed or could have come to on their own."[2] This is the synergy created within the team where the sum is much more than the sum of the parts. Creative collaboration is what allows teams to solve tough problems. Creative collaboration is the essence of why to use a team. Throughout history we have had many examples of creative collaborators in music (Gilbert and Sullivan), in science (Watson and Crick) and in engineering (Wilbur and Orville Wright). How do we foster a team environment where our students can experience the excitement and creative energy of collaborating on a successful team?

Engineering educators don't have the luxury of forming teams the way some teams are formed in research or industry. In our classes, we can't select a known leader, tell that individual to form a hand-picked team with other members that have the necessary experience and skills, and let the team function. First, many students don't possess the experience and skills required to be part of a successful team. Second, as engineering educators, we are committed to furthering the educational growth of <u>all</u> our students in our course, not just the few talented ones who already possess the skills to succeed. In an educational setting, how can we teach team skills in order to better prepare students for teamwork in later courses, research and industry?

The *purpose* of this Guide is to provide practical advice on how to develop your students' team skills in an educational setting.

Our approach is based on the premise that students learn better *by doing* rather than by watching or listening. Students need to experience being on <u>successful</u> teams to understand and appreciate the values of good teamwork. However, we have learned that many students lack appropriate team skills, e.g., being a good listener and being able to resolve conflicts. Also, we have learned that just placing several students in a group and telling them "Be a team!" results in many dysfunctional teams. Students require an instructor-designed framework to learn teamwork.

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[1] Oakes, William C. et al., *Engineering Your Future*, Great Lakes Press, Inc, 2000, p. 338.
[2] Schrage, Michael, *Shared Minds: The New Technologies of Collaboration*, Random House, 1990.

Our approach uses the pedagogical framework of "cooperative learning" to practice teamwork and allow students to develop and gain confidence in their team skills.

> "*Cooperative learning* is instruction that involves students working in teams to accomplish an assigned task and produce a final product (e. g., a problem solution, critical analysis, laboratory report, or process or product design), under conditions that include the following elements (Johnson et al. 1998):
>
> - *Positive interdependence*. Team members are obliged to rely on one another to achieve the goal. If any team members fail to do their part, everyone on the team suffers consequences.
> - *Individual accountability*. All team members are held accountable both for doing their share of the work and for understanding everything in the final product (not just the parts for which they were primarily responsible).
> - *Face-to-face promotive interaction*. Although some of the group work may be done individually, some must be done interactively, with team members providing mutual feedback and guidance, challenging one another, and working toward consensus.
> - *Appropriate use of teamwork skills*. Students are encouraged and helped to develop and exercise leadership, communication, conflict management, and decision-making skills.
> - *Regular self-assessment of team functioning*. Team members set goals, periodically assess how well they are working together, and identify changes they will make to function effectively in the future."[3]

Reading the above *five tenets*, we can see that teamwork is an integral part of cooperative learning. Cooperative learning has many benefits beyond being a training ground for teamwork.

> "An extensive body of [educational] research confirms the effectiveness of cooperative learning in higher education. Relative to students taught conventionally, cooperatively-taught students tend to exhibit better grades on common tests, greater persistence through graduation, better analytical, creative, and critical thinking skills, deeper understanding of learned material, greater intrinsic motivation to learn and achieve, better relationships with peers, more positive attitudes toward subject areas, lower levels of anxiety and stress, and higher self esteem (Johnson et al. 1998; McKeachie 1999)."[4]

It is important to define what a team is and what it is not. A team is not the same as a group. The term "group" implies little more than a collection of individuals. The term "team" implies much more. Some authors define a team as two or more persons who work together to achieve a common purpose. For this Guide, a *team* is two or more persons who work together to achieve a common purpose *and* practice the five tenets of cooperative

[3] Felder, Richard M. and Rebecca Brent, "How to Improve Teaching Quality," *Quality Management Journal*, Vol. 6, No. 2, 1999, pp. 4-5.
[4] Op. cit. p. 5.

learning. However, we do not want to imply that group work is inferior to teamwork. Group work such as having students turn to their neighbor in class to solve a problem can be valuable learning experiences. For effective learning, the educator needs to provide a variety of learning activities, e.g., lecture, group work, and teamwork.

Teamwork can be used in many educational contexts. Teams could be formed for collaborative study, laboratory exercises, design projects and homework. Since teams need time to become productive, the lifetime of student teams is usually more than several days. For example, an educator might form a team for a semester long design project. Less structured group work is more appropriate if the activity is only for a few minutes in class or one homework assignment. However, group work-style exercises could be used for team building if the same individuals work together over a length of time.

Based on their research work to better specify the eleven ABET program outcomes (3.a-k) defined in Engineering Criteria 2000, Besterfield-Sacre, et al[5]. provide attributes needed to achieve Program Outcome 3.d of "An Ability to Function on Multi-Disciplinary Teams." The table below and on the next page summarizes the 15 outcome elements needed to develop students' skills in teamwork. These outcome elements are categorized into collaboration/conflict management, team communication, team decision-making, and self-management, with each outcome element having six to eight attributes, based primarily on Bloom's cognitive/affective domain. These attributes are measurable, student learning outcomes, and they provide the instructor with a buffet from which to pick and choose, in order to reach a specific program outcome element. The 15 elements in the table for ABET Program Outcome 3.d serve as a basis from which to develop the integration of teamwork skills in a course and across the curriculum.

Learning Outcome Elements for the Ability to Function on Teams

Collaboration/Conflict Management	
• Team Development:	Basic principles of group development and interpersonal dynamics.
• Interpersonal Style:	Recognizing and capitalizing on differences in style and perspective.
• Conflict Management:	Principles of problem-based conflict management.
• Participation:	Understanding of and willingness to be fully involved in team efforts.
Team Communication	
• Active Listening:	Conveying understanding and using listening skills to move a conversation forward.
• Feedback:	Giving and receiving constructive criticism.
• Influencing others:	Persuading others through well-reasoned use of facts and clear conveyance of ideas.
• Sharing Information:	Providing and reviewing information in a timely manner.

[5] Besterfield-Sacre, Mary E, et al., "Defining the Outcomes: A Framework for EC 2000," *IEEE Transactions on Engineering Education*, Vol. 43, No. 2, May, 2000. Also, available at http://www.engrng.pitt.edu/~ec2000.

Team Decision-making	
• Defining a Problem:	Identifying and articulating the problem to be solved.
• Innovation/Idea generation:	Generating creative and viable solutions.
• Judgment/Using facts:	Reaching conclusions based upon clear analysis of facts and ideas.
• Reaching Consensus:	Ensuring buy-in and commitment to decisions reached.
Self-Management	
• Establishing directions and standards:	Helping create plans and structure for the team.
• Managing meetings:	Using principles of effective team meetings
• Personal conduct:	Demonstrating personal responsibility to the team and respect for team members.

This Practical Guide provides engineering faculty with a road map on how to implement and integrate teamwork in their courses, in order to reach the learning outcomes in the above table. The next chapter focuses on team organization. It includes how to form teams, how to assign or encourage roles within a team, and how to encourage leadership within teams. Chapter 3 discusses and provides exercises for students to develop their interpersonal skills such as conflict management and reciprocal teaching. Since effective communication is such an important interpersonal skill, Chapter 4 is devoted to it. Chapter 5 is about team processes with discussions on stages that teams experience, project planning and how to run a team meeting. And lastly and perhaps most important, Chapter 6 is about faculty issues and tips on how to integrate teamwork in your courses.

Each chapter consists of a series of modules. The structure of each module includes objectives of the module, discussion aimed at faculty, sample student exercises and citations and links where you may find more information on the topic.

Chapter 2. Team Organization

This chapter covers structures or organizations that an instructor may use to foster a favorable environment for building successful teams. The instructor needs to formulate the team carefully.

The following modules are in this chapter:

1. Team Formation
2. Team Contract
3. Team Roles
4. Team Leadership
5. Formal Lines of Communication
6. Documentation
7. Self-Assessment of Team

Module 1: Team Formation

A. Objectives

1. Discuss the importance of the instructor forming the team.
2. Make the teams heterogeneous.
3. Be sensitive to under represented populations being outnumbered on a team.

B. Discussion

Instructors should form the teams. Avoid student self-selection or the students will team with friends and roommates. Research indicates that instructor-formed teams perform better than self-selected teams [Felder and Brent, 2001, p. E-6].

Groups of 3-4 members work best. Two is too small because there is not enough diversity of ideas and more than four leads to some members of the group not actively participating. Also, groups larger than four become harder to coordinate and increase non-linearly the possible lines of internal communication.

Groups should be heterogeneous with a mix of ability levels, experiences and skills. However, be sensitive to under represented populations, e.g., women in engineering, on a team. Research indicates students from under represented populations who are outnumbered in a group will tend to be passive.

Researchers suggest that instructors keep teams intact for at least a month. It takes that long for the team to encounter problems and learn to work through the problems [Felder and Brent, 2001, p. E-8].

C. Exercise: Sample Approach to Team Formulation

An instructor forms design project teams of four students for the whole year (a two semester course). The instructor bases the formation on the diversity of talent, self-reported grade point average and other student-supplied constraints. Prior to the selection, each student wrote an essay describing their previous courses, design experiences and other characteristics. The students were allowed to submit one individual's name they wanted on their team and one individual's name they did not want on their team. The instructor formed the teams first on design and critical course background, and then spread high grade point average individuals among the teams. Lastly, the instructor considered the desires of the students.

D. Reference

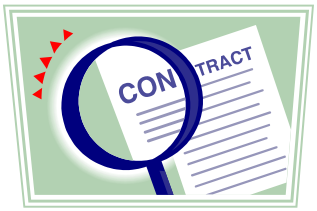
1. Felder, Richard M. and Rebecca Brent. "Effective Teaching: A Workshop," given at Bucknell University, Lewisburg, PA, May 15-16, 2001.

Module 2: Team Contract

A. Objectives

1. Initiate team building by a "get acquainted" activity where each team shares each other's favorite sport, music, etc. and where they have to decide on a team name.
2. Introduce and practice team roles of notetaker, timekeeper and facilitator.
3. Practice conflict resolution by the team reaching consensus on the ranking of the two lists.
4. Formulate a team contract based on team-generated lists of responsibilities that the individuals have to the team and that the team has to its individual members.
5. Foster shared ownership by having each member of the team sign its contract.
6. Practice self-assessing the performance of the team.
7. Have the team create their own self-assessment form based on their team contract.

B. Discussion



The primary purpose of this module is for the team to formulate their own contract on team behavior that they will follow for the rest of the project. We have learned <u>not</u> to hand out a sample contract and to tell the students to develop their own based on it. They will take the easy route and all the resultant contracts will look very close to the sample. The instructor needs to provide resources with good ideas that the students must process to formulate their own contract. The instructor wants to foster shared ownership by the team.

This module consists of a series of four exercises that were given in a senior-level capstone design course the second day of the semester. The instructor formed the teams by

using self-reported grade point average and previous design experience important to the project. After announcing the teams of three or four students, they were asked to form groups by sitting together at the beginning of the class. The four exercises were administered individually one after the other and took a total of an hour. Before class, the students had been assigned to read the four-page article "So, You're Going to be a Member of a Team" by Phillips [1997].

In the second exercise, the teams brainstorm and use reference material to form two lists of responsibilities. The first list is the responsibilities of a team member to the team. The second list is the team's responsibilities to its members. Outside of class the teams refine their two lists, type them up, and had all the members of the team sign it. This document becomes a "contract" between the team members and they place it in the front of their required Team Notebook, as well as hand it into the instructor.

Surprisingly, this notion of the team deriving its own rules and responsibilities of conduct seems to work. Since we have introduced this mechanism, we have had little problems with teams being dysfunctional. Each individual has to write up an assessment of how well his or her team functioned and how well he or she functioned on the team during the class. To encourage candid responses, these assessments are seen only by the instructor. They make interesting reading! Some students seem to be writing to please the instructor. Others are insightful and truthful, e.g., one student wrote that one member of his team always hogs the floor and doesn't let others give their opinions. A different student from the same team says everyone had an equal voice in the deliberations. The instructor could use this feedback to create new exercises that bring out the issues or to chat privately with the team.

C. Exercises Including Student Processing (Guided Reflection)

Exercise 1: Team Building

Teamwork is an important element of this course. While you will certainly be in situations throughout your careers where you work independently, it is equally certain that you will often be part of a team. Surveys from employers consistently rank team skills as one of the critical abilities that they look for when recruiting. Consequently, team building is one element of this course, and your ability to function well on a team is explicitly part of your course grade. In addition, how well your group works together will influence the quality and hence the grades of your reports - not to mention how much fun vs. frustration you have in the process. The bottom line is that getting your team to perform well will not only improve your course grade, but it should also make the course more fun and educational for you.

Being a good team member takes practice and effort. It is a skill, just like the ability to write a clear report or give a good oral presentation. One of the ways that you can become a more effective team member is to be conscious of your behavior in a team and to become knowledgeable about different aspects of team dynamics. Teams generally go through well-known phases. Conflicts, frustrations and bruised egos are almost inevitable in teamwork. On the other hand, if you become familiar with typical team dynamics, make a conscious effort to practice behaviors that characterize good teamwork, and take time to reflect on your

team dynamics with an eye towards constantly improving your teamwork, you will have gone a long way towards gaining a very valuable skill.

Today's exercises are meant to start you on this process.

1. First, meet with your team and get acquainted. Ask yourselves questions such as "What is your favorite sport?" "What is your favorite style of music?" Decide on a team name. If you are having trouble arriving at a team name, consider a name based on your commonalities.

2. Second, you should have read the short article, "So, You're Going to be a Member of a Team" [Phillips, 1997]. This is your introduction to typical team dynamics and a set of behaviors that experts consider to be important for effective teamwork. Assuming all of your members have read the article, take a few minutes to discuss it with your teammates, and come up with at least one question or comment that your group would like to share with the class.

Exercise 2: Team Expectations and Responsibilities

The purpose of this exercise is to establish expectations of the individuals that make up your team. These expectations will act as the team's supporting structure and will remain in effect until the team is disassembled. The **notetaker** or recorder should write down all the ideas and opinions that the team comes up with, and it is vital that every member actively participates.

1. Find out which team member's birthday is coming up soonest. That person is the **notetaker**, who must keep track of the items generated during the brainstorming session. The person on the notetaker's right is the **facilitator**, who is responsible for making this process run smoothly, keeping people on task and making sure that everyone participates. The person on the facilitator's right is the **timekeepe**r, who is responsible for timing the activities and gently reminding the team of how much time is left.

2. Take five minutes to read and discuss the formal roles of "meeting" leader (our facilitator), notetaker and timekeeper on pages 79-84 of *The Team Memory Jogger* [GOAL/QPC, 1995] to familiarize yourselves with their roles. As the semester progresses, the roles should be rotated among the individuals of the team.

3. Brainstorm a list of responsibilities that individuals have as members of the team. This should take at least five minutes. For example, a responsibility of an individual in the team might be to show up on time for all meetings and to be prepared for the meeting by doing any required work before hand. These lists will be used to evaluate your teamwork over the course of the semester, so take them seriously.

4. Now brainstorm a list of responsibilities that the team has to each of its individual members. Responsibilities of the team towards an individual might include being

flexible about setting meeting times to accommodate individual schedules as much as possible, or listening to all opinions. Allow five minutes for this.

5. Come to a consensus on a ranking for each list. Which items are most important? The notetaker should record this. This exercise should take approximately ten minutes to complete.

Exercise 3: Reflections on Team Behavior

1. Reflect on how your team interacted during the previous exercises and compare your behaviors to the characteristics of good team performance on page 144 of the "So, You're Going to be a Member of a Team" handout [Phillips, 1997]. This is a low stress activity and because of its short duration there is not time to assess each aspect of good teamwork. Therefore, think about items 1, 2, 3, 7, 8, 9 and 10 and reflect on how both you and your teammates did with respect to these issues. If you think there is room for improvement, make a conscious effort to improve your teamwork skills with the next group effort. Have the notetaker record impressions.

2. **Team Hands In**: Using ideas from page 144 of "So, You're Going to be a Member of a Team" handout [Phillips, 1997] and pages 6-27 of *The Team Memory Jogge*r [GOAL/QPC, 1995], refine your two lists of responsibilities from the previous exercise. Come to a consensus on the list, write up a clean final version (easy-to-read handwritten version or, even better, typed) and have all the team members sign it. This becomes a working "contract" for behavior on the team. The team hands in the signed copy to the instructor before the next class period and places a second signed copy in the front of their Team Notebook.

3. **Each Individual Hands In**: Write up your assessment of how your team functioned and how you functioned on the team (not necessarily the same thing). Also include your response to this set of team building exercises. Were these activities worthwhile, and if not, what kinds of activities would help you become a more effective team member? Do you even believe that teamwork should be part of this course? Finally, an emphasis on teamwork can be new, threatening and stressful. Do you have any concerns about working in a team that you would like to share with the instructor? If so, include them so I can get a sense of where the class stands and so I can have the opportunity to try to alleviate some of your concerns. Please use good, easy-to-read handwriting or type it. Hand in to instructor before the next class period.

Exercise 4: Team Member Evaluation Instrument

From the results of Exercises 1, 2, and 3 and their references create a Confidential Group Member Evaluation Form. This form should allow each member to evaluate each member on his/her performance. Allow at least 4 levels of distinction from poor to excellent. Also, allow for written comments. You will use this form periodically to do group member evaluation. The instructor will keep the results of your form confidential.

The results will be used to discuss problems or issues and as contributing information to determine individual grades.

Below is a sample of a Confidential Group Member Evaluation Form designed by an actual team of three students in a Mechanical Engineering Senior Design course. Since each team created their own Evaluation Form, the resulting forms were widely different.

MECH 4XX Confidential Group Member Evaluation
Fiber Composites Group

Directions: Fill out the evaluation for EACH member of your group in the correct column. Include yourself. Rate the performance of each student in each category on a 5 point scale (1 – Pathetic, 2 – Poor, 3 – Fair, 4 – Good, 5 – Excellent).

Names: A: _____ B. _____ C. _____

Evaluation:
1. Student attended and contributed to the group meetings.
A: _____ B: _____ C: _____

2. Student performed his/her assigned tasks in a timely manner.
A: _____ B: _____ C: _____

3. Student performed technical tasks in a quality manner.
A: _____ B: _____ C: _____

4. Student contributed to setting weekly goals and dates for tasks.
A: _____ B: _____ C: _____

5. Student was willing to work toward the benefit of the group.
A: _____ B: _____ C: _____

6. Student kept up to date with current project progress and logbook.
A: _____ B: _____ C: _____

7. Rate the overall performance of the student as a member of the team on this project.
A: _____ B: _____ C: _____

Please include comments justifying any extreme evaluation of group members. Use the back if necessary.

D. Recognized Principles of Cooperative Learning

1. Positive Interdependence. The exercises encourages the students to work together to complete the tasks.
2. Individual Accountability. Each student is required to write an assessment of the team's performance that is read by the instructor.
3. Face-to-face promotive action. These exercises are done face-to-face in the classroom.
4. Appropriate use of teamwork skills. Student practice serving in team roles, brainstorming, extracting useful information from references and reaching consensus.
5. Regular self-assessment of team functioning. Each team member writes a paragraph on how the team is functioning. Also the teams create an evaluation form for later

self assessment. The instructor provides feedback to the team based on the periodic use of the form.

E. References

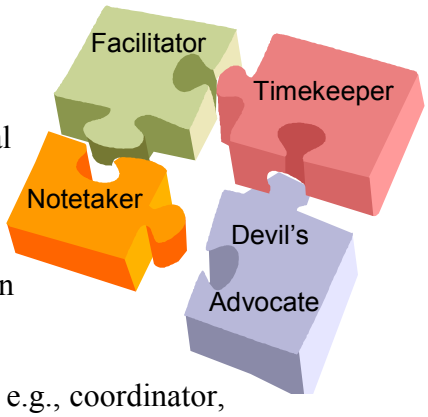
1. Felder, Richard M. and Rebecca Brent, "Effective Teaching: A Workshop," given at Bucknell University, Lewisburg, PA, May 15-16, 2001, p. E-8.
2. Phillips, P., "So, Your're Going to be a Member of a Team," *Chemical Engineering Progress*, January 1997, pp. 141-144.
3. GOAL/QPC and Joiner Associates, Inc., *The Team Memory Jogger: A Pocket Guide for Team Members*, First Edition, GOAL/QPC, Methuen, MA, 1995, pp. 8-11 and 53-60.
4. Stein, R. F. and S. Hurd, *Using Student Teams in the Classroom*, A Faculty Guide, Anker Publishing Company, Inc., Bolton, MA, 2000, pp. 51-54.
5. Millis, Barbara J. and Philip G. Cottell, Jr., *Cooperative Learning for Higher Education Faculty*, American Council on Education and The Oryx Press, Phoenix, AZ, 1998, pp. 57-60.
6. Lumsdaine, E., M. Lumsdaine, and J.W. Shelnutt, *Creative Problem Solving and Engineering Design*, McGraw-Hill, New York, NY, 1999, pp. 111-112.

Module 3: Team Roles

A. Objective

1. To communicate that roles on a team are necessary.

B. Discussion



As anyone who is familiar with team sports knows, individual players have specific roles. For example, in American football, the quarterback throws the ball and a receiver catches it, and if a player fails in his or her role, the whole team suffers. The same principle applies with student teams. Students need to learn that team roles are necessary for successful teams.

The instructor should assign different roles to team members, e.g., coordinator, recorder/notetaker, timekeeper, devil's advocate and consultant. The instructor should encourage the teams to rotate the roles periodically or for each exercise or assignment.

C. Exercise on Team Roles

See Exercise 2 under "Module 2: Team Contract."

D. References

1. Felder, Richard M. and Rebecca Brent, "Effective Teaching: A Workshop," given at Bucknell University, Lewisburg, PA, May 15-16, 2001, p. E-8.
2. GOAL/QPC and Joiner Associates, Inc., *The Team Memory Jogger: A Pocket Guide for Team Members*, First Edition, GOAL/QPC, Methuen, MA, 1995, pp. 79-84.
3. Millis, Barbara J. and Philip G. Cottell, Jr., *Cooperative Learning for Higher Education Faculty*, American Council on Education and The Oryx Press, Phoenix, AZ, 1998, pp. 53-56.

Module 4: Team Leadership

A. Objectives

1. Distinguish between a leader and leadership.
2. Demonstrate the importance of leadership.
3. Demonstrate that all team members should provide leadership.

B. Discussion

Instructors might think they should assign a leader to each student team or provide a mechanism for each team to select a leader. However, it is a myth that a team has to have a leader. Each team requires not a leader but *leadership,* i.e., actions that keep the team focused and moves the team closer to its goals. For synergy all team members should share this leadership. [Stein and Hurd, 2000, p. 171].

"Every successful human endeavor involving collective action requires leadership." [Oakes, 2000, p. 349] Without leadership, humans tend to drift apart, act alone and lose purpose. Many times this leadership is supplied by an appointed leader or by a leader selected by the team. However, it is important for members of a team to realize that all members can provide leadership, e.g., keep the team focused and productive.

C. Exercises

Exercise 1: Wandering Chairs

Create a deck of cards with five each of "Take 1 baby step", "Take 1 step", "Take 1 Hop" and ten each of "Turn right 90 degrees" and "Turn left 90 degrees."

Assuming four team members, place four chairs in a square about 10 feet on a side facing the center. Each team member starts standing at the center facing his or her chair. The goal is for team members to move such as they can sit in their chair.

a. **Scenario 1, Wandering Aimlessly:** Have one team member shuffle the cards. He or she reads the top card, all team members do the action and the card goes on the bottom. Repeat for at least 10 times or until team members reach their chairs.

b. **Scenario 2, Shared Leadership:** Have one team member shuffle the cards and deal all the cards to the team members. In turn going clockwise, each team member looks at his or her cards and selects one that will move the team closer to the goal.

Exercise 2: Traffic Jam

This exercise involves teams in physical activity [Bellamy, et al., 1994, p. Section III-9]. The directions are given in the table below. These directions should be copied and distributed to each team (try one copy per team to build interdependence). It is unfortunate that six participants per team work nicely, since six may not match the number of members on each team. Fewer than six participants per team reduces the complexity to where the challenge is gone, although four is doable. More than six participants per team increases the complexity somewhat. The exercise can consume anywhere from 10 to 30 minutes.

Traffic Jam Rules

Instruction: 

represents Person 1 facing in the indicated direction.

Each team member is to take a starting position as shown:

The object is for all persons on the left to end up on the right and vice versa using only the legal moves described below.

Legal Moves:

1. A person may move into an empty space in front of him or her.
2. A person may move around a person who is facing her or him into an empty space.

Illegal Moves:

1. Any move backwards.
2. Any move around someone facing the same direction you are.
3. Any move which involves two or more persons moving at the same time.

The team members (P1, P2, P3, P4, P5, P6) should take positions a shown above leaving a comfortable distance between each other and an empty position in the middle. The arrows show the direction that the members should be facing. Pieces of paper stuck to the floor to mark the seven spots are desirable.

One question that always arises is does P1 have to get to where P6 began, P2 to where P5 began, and P3 where P4 began? The answer is no; in fact the rules will prohibit that (*Illegal Move 2: Any move around someone facing the same direction you are*). At the successful completion of this exercise, people will have moved from

to

Often, the first team to succeed will not have deciphered the algorithm involved. In a successive round another team may win.

To build intra-team cooperation, you can have the first team that solves this puzzle go work with other teams that have not solved it as yet.

If you want to increase the competitiveness of the game once the teams have played a round or two, ask them to solve it without talking or while holding their breath. They can also complete against their previous time.

D. Group Processing (Self-Reflection)

1. Discuss the results of the two exercises.
2. Have there been times when you felt the team was wandering aimlessly?
3. Reflect on the need for each team member to direct the team to work toward the team's goal.
4. Discuss the need for each team member to practice leadership, i. e., perform actions that keep the team focused and productive.
5. Discuss the situation of an army sergeant and a group of new recruits. Is this a team? Can each member exhibit leadership?

E. References

1. Stein, R. F. and S. Hurd, *Using Student Teams in the Classroom*, A Faculty Guide, Anker Publishing Company, Inc., Bolton, MA, 2000, pp. 171-172.
2. Oakes, William C. et al., *Engineering Your Future*, Great Lakes Press, St. Louis, MO., 2000, pp. 346-350.
3. Millis, Barbara J. and Philip G. Cottell, Jr., *Cooperative Learning for Higher Education Faculty*, American Council on Education and The Oryx Press, Phoenix, AZ, 1998, pp. 209-210.
4. Bellamy, L., et al., "Teams in Engineering Education: A Final Report," NSF Grant USE 91-56176, College of Engineering, Arizona State University, Tempe, AZ, 1994.

Module 5: Formal Lines of Communication

A. Objective

1. Discuss the importance of establishing formal lines of communication.

B. Discussion

An instructor will want to set up formal lines of communication between the team and instructor and between team members. Electronic mail works well but also consider more sophisticated software such as the web-based, Blackboard course management system (see web link http://www.blackboard.com). Possible written communication includes memos and reports.

To encourage communication, the team should have available a comfortable seminar room where they can meet. Also, each team needs a place to store team materials such as a team notebook that is secure but accessible to all team members.

Module 6: Documentation

A. Objective

1. Discuss the importance of documenting a team's activities on a project.

B. Discussion

For long projects, a team needs a way to document team activities. One way is to require a team project notebook. It is important to impress on the team members the importance of keeping the notebook up to date. This is part of being a professional.

C. Sample Student Handout on Keeping a Team's Project Notebook.

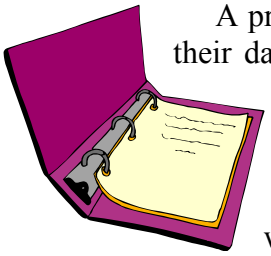
> "The writing that engineers and scientists do can be legally crucial. Your writing constitutes part of the legal record of a project and might end up as evidence in litigation. Thus, part of your responsibility as an engineer or scientist is to make your writing precise and to keep records of what you've written." [Woolston, Robinson, and Kutzback, p. 151]

Mathes and Stevenson in their *Designing Technical Reports: Writing for Audiences in Organizations*, Second Edition, Macmillian, 1991, pp. 455-469, present six basic precepts that engineers and scientists need to observe in order to protect their readers, their company, and themselves in the legal context. These precepts are as follows:

- Don't assume confidentiality.
- Write so that your documents can continue to function effectively for years.

- Don't promise what your company can't deliver.
- Write adequate instructions.
- Warn your readers of dangers.
- Be accurate and complete.

These basic precepts apply to all your written documents - letters, memoranda, laboratory notebooks, project notebooks as well as technical reports. You never know what might be used in litigation.



A project notebook is a three-ring binder of bound pages in which your team can keep their daily technical work and written reports. It allows your team to keep precise and accurate records of what each member is doing. Because no one can remember everything precisely, a written record at the time something happens is the only way to insure accuracy of the event. (Note: Documenting meetings is discussed in Chapter Three.) Obviously, engineers have an ethical responsibility to keep written records that are precise and clear in their project notebook.

In order to develop good documentation habits, you must maintain the team's project notebook. The Project Notebook Standards handout describes the procedures for the daily keeping of your team's project notebook. You will record such information as literature reviews, bibliographical information, ideas, design notes, team meetings, drafts of reports, critiques of reports and reports. Provided you develop a daily habit of placing information in the Project Notebook, you will be able to write precise and clear technical reports because all the necessary information will be at the team's disposal. Your project supervisor will periodically read, evaluate, and sign your team's Project Notebook.

D. References

1. GOAL/QPC and Joiner Associates, Inc., *The Team Memory Jogger: A Pocket Guide for Team Members*, First Edition, GOAL/QPC, Methuen, MA, 1995, pp. 120 & 126.
2. Woolston, D. C., P. A. Robinson, and G. Kutzback, *Effective Writing Strategies for Engineers and Scientists*, Lewis Publishers, Inc., Chelsea, MI, 1988, p. 151.

Module 7: Self-assessment of Team

A. Objective

1. Discuss the importance of regular self-assessment of teams.

B. Discussion

The fifth tenet of cooperative learning "*Regular self-assessment of team functioning*" (See Chapter 1, Page 2) is critical for a team's success. That is team members set goals, periodically assess how well they are working together, and identify changes they will make to function effectively in the future. However, this is rarely done by student teams unless the

instructor explicitly requires it. Doing the self-assessment at the end of a semester is not enough. The students need to practice it several times to understand and be comfortable with the feedback from fellow teammates.

See Chapter 6 for ideas on how to structure self-assessment for teams.

C. References

1. GOAL/QPC and Joiner Associates, Inc., *The Team Memory Jogger: A Pocket Guide for Team Members*, First Edition, GOAL/QPC, Methuen, MA, 1995, p. 124.

Chapter 3. Interpersonal Skills

This chapter addresses development of skills that can help make students more effective team members and foster team leadership. Desirable student outcomes include:

- Identification of own preferred thinking/learning style
- Appreciation of other preferred thinking/learning styles
- Confidence in taking on leadership/instruction roles
- Articulation and demonstration of conflict resolution methods

The following modules are in this chapter:

1. Thinking/Learning Styles
2. Reciprocal Teaching
3. Conflict Resolution

Module 1: Thinking/Learning Styles

A. Objectives

1. Identify own preferred thinking/learning style.
2. Appreciate other preferred thinking/learning styles.

B. Discussion

People think, learn, and approach problems differently. These varied *styles* give diverse teams the potential to be far more effective than individuals working alone. Unfortunately, those same distinctions can lead to friction and confusion among team members, especially those relatively new to teamwork activities. It is therefore important for students to recognize that styles other than their own exist, and that a mixture of preferred styles can ultimately be beneficial in a team setting.

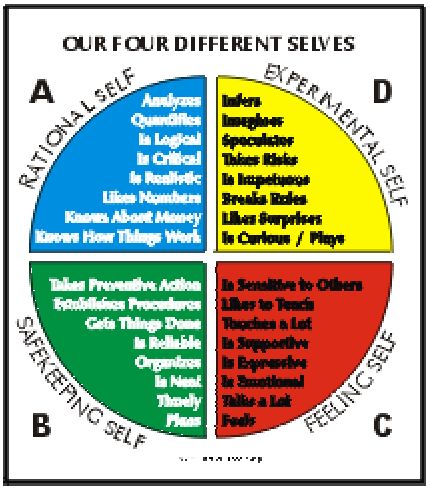
Herrmann Brain Dominance Model

Ned Herrmann describes one method of categorizing people's preferred or dominant thinking styles (1). This Herrmann Brain Dominance (HBD) Model has become widely employed in business and academic settings since its initial publication in 1990, and is addressed in several introductory engineering texts (2, 3).

HBD identifies four thinking modes or quadrants (with associated characteristics):

A: Analyzer: mathematical, technical, logical, factual…

B: Administrator: organized, conservative, reliable, sequential…



Source: http://www.hbdi.com/ -- "Our Four Selves" Model Sheets

C: Collaborator: intuitive, interpersonal, supportive, expressive…

D: Synthesizer: imaginative, conceptual, artistic, risk-taking…

Quadrants A and B are associated with "left-brain" characteristics (sequential, logical), and C and D with those of the "right brain" (intuitive, imaginative).

While everyone inherently possesses some capacity in each area, there likely exists one (or two) dominant mode for a given individual. It should be noted that all four modes have particular importance for various specific tasks within engineering practice (2). While it is normal and positive to possess dominance and personal strength in an area, engineering students should recognize the importance of personally becoming more comfortable with non-dominant activities, as well as the benefit of having different dominant modes within an engineering team.

To this extent, it is useful for students to have some means of assessing their own preferred thinking style. A formal assessment instrument is available from Herrmann International at their web site (4). Its cost may be prohibitive (nominally $65 per survey) for large classes, but modest educational discounts are available. An alternative, rough in-class instrument, based loosely on activities in Lumsdaine (2), has been used in Bucknell's Engineering 100 class and is presented in Section 3. While not as rigorous as the formal HBD instrument, it does allow students to begin thinking about diversity of thinking styles, and identifying their own preferences and particular aptitudes. Also available from the Herrmann web site (4) are instructional materials and games which may be used to introduce student groups to HBD styles. One such interactive game is "Diversity", in which group members receive and trade cards listing specific characteristics associated with particular thinking styles, to come up with a representation of their own and the group's preferences.

Felder/Silverman Model

This model explicitly addresses preferred ways in which people learn and process information. This "learning" style model shares many similarities with the HBD "thinking" style model. As described above, in a teamwork setting knowledge and recognition of individual and team preferences (and weaknesses) can be very helpful. The Felder/Silverman Model (FSM) classifies students as having possible preference within each of these five pairs:

- sensing/intuitive
- visual/verbal
- inductive/deductive
- active/reflective
- sequential/global

This model is supported by several descriptive resources at the home page of North Carolina State's Professor Richard Felder (5). Included on this home page are a paper- and web-based 44 item questionnaire that students can self administer to assess their own preferred styles within the five pairs.

Other

Additional information and references on the above models as well as the Myers-Briggs Type Indicator and Kolb Learning Style Model, can be found in a reference by Felder (6), which is also reprinted at his web site (5).

C. Diverse Styles—Instructor Notes

If a team were composed of students with identical thinking style preferences, it is expected that members would reach consensus quickly, have minimal conflicts, and solve problems adequately but not much differently (with the exception of faster) than would be the case if they worked individually. On the other hand, heterogeneous teams may have difficulty communicating, get sidetracked easily, and have trouble getting started (see stages of team development in Chapter 5). However, it is the heterogeneous teams that are expected to generate more innovative and creative solutions to problems (2), and exhibit the desired result of the team being truly superior to the sum of its parts. The advantages and expected rough spots for diverse teams should be explained to students so that they do not become too discouraged with early communication difficulties and recognize the ultimate potential benefits.

So that students can practice working with thinking style diversity and (hopefully!) see its positive end result, the instructor can purposely compose teams so that they contain mixed thinking preferences. Short of that, random selection is much more likely to yield heterogeneous teams than allowing students to self-select.

It is important for students to understand that thinking/learning style assessments are not tests, and there are no right or wrong answers, as particular preferences are neither inherently good nor bad. Further, today's broad requirements of the engineering profession (2,3) dictate that there is no "best" or "worst" type of preference for future engineers.

D. Exercises

a) Of course, meaningful exercises on styles and teamwork require that members perform some type of personal assessment or inventory of their preferred modes. While students may have a reasonable chance to "guess" their dominance just based on the categories, it is considerably more instructive for them to see some detailed statements or questions relating to the various styles. So, the seminal exercise is to have students perform some type of self-assessment.

   A quick exercise (modified from exercises in Lumsdaine et al. (3)), which attempts to identify preferred modes according to the Herrmann Brain Dominance Model, is shown

HBD-Based Inventory: Circle all bullets corresponding to activities you feel you particularly enjoy or are good at:

Quadrant A	Quadrant D
I enjoy or am good at: • Collecting data and information. • Testing hypotheses to see if they're true. • Understanding details about using computers. • Knowing how much things cost. • Studying example problems and solutions. • Judging ideas based on facts and logical reasoning. • Taking things apart to see how they work. • Playing chess or other logic games. • Figuring out a budget or other financial information. • Algebra.	**I enjoy or am good at:** • Looking for the big picture, not the details of a topic. • Trying a different way of doing things just for the fun of it. • Thinking about the future and making up long-range goals. • Asking "what if?" questions and coming up with a lot of different answers. • Making sketches to help memorize material. • Appreciating the beauty of an object, building, or appliance. • Playing with Tinkertoys, Legos, etc. to invent a useful gadget. • Taking a drive or walk to nowhere in particular without feeling guilty. • Traveling to other cultures for adventure and exploration. • Thinking about trends.
Quadrant B	**Quadrant C**
I enjoy or am good at: • Carefully following directions or instructions. • Using tutorial (how-to) software on computers. • Finding practical use for what I learn (theory is not enough). • Taking detailed notes. • Studying according to a fixed schedule in a controlled environment. • Setting up a filing system for paperwork or personal correspondence. • Organizing my CD, photograph, or other collections. • Writing a sequential report on the results of a laboratory experiment. • Being exactly on time all day. • Plan an activity by writing down each step, then doing it.	**I enjoy or am good at:** • Listening to others and sharing ideas. • Reading the preface of a book to get an idea about the author's purpose. • Keeping a journal to record feelings. • Doing acting or theater. • Learning by teaching others. • Respecting other people's rights and views. • Playing with a small child the way he/she wants to play. • Sending greeting cards or other expressions of thanks/friendship. • Using artwork/decoration to create a specific mood in my room. • Discussing and helping others with their personal problems.

on the next page. Students are given 5-10 minutes to circle bullets for appropriate statements. While results could be quantified based on a percentage of total circled statements contributed from each category, simply identifying a most and least-preferred quadrant is very enlightening and is sufficient in many cases.

Alternatively, visit the Herrmann web site (4) for information on procedures and costs of the formal HBD Indicator test, or make use of one of their "games" which identify individual and team preferences, such as the "Diversity" card game mentioned earlier.

As discussed previously, materials to administer a Felder/Silverman learning style inventory are available at the Felder web site (5).

b) Class: Which Herrmann quadrant or collection of Felder/Silverman categories best describes a traditional or stereotypical view of an engineer? How does that compare to the preferences contained in the class?

c) Individual: Make a list of your _____ (roommates, immediate family members, professors this semester, etc.). Identify their probable preferred Herrmann quadrant.

d) Individual: Which is your least preferred Herrmann quadrant? List two activities you could engage in to help you practice that type of thinking. [Examples (3): join an investment club (A); be exactly on time all day (B); study in a group (C); create a personal logo (D).]

e) Team: Compare teammates' individual preferred thinking/learning styles. Can you identify areas of your teamwork that you feel will go exceptionally smoothly? Can you identify areas in which some friction might be expected?

f) Team: Are there thinking/learning areas that are not preferred by anyone on the team? List a goal or activity of your current team project that might require skills in one of the "missing" areas. How will your team address this?

E. References

1. Herrmann, N., *The Creative Brain*, Brain Books, Lake Lure, North Carolina, 1990.
2. Lumsdaine, E., Lumsdaine, M., Shelnutt, J.W., *Creative Problem Solving and Engineering Design*, McGraw-Hill, New York, NY, 1999.
3. Oakes, W.C., Leone, L.L. et al., *Engineering Your Future*, Great Lakes Press, St. Louis, MO., 2000.
4. Herrmann International, *www.hbdi.com*.
5. Richard Felder, Resources in Science and Engineering Education, *www2.ncsu.edu/unity/lockers/users/f/felder/public/*.
6. Felder, R.M., "Matters of Style", ASEE Prism, 6(4), 18, 1996.
7. "Our Four Selves" Model Sheets, *www.hbdi.com*.

Module 2: Reciprocal Teaching

A. Objective

1. Develop confidence in taking on leadership/instruction roles.

B. Discussion

Members of effective student teams must often assume responsibility for teaching concepts and techniques to their teammates. In these cases, members (whether giving or receiving information) will utilize a number of skills in areas such as listening, giving/receiving feedback, organization, and creativity. Practice in a classroom setting can be accomplished using structured activities that require students to teach their peers. Beyond the teamwork and skills development, such peer or reciprocal teaching activities can be extremely effective learning experiences. Considerable evidence (1,2) indicates that students engaged in reciprocal teaching of material can demonstrate superior retention and learning.

C. Exercises

A number of reciprocal teaching activities of varying degrees of complexity have been developed, and many are nicely summarized in References 2 and 3. Several are presented below. Each involves face-to-face interaction and use of interpersonal skills.

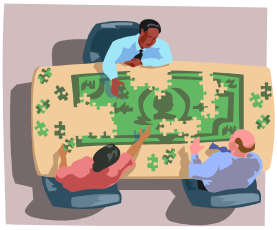
a) Thinking-Aloud Pair Problem Solving

This activity encourages students to examine their own thought processes and articulate the steps used to solve a problem. Student pairs are presented with one or more class-appropriate questions or problems. As one student attempts to solve the problem, he/she talks through his thought processes and methods of addressing the problem. The second student (listener), prods and encourages the first student to verbally think aloud, and asks questions to lead the problem solver and seek clarification. During this time, the instructor focuses on encouraging generous thinking aloud and talking, and assisting groups. Students then switch roles for the next problem. Felder (2) recommends that this powerful yet time-consuming activity not be conducted more than a few times per semester.

b) Reciprocal Peer Tutoring

Here, semester-long pairs engage in a review activity at various times during the semester (such as before each examination). At these times, each partner prepares a (5, 10, 15, etc.)-question multiple choice quiz. Questions can be put on individual index cards, with correct answers on the back, along with elaboration if appropriate. In or out of class (preferably in some organized session, at least at first), students administer the quizzes to their partners (and score them), explaining missed questions and discussing unclear points. The instructor collects each student's quiz materials.

c) Jigsaw



Jigsaw is a very effective activity that can be used in a variety of settings. The basic premise is that individual team members develop expertise in a certain sub-area of a topic or project, which must then be taught to the remainder of the group (each member brings a piece of the "puzzle" to the group, which must then be assembled). Typically this expertise is acquired and refined in secondary groups called "expert groups", which contain one member from each of the original ("home") teams. Discussion within expert groups should include ideas for effectively teaching the material to other members of the home group.

In each case positive interdependence and individual accountability can be assessed by presenting quizzes (or oral questions in class) to individuals on each area of the topic/project. Grading of these individual quizzes can include both an individual and group component (so that the group benefits if all members demonstrate adequate knowledge of each area). Peer assessment of each team member's contributions can also be conducted.

- In-class jigsaw: The instructor breaks a topic into several sub-areas. Designated experts for these sub-parts (who may have been previously presented with readings or other background material) convene in an expert group and receive additional input/training from instructor. After discussion, home teams reconvene, share expertise, and report to instructor/class, and/or take quiz.

- Laboratory experiment cycle jigsaw: Before a sequence of experiments is conducted, the instructor or teaching assistant meets with expert groups (one from each home laboratory group) to provide training on a certain experiment or piece of equipment. When the time comes for the home group to conduct the experiment, the expert becomes the laboratory supervisor, and must instruct the teammates. It could be specified that the non-expert students alone collect data/run equipment/write report at the direction of the expert.

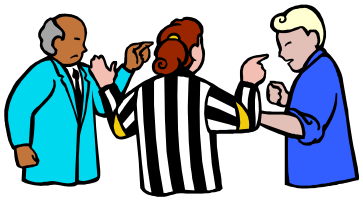
- Design project jigsaw: In design projects (especially those with considerable complexity), expert groups on various sub-areas (literature search, theory, economics, etc.) can be given specialized training and resources. All areas must be assembled and integrated in the final project.

D. References

1. McKeachie, W.J., *Teaching Tips, 10th ed.*, Ch. 14, Houghton Mifflin, 1999.
2. Felder, Richard M. and Rebecca Brent, "Effective Teaching: A Workshop," given at Bucknell University, Lewisburg, PA, May 15-16, 2001.
3. Millis, Barbara J. and Philip G. Cottell, Jr., *Cooperative Learning for Higher Education Faculty*, American Council on Education and The Oryx Press, Phoenix, AZ, 1998.

Module 3: Conflict Management

A. Objectives



1. Articulate and demonstrate methods of conflict resolution.

B. Discussion

Some conflict of ideas and resulting frustration are to be expected at varying points throughout a team project. In fact, the complete absence of disagreement is not a good sign for effective teamwork and problem solving. It signals that little meaningful idea integration or decision making is occurring, and/or that people are not openly communicating about their true feelings. If approached and managed constructively, conflict can lead to good and creative choices. On the other hand, poorly managed conflict can lead down a destructive path, resulting in anger, hurt feelings, and poor team performance.

Guidelines and Strategies to Implement Constructive Conflict Resolution (see References 1, 2, 3)

- Recognize that some disagreement is positive and desirable. It means that you are evaluating ideas and progressing toward an optimal solution.
- Refer back to (or expand on) the project goals so that objective criteria can be used to evaluate proposed differences of opinion.
- Refer back to (or expand upon) team ground rules so that expectations regarding team member behavior and methods of decision-making are understood.
- Focus on concrete issues, not the individuals involved or their personalities.
- Practice active and empathic listening while discussing conflicts.
- Look forward (opportunity), not backward (blaming).
- Try to look at the big picture and the team's goals; not only your own ideas.
- Brainstorm and explore several options before judging and agreeing on a solution.
- Recall team members' preferred thinking/learning styles. If conflicts can be partially rationalized by different preferences, they still need to be resolved, but this understanding can make conflicts seem more normal and less personal.
- Use structured discussion methods:
  1) List on a flip chart items that the team agrees on, and in a separate column, areas of disagreement. This can: encourage discussion of the team's goals; identify objectively what the issues of disagreement are; identify the relative importance of the items in question; and perhaps improve the team's morale by identifying critical areas of consensus ("Look, we really do agree on all these important points!").
  2) "Time out"—The group takes a several minute break for individuals to write down ideas about resolving the conflict. These are then shared with the group.

3) "Round robin"--Each member in turn is asked and expected to present ideas regarding solution of the conflict. This can be done with or without an associated time out.

- View the conflict as a problem to be attacked using a formal methodology. This will also be helpful if you need to mediate a conflict within a group. Johnson and Johnson (4) elaborate on a series of negotiating steps that include:

  – agree on a conflict definition,
  – exchange reasons for positions,
  – understand the other's perspective,
  – invent options for mutual gains.

C. Exercises

1. (from Smith (5)) Ask students to write the word "conflict" with a circle around it on a blank piece of paper. Then they quickly jot down other words or phrases associated with "conflict" and arrange them around the circle. Then ask students to categorize these associations as positive, negative or neutral.

   By show of hands, see how many students had mostly negative associations, or more than 90% negative (or 90% positive). Use the likely more prevalent negative connotations to begin discussion of how this perception tends to make us likely to not constructively manage conflict.

2. Think back to a group (work, school, family, etc.) conflict (nothing so personal that you'd be uncomfortable sharing it with your group). What steps were taken to resolve that conflict? Do you think any of the guidelines/strategies from the previous section would have helped to resolve that conflict more quickly or constructively?

3. Have teams develop a set of assessment questions based on the checklist of common problems found in the Team Memory Jogger [GOAL/QP, 1995, p. 136]. At least once or twice before the assignment is due, have the teams do their self-assessment using the questions they generated. Then, have them reflect on the collated results and develop a plan of action, based on the suggestions in the Team Memory Jogger.

D. References

1. GOAL/QPC and Joiner Associates, Inc., *The Team Memory Jogger: A Pocket Guide for Team Members*, First Edition, GOAL/QPC, Methuen, MA, 1995.
2. McGourty, J. and K. P. De Meuse. *The Team Developer: An Assessment and Skill Building Program*, Student Guidebook. John Wiley & Sons, Inc., New York, 2001.
3. UCSD Guide to Conflict Resolution, www-hr.ucsd.edu/~employeerel/complete.html.
4. Johnson, D.W. and R.T. Johnson, *Teaching Children to Be Peacemakers,* Interaction Book, Edina, MN, 1991.
5. Smith, K.A., *Project Management and Teamwork*, McGraw-Hill, New York, NY, 2000.

Chapter 4. Effective Communication in Teams

Introduction

Teamwork requires effective communication among team members and to people outside of the team. Much of the communication to groups external to the team is often performed formally through reports and presentations. There are many books and articles on effective report writing and presentations [See references at end of chapter]. The focus here is more on the communication among individual members or subgroups within the team.

The following modules develop skills of intra-team communication in this chapter:

1. Birthday Sort Ice Breaker
2. Over-the-Wall
3. Empathetic Communication

The first module introduces students to the importance of effective communication and the role of different human senses. The second module establishes the need for accurate record keeping and documentation to enhance comprehension and consensus. The third module introduces the concept of empathic listening to facilitate communication. Stephen Covey in his book *The Seven Habits of Highly Effective People* affirms, "Seek first to understand, then to be understood."

Module 1: Birthday Sort Ice Breaker

This module is useful for getting a team started (ice breaker). It highlights the importance of communication by effectively removing the common modes.

A. Objectives:

1. Establish an appreciation for effective communication in achieving a common goal.
2. Recognize our dependence on verbal and written communication.
3. Recognize the value of non-verbal and non-written communication.
4. Establish the atmosphere for cooperative learning and effective communication.

B. Exercise:

This exercise can work with groups as small as three people. Larger groups may take a bit longer to complete, but required time is not linearly proportional to the number of people. Start by laying out the ground rules, which are simply that there can be no verbal or written communication during the exercise. Students are then instructed to establish their order based on their birthday. Go.

C. Processing (Guided Reflection):

After the exercise ask the students to work in their group to answer some of the following questions. Students should prepare a written response to be shared with the larger group.

1. Describe the primary means of communication in your group.
2. The instruction was to base your order on birthdays, which is a purposely ambiguous statement. How did your group establish the meaning of "order"? Was it oldest to youngest? Perhaps age was not a factor, but instead the time in the calendar year?
3. What frustrations arose from the rules?
4. Were the rules broken at any time? If so, what caused that?
5. How were team roles established in the exercise? Was there an identified leader?
6. Briefly comment on the effectiveness of non-verbal, non-written communication.
7. How would you perform the exercise differently if asked to do it again in a new group?
8. Rate the team's performance on the exercise? What criteria did you use?

D. Individual Exercise

Individuals are asked to describe, in writing, a similar exercise to promote an appreciation of modes of group communication.

E. Possible Follow-Up Exercise

The ground rules for this exercise are similar in that members are not permitted to speak. Additionally, members must either be blindfolded or agree to keep their eyes closed. The team is then asked to order themselves by shoe size.

F. Recognized Principles of Cooperative Learning

1. Positive Interdependence. Team members must work together to complete the task. All members of the team must communicate his/her birthday to establish order.
2. Individual Accountability. Each individual must complete the follow-up exercise.
3. Face-to-face promotive action. This is clearly an active learning exercise.
4. Appropriate use of teamwork skills. Primarily establishes an appreciation for communication modes.
5. Regular self-assessment of team functioning. The processing questions serve to review the benefits of the exercise and provide an opportunity for team self-assessment.

Module 2: Over-the-Wall

A. Objectives

1. Demonstrate the importance of documenting information.

2. Illustrate how easily miscommunication occurs.
3. Establish effective modes of communicating descriptions of objects.
4. Introduce the concept of artifacts and features.

B. Exercise

This exercise is best with groups of four to 6 people.

1. Each member writes down the description of some object (it can be helpful if it is not a common object, but not necessary). The description should contain at least six different nouns that describe features of the object. Use one or more adjectives to describe each noun. The result should be six sentences describing the object.
   Example:
   The face is round and white.
   One hand is large and black connected to the face at the center.
   Another hand is smaller and black connected to the face at the center.
   Twelve Arabic numerals are located on the face around the perimeter.
   The face is protected by a plastic cover.
   The hands are driven by an electric motor.
2. Select one person to use his/her description (Do NOT discuss anyone's description).
3. Without showing the description to the others, read the sentences to one other person (nobody else should hear). Limit the description to what was written down. No-one is permitted to write anything.
4. The second person then conveys the description to the third person and so on until the last person has heard it.
5. The last person re-describes the description to the whole group.
6. Compare the results.

C. Processing

After the exercise, have the students work in their group to answer the following:
1. How did the final description compare to the original?
2. What elements of the exercise made it difficult to have an accurate final description?
3. How can we improve our description to result in better accuracy?
4. How can we improve our communication to result in better accuracy?

D. Individual Exercise

Individuals are asked to prepare a new description of an object. As part of the assignment the student must explain the elements of the new description that will lead to better accuracy in the exercise.

E. Possible Follow-Up Exercise

Select one description from two groups. Have the members proceed as before passing the description along. At the end, have the groups compare the outcome.

F. Recognized Principles of Cooperative Learning

1. Positive interdependence. Team members must work together to complete the exercise. They then work together to answer the processing questions.
2. Individual accountability. Individuals must complete the follow-up exercise.
3. Face-to-face promotive action. This is an active-learning exercise.
4. Appropriate use of teamwork skills. Enhances communication skills.
5. Regular self-assessment of team functioning. Processing questions pertain to self-assessment of the team's performance on the exercise.

Module 3: Empathic Communication

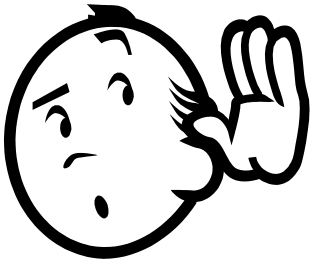
A. Objectives

1. Identify the 5 levels of listening.
2. Define empathic listening.
3. Utilize the 4 steps of empathic listening.
4. Understand the power of listening and how you can benefit from better listening skills.
5. Utilize ethos, pathos and logos in communication.

B. Discussion

Stephen Covey, author of *The Seven Habits of Highly Effective People* states, "Seek first to understand, then to be understood." His fifth habit describes principles of empathic communication where individuals pay attention to the words and the feelings with the intent to truly understand.

Covey describes 5 Levels of Listening:



1. Ignoring – not listening at all
2. Pretending – "yeah, uh huh…Right"
3. Selective Listening – hearing only parts of the conversation.
4. Attentive – paying attention and focusing on the words that are being said.
5. Empathic – paying attention to the words and the feelings from the speaker's viewpoint.

Empathic Listening involves getting inside another person's frame of reference. This means seeing the world as they see it and seeking to understand their position. One does not have to agree, but "empathize".

Commonly we tend to listen autobiographically; that is, from our perspective. There is a tendency to evaluate, probe, interpret or advise. However, listening through an autobiographical filter can often lead to misinterpretation, miscommunication, and mistrust.

Four steps to empathic listening:

1. Mimic – This involves repeating back to the speaker what was just said. This is a common tool of active listening. This is a good first step. At least you indicate that you have heard the words. But there is not necessarily an indication of understanding the meaning. The speaker can often be insulted by these actions or feel manipulated. When using the mimicking technique, it is best to inform the speaker that this is what you are doing.
2. Rephrase - This involves taking the words that were spoken and rephrasing them with new words but same content. With this technique you demonstrate that you have heard the words and processed them.
3. Reflect feeling – This involves a demonstration that you are seeking to interpret the underlying feelings behind the statements. Reflecting the feelings provides the opportunity to clarify the unspoken.
4. Rephrase the content and reflect the feeling – This can help the speaker work through his/her own thoughts and feelings.

Elements to being understood

- Ethos – describes your personal credibility; the faith people have in your integrity and competency.
- Pathos – describes your empathic side. You demonstrate that you are an empathic listener and in alignment with the other person's communication.
- Logos – is the logic; the reasoning part of the communication.

While most people focus on the logos, effective communication requires elements of ethos and pathos for the logos to be interpreted with value.

C. Exercise - Role Play

1. Have the students work in groups of 3 or 4 students to talk about situations where they have witnessed each of the five levels of listening. Ask them to log the instances that are mentioned and label the type of listening demonstrated. Do any of the levels seem to be more heavily represented? Why might that be? How do you think the level of listening demonstrated affected the outcome of the communication?
2. Have the students generate a skit or role-play demonstrating each of the steps of empathic listening: mimic, rephrase, reflect feeling, rephrase content and reflect feeling. The topic or theme of the communication should be the same for each skit. The intention is to demonstrate how the different steps of empathic communication can affect the total outcome of the communication.
3. Ask the students to discuss among themselves the insights gained from the skit. Were there scenarios that seemed better suited for employing one or more of the particular

steps? What challenges can they see in employing empathic listening on a regular basis? Do you think the benefits outweigh the added effort?

D. Individual Exercise

In your upcoming group meetings or conversations, make an effort to employ one or more of the steps of empathic communication. Pay attention to the reactions and the flow of the conversation. Write a brief description of the communication and its result to be turned in to the instructor.

E. Recognized Principles of Cooperative Learning

1. Positive Interdependence. Team members must work together to complete the tasks in the exercise. Each member must take part in the role play.
2. Individual Accountability. Each individual is asked to complete a follow-up exercise on his/her own and write about it.
3. Face-to-face promotive action. This clearly is an active learning exercise. The instructor must first provide a background lecturette to get things started.
4. Appropriate use of teamwork skills. This exercise helps students develop communication skills that will prove effective in team functions. The follow-up exercise is intended to prompt the use of these skills beyond the "controlled" setting with the intent of leading to ownership.
5. Regular self-assessment of team functioning. The processing questions serve to review the benefits of the exercise and provide an opportunity for self-assessment.

F. References

1. Covey, Stephen R., *The 7 Habits of Highly Effective People*, Simon and Schuster, New York, NY, 1989, Habit 5.
2. Decker, Bert (1988*, The Art of Communicating – Achieving Interpersonal Impact in Business*, Crisp Publications, Inc., Los Altos, California, ISBN 0-931961-45-9.
3. Rohnke, Karl and Steve Butler (1995), *Quicksilver – Adventure Games, Initiative Problems, Trust Activities and a Guide to Effective Leadership*, Kendall/Hunt Publishing Company, Dubuque, Iowa, ISBN 0-7872-2103-1.
4. GOAL/QPC and Joiner Associates, Inc., *The Team Memory Jogger: A Pocket Guide for Team Members*, First Edition, GOAL/QPC, Methuen, MA, 1995*,* pp. 15-26.

Chapter 5. Team Processes

Introduction

This chapter includes modules associated with processes that teams typically do or should experience. The following modules are in this chapter:

1. Stages that Teams Experience
2. Project Planning
3. Effective Meetings
4. Meeting Minutes
5. Characteristics of Effective vs. Dysfunctional Teams

The first module describes the five stages of development that most teams work through. The next module describes how newly formed teams can maximize their performance by first establishing clear expectations about the project among team members and by performing explicit project planning. The next two modules discuss how to conduct and record effective team meetings. Finally, the chapter discusses the characteristics of effective and dysfunctional teams.

Module 1: Stages that Teams Experience

A. Objective

1. To make students aware of the five typical stages that teams often experience.

B. Discussion

Organizational behavior theory suggests that teams and other groups typically go through five stages: forming, storming, norming, performing and adjourning.

1. Forming: attraction bonds, orientation to others, dependency, inclusion
2. Storming: dissatisfaction, competition, fight, counter dependency
3. Norming: development of structure, increased harmony
4. Performing: Achievement orientation, productivity
5. Adjourning: termination of duties, reduction in dependency

During the forming stage, team members are typically uncertain about what they are supposed to accomplish, how they (as individuals) should contribute to the discussion, and how well the team members will get along. During the storming stage, tension within the team may manifest itself as outright hostility as members question whether other members are doing what they are supposed to be doing, cliques form, and personality conflicts arise. Conflict is alleviated during the norming stage, as members affirm expectations on how the team should pursue its task and how team members should behave. As the name implies, the performing stage is characterized as a period of genuine progress towards team goals.

Members understand and are committed to their individual responsibilities and to the team's overall success. Team members know how to work together and to relatively painlessly deal with unexpected events.

Students should be aware of these stages so they do not become demoralized by the low productivity and personality conflicts that are typical of new teams. Being aware of the five group stages is also important because each stage has implications for the leadership style that works best with it. Faculty should be aware of the instructional strategies appropriate for managing teams in each of the five stages [Stein and Hurd, 2000, pp. 16-20].

C. Exercises

There are several straightforward active learning exercises that can be used to help students learn or to assess how well students have learned the five stages. All three exercises assume students have already read an excerpt from a book that summarizes the five stages. The most obvious exercise is simply to have students individually describe each stage that groups typically experience, during class as part of a quiz or five-minute active learning exercise or for homework.

A better exercise is to have team members first individually describe in writing which stages their team has experienced (using details to support their analysis) and what steps they took or should have taken to better manage team performance through these stages. Next, have team members discuss their answers with other team members. Hopefully, students will realize that their team members had thought of things they had not considered prior to the team discussion. Also, students may appreciate that their teammates have perspectives that are quite different from their own.

A third potential exercise that is less straightforward but potentially more effective is to have students create and perform a series of 2- to 5-minute skits that illustrate behaviors typical of each stage. Having skits performed shortly after teams are formed will ensure students are aware of the stages before they enter the storming stage and will contribute to team building because it encourages a creative and jovial approach to the assignment. The assignment can be made on the first day of class with teams required to perform their skits at the first lab session. The teams not performing at the time can huddle for five minutes after each skit to identify all the typical behaviors exhibited in the skits.

D. Recognized Principles of Cooperative Learning

1. Appropriate use of teamwork skills.
2. Regular self-assessment of team functioning.

E. References

(Faculty)

1. Stein, R. F. and S. Hurd, *Using Student Teams in the Classroom*, A Faculty Guide, Anker Publishing Company, Inc., Bolton, MA, 2000, pp. 16-20.

(Student)
2. Phillips, P., "So, Your're Going to be a Member of a Team," *Chemical Engineering Progress*, January 1997, pp. 141-144.
3. Lumsdaine, E., M. Lumsdaine, and J.W. Shelnutt, *Creative Problem Solving and Engineering Design*, McGraw-Hill, New York, NY, 1999, pp. 98-99.
4. Johnson, V.R., *Becoming Engineers and Teaming on Design Projects*, Primus Custom Publishing, 1997, pp. 43-46.
5. Oakes, William C. et al., *Engineering Your Future*, Great Lakes Press, St. Louis, MO., 2000, pp. 520-522.

Module 2: Project Planning

A. Objective

1. To make students aware of the need for explicit planning at the start of a project in order to maximize team success.

B. Discussion

Numerical problems and small projects assigned to teams of engineering students typically can be solved without the team explicitly performing any planning before they begin solving the problem. Larger and more complex projects, however, generally require such planning. The project elements that should be discussed and planned at the start of a large project are shown in the Table 5-1 on the next page.

Of the four project elements listed in Table 5-1, scope and tasks are probably the most critical for student teams. Project scopes that are not explicitly pinned down have a habit of growing or shifting over time, often making it very difficult to complete the project on time. It is important to identify all of the project tasks early in the life of the project to ensure there is sufficient time to complete each task in the proper order. Tasks identified late in the project typically result in a mad rush to complete the rest of the project by the due date.

Once tasks are identified, they should be explicitly scheduled. The range of appropriate scheduling techniques depends on the project and the team. In some cases, merely identifying all of the tasks—that is, creating one big "To Do" list—is sufficient. Often, the estimated durations and task sequencing should be identified so the completion date for each task can be shown on a project calendar or on a Gantt (aka Bar) chart. Scheduling for large and complex projects is typically performed using the Critical Path Method (CPM), but this technique requires several hours of instruction before students can be expected to use it. (Ambitious students could probably teach themselves using the tutorial on Microsoft Project.)

Table 5-1. Key Project Elements to be Managed

Element	Description	Examples from a Senior Design Project
Scope	What constitutes project completion? What must be included in the final product? What items potentially associated with the final product are NOT to be included in the project?	Capstone design projects typically include the amount of calculations and drawings necessary to convey the team's design intent. Student teams are not expected to produce the number and quality of engineering drawings that would be produced for a "real" project in industry.
Goals	Typical industry project goals include accomplishing the project by the completion date, within budgeted manhours, and meeting quality specifications.	Student projects typically do not have manhour or cash budgets. Instead, students may establish the goals of completing the project in as few hours as possible (so they can work on other classes) while still earning an "A" on the project.
Tasks	Tasks are the discrete steps necessary to achieve the project completion.	Tasks in a capstone design project may include identifying design constraints, concept design, detailed calculations, writing design report, etc.
Resources	Typical industry project resources include the capabilities provided by each team member, budgeted cash, equipment and materials available to the team.	Resources for student projects typically include the team members' skills, lab and computer equipment, and external information resources such as the library, the instructor and the World Wide Web (WWW).

C. Exercises

1. 5-minute in-class exercise: After "lecturing" on the elements of project management, have students perform a Think-Pair-Share exercise in class identifying the scope, goals, tasks and resources for a small, non-technical project, such as planning a party.
2. 1-hour team homework: Have teams hand in a plan for a major project, including listing tasks, identifying the duration, resources and logic (precedence) for each task, and preparing a Gantt chart. Possible projects include their capstone design, a group term project, or a fun project that they would all be familiar with.
3. 1-hour team homework: After or near the completion of their major class project, have teams submit a 1-2 page analysis of how their project planning could have been improved. Students should address whether they specifically performed task identification, duration estimating and resource assignment and, if they did, whether their planning was accurate.

D. Recognized Principles of Cooperative Learning

1. Positive interdependence.
2. Individual accountability.
3. Appropriate use of teamwork skills.
4. Regular self-assessment of team functioning.

E. References

(Faculty)

1. Lewis, J.P., *Project Planning, Scheduling and Control*," Irwin, 1995.
2. Shtub, A., J. F. Bard, and S. Globerson, *Project Management: Engineering, Technology and Implementation*, Prentice Hall, 1994.

3. Angus, R. B., N. A. Gundersen, and T. P. Cullinane, *Planning, Performing and Controlling Projects*, Prentice Hall, 2000.

(Student)

4. GOAL/QPC and Joiner Associates, Inc., *The Team Memory Jogger: A Pocket Guide for Team Members*, First Edition, GOAL/QPC, Methuen, MA, 1995, pp. 64-70.
5. Chapter One in Microsoft Project Users Manual.

Module 3: Effective Meetings

A. Objective

1. To make students aware of the ways to make project meetings efficient and effective.

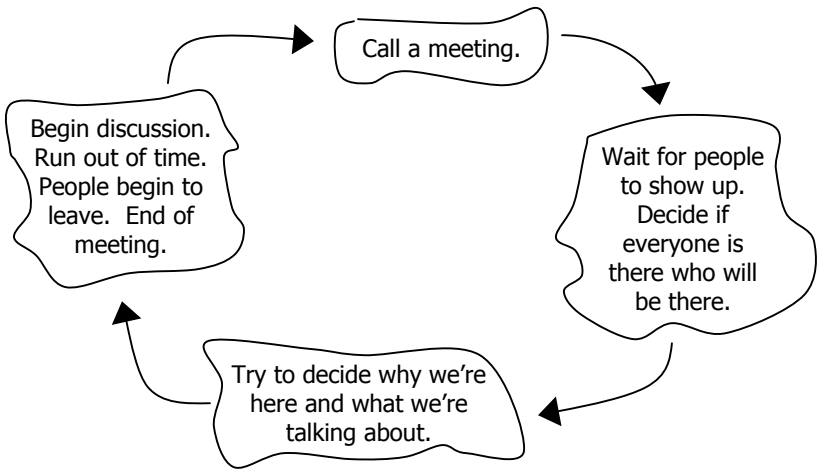
B. Discussion

One of the principles of cooperative learning is that teams will have frequent face-to-face interaction. But the difficulty of finding times when all team members are available may cause some student teams to try to communicate and make decisions solely through email. It is therefore important that the instructor require teams to meet regularly.

In light of the difficulty of scheduling meetings, it is important that meetings are as efficient (that is, they accomplish the meeting's agenda in the shortest time) and as effective (that is, the decisions made are good decisions) as possible. Effective team meetings are like effective teaching in that both do not happen by accident. Both require preparation, an explicit agenda and rules governing behavior during the session. Students need to understand the elements necessary to achieve effective team meetings.

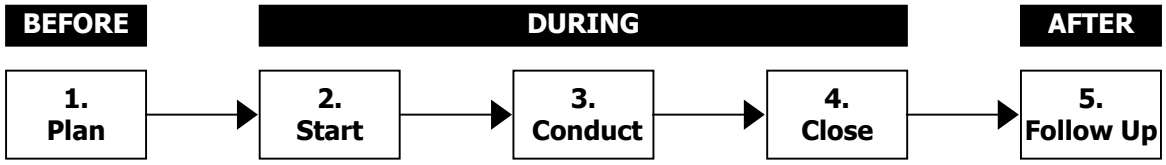
Before summarizing the key elements for an effective meeting, it may be helpful to consider the wrong way to hold a meeting, as given in the Team Memory Jogger [GOAL/QPC, 1995, p. 71]:

Wrong Way to Hold Meetings



Unfortunately, we have all experienced these situations many times – meetings that go around in a circle without accomplishing the goals!

The Team Memory Jogger [GOAL/QPC, 1995, 74-75] suggests that a key step toward holding effective meetings is to follow a proper meeting process:



1. **Plan** – Set date, time, location, agenda, and who will attend.
2. **Start** – Start on time, review agenda, and assign roles.
3. **Conduct** – Cover one item at a time, manage the discussion and maintain focus.
4. **Close** – Summarize decisions and action items and schedule next meeting.
5. **Follow up** – Distribute minutes and perform action items.

Two of the items included in Step 2 above deserve further discussion. Establishing a realistic **meeting agenda** before the meeting begins is critical. There are two common agendas that may be followed. One option is the traditional meeting agenda, which includes approving the minutes of the last meeting, discussing old business then new business, etc., as reflected in the **Sample Instructions for Team Minutes** shown below. A second option is the project progress agenda, which focuses on the project schedule. Specifically, each task is discussed regarding its scheduled percentage complete versus it actual percent complete, resource conflicts, and other potential problems. Critical tasks—those that most directly affect the project completion date—should receive the most attention.

The second key item included in Step 2 above is the assignment of **explicit roles** for each meeting. Most of the literature suggests at least two specific roles be assigned (see, for example, pages 79-81 in the Team Memory Jogger), and that these roles be rotated among team members to provide each student with the opportunity to practice each role.

1. Facilitator – Opens meeting, reviews agenda, confirms notetaker, manages discussion of one item at a time, and closes meeting.
2. Notetaker/Timekeeper – Captures key points for each agenda item, including what is decided and why, informs team when time spent on an agenda item exceeds budgeted time, and distributes minutes shortly after meeting.

C. Exercises

1. 10-minute Team Exercise: Prior to the teams starting to work on an assignment, have each student describe to his/her team members in two minutes the most effective and least effective meetings they have ever participated in.
2. 30-Minute Individual Exercise: Have each student act as a facilitator at a team meeting early in the life of the project. The student should describe in approximately

one page the preparation she performed, the agenda she established prior to the meeting, the results of the meeting, and how the meeting could have been improved.

3. 40-Minute Team Exercise: A variation on the previous exercise is to have the minutes from the meeting that the student ran reviewed at the next team meeting, then to have the student lead a 5-10-minute discussion on how the meeting could have been improved. The student would then hand in a copy of the minutes and a half page summary of the post-meeting review discussion.

Sample Instructions for Team Minutes

Your team should meet at least once a week. It is the responsibility of the facilitator to run the next meeting, making sure that everyone knows the date, time and place. When the team meets, an individual will be assigned the task of notetaker or scribe. The scribe takes notes which includes:

- ***Administrative***
  List team name, date, time and place of meeting. List individuals present. Who was absent and why. (Was team informed?) List meeting facilitator, notetaker, timekeeper and any other roles assigned.
- ***Old business***
  What is the status of assigned activities? What are the major objectives or plans? Scribe should summarize the discussion with focus on final decisions, problems encountered and problems solved.
- ***New business***
  Discuss topics for the next meeting. Assign new tasks/action items.
- ***Adjournment***
  Decide on next meeting's date, time and place. Appoint a new facilitator for the next meeting. We recommend that the team rotate the roles. The facilitator reminds the team members of the next meeting and makes sure they attend.

D. Recognized Principles of Cooperative Learning

1. Face-to-face interaction.
2. Appropriate use of teamwork skills.
3. Regular self-assessment of team functioning.

E. References

1. GOAL/QPC and Joiner Associates, Inc., *The Team Memory Jogger: A Pocket Guide for Team Members*, First Edition, GOAL/QPC, Methuen, MA, 1995, pp. 71-86.
2. Lumsdaine, E., M. Lumsdaine, and J.W. Shelnutt, *Creative Problem Solving and Engineering Design*, McGraw-Hill, New York, NY, 1999, pp. 112-113.
3. Johnson, V.R. *Becoming Engineers and Teaming on Design Projects*, Primus Custom Publishing, 1997, p. 63.

Module 4: Meeting Minutes

Note to reader: Module 6 in Chapter Two addresses documenting of teamwork over the life of the project, such as through a team notebook. This module addresses documenting only the results of team meetings.

A. Objective

1. To make students aware of the need to document project meetings.

B. Discussion

It is human nature to leave even a highly enjoyable and productive meeting and, within two hours, forget some or all of the decisions made at the meeting. For a meeting to be considered truly effective, all team members must accomplish the tasks assigned to them at the meeting. Also, to prevent future second-guessing of decisions and to communicate the decisions made to team members who could not attend the meeting, all decisions and task assignments should be documented in meeting minutes and distributed to team members.

C. Exercises

1. 5-minute in-class exercise: After students have read about or heard about documenting meetings in class, have them list the items that should be included in meeting minutes as a Think-Pair-Share exercise.
2. 5-minute in-class exercise: After students have read about or heard about documenting meetings in class, have students Think-Pair-Share about the last meeting they attended and how many of the details they can remember.
3. Have each student act as a notetaker at a team meeting and to submit a copy of their minutes. Probably the easiest way to make this happen is to ask students to copy (cc:) the instructor on emails that distribute meeting minutes.

D. Recognized Principles of Cooperative Learning

1. Individual accountability.
2. Regular self-assessment of team functioning.

E. References

1. GOAL/QPC and Joiner Associates, Inc., *The Team Memory Jogger: A Pocket Guide for Team Members*, First Edition, GOAL/QPC, Methuen, MA, 1995, pp. 87-91, 108-110, and 120-121.
2. Lumsdaine, E., M. Lumsdaine, and J.W. Shelnutt, *Creative Problem Solving and Engineering Design*, McGraw-Hill, New York, NY, 1999, p. 113.

Module 5: Characteristics of Effective vs. Dysfunctional Teams

A. Objective

1. To increase students' awareness of ways they can make their team most successful.

B. Discussion

While no two teams are alike and things that work for one team may fail in another, there are general, controllable characteristics that distinguish high-performing teams from low-performing teams. Parker (1996) suggests that the characteristics shown in the attached evaluation sheet characterize effective teams.

C. Exercises/Assessment

1. 5-minute in-class exercise: Have students Think-Pair-Share about the effective versus dysfunctional characteristics identified in the readings and compare them with their own experiences with groups outside of the class.
2. 1-hour Homework: Have each team submit a 1-2 page memo that describes the effective versus dysfunctional characteristics identified in the readings and compares them with their team's experiences.
3. 15-minute in-class exercise: Have small groups of students use the following evaluation sheet to analyze videotaped skits of effective, ineffective, and mixed teams.
4. Have students create and perform skits of effective, ineffective, and mixed teams. Classmates not giving the skits can use the following evaluation sheet to analyze the teams shown in the skits, spending five minutes between skits comparing their scores.

D. Recognized Principles of Cooperative Learning

1. Positive interdependence.
2. Individual accountability.
3. Face-to-face interaction.
4. Appropriate use of teamwork skills.
5. Regular self-assessment of team functioning.

E. References

1. GOAL/QPC and Joiner Associates, Inc., *The Team Memory Jogger: A Pocket Guide for Team Members*, First Edition, GOAL/QPC, Methuen, MA, 1995, pp. 136-160.
2. Oakes, William C. et al., *Engineering Your Future*, Great Lakes Press, St. Louis, MO., 2000, pp. 518-519 and 523-528.
3. Parker, G.M., *Team Players and Teamwork*, Josey-Bass, 1996, Chapters 2 to 4.
4. Lumsdaine, E., M. Lumsdaine, and J.W. Shelnutt, *Creative Problem Solving and Engineering Design*, McGraw-Hill, New York, NY, 1999, pp. 101-106.

5. Johnson, V.R., *Becoming Engineers and Teaming on Design Projects*, Primus Custom Publishing, 1997, pp. 42-43.

CHARACTERISTICS OF AN EFFECTIVE TEAM[6]

The following characteristics should be rated by team members on a 7 point scale, where 1 = never, 4=about half the time, and 7 = Always.

Characteristic	Skit 1	Skit 2
Clear purpose: The vision, mission, goal, or task of the team has been defined and is accepted by everyone. There is an action plan.		
Informal climate: The climate tends to be informal, comfortable, and relaxed. There are no obvious tensions or signs of boredom.		
Complete participation: There is a lot of discussion, and everyone is encouraged to participate.		
Effective listening: The members use effective listening techniques such as questioning, paraphrasing, and summarizing to get out ideas.		
Disagreement and resolution: There is disagreement, but the team is comfortable with this and shows no signs of avoiding, smoothing over, or suppressing conflict.		
Consensus decision making: For important decisions, the goal is substantial, but not necessarily unanimous agreement through open discussion of everyone's ideas and avoidance of formal voting and easy compromises.		
Open communication: Team members feel free to express their feelings on the task as well as on the group's operations. There are few hidden agendas. Communication takes place outside of meetings.		
Clear roles and assignments: There are clear expectations about the roles played by each team member. When action is taken, clear assignments are made, accepted, and carried out. Work is fairly distributed among team members.		
Shared leadership: While the team may have a formal leader, leadership functions shift from time to time depending upon the circumstances, the needs of the group, and the skills of the members. The formal leader models the appropriate behavior and helps establish positive norms.		
External relations: The team spends time developing key outside relationships, mobilizing resources, and building credibility with important players in other parts of the organization.		
Style diversity: The team has a broad spectrum of team-player types including members who empathize attention to tasks, goal setting, a focus on process, and questions about how the team is functioning.		
Self-assessment: Periodically, the team stops to examine how well it is functioning and what may be interfering with its effectiveness.		

[6] Source: "Team Players and Teamwork" by G. M Parker. Jossey-Bass: 1996.

Chapter 6. Faculty Issues and Tips

This chapter provides advice on how instructors can integrate teamwork into their courses. Modules are present on the design of problems for teams, the use of assessment and evaluation, and the motivation of teamwork.

Module 1: Constructing Problems Appropriate for Teams

A. Objective

To help faculty members recognize the elements of a good team problem, and give them tools to help construct such problems.

B. Discussion

A key to cultivating good teamwork in the classroom is having good problems on which the teams can work. Given a problem which can be just as easily solved by one person, even students who are committed to teamwork will be tempted to let the person-who-wants-to-do-it-all have his or her way. Problems may also be poorly constructed by being too complex, or too linear (requiring that one team member wait until another is done). A good problem, on the other hand, can foster teamwork, as students realize that they actually need each other to accomplish their goal. Further, it will help them realize that the team member tasks discussed previously in Chapters 2 and 5 are useful in getting the job done. A well-constructed problem can be the carrot that compliments the stick of a course grade.

The characteristics of a good team problem [Hoyt, 2001] include ones that:

1. motivate students to learn,
2. require decision making,
3. require cooperation,
4. encourage interaction, and
5. achieve learning/course objectives.

In the above list, Elements 1, 2, and 5 deal with the course design, and are relatively easy to achieve. Items 3 and 4, on the other hand, can be quite tricky, but their integration into problem designs can be gauged by student feedback. Cooperation, interaction, and feedback will be discussed next in this module. Then, four application areas are presented that outline ideas for the construction of good team problems.

Fostering Cooperation

Good problems require that team members cooperate with each other. While we hope that our students might do this naturally, the most effective way to insure their cooperation is to design the problem such that it is not possible for it to be solved by a single person. Some possible ways in which this can be achieved include:

- Time constraint: A problem could be done by an individual given sufficient time; however, teamwork is required to complete the task by the end of the allowed period.
    - Good method for in-class problems.
    - A good method for lower-level problems (knowledge, comprehension, application).
    - Good "beginner" method.
- Assignment constraint: The assignment is given in such a way that individuals must work together in order to complete the task. That is, each student is assigned a team task, and held accountable for its completion (e.g., you ask the recorder for his or her notes at the end, etc.)
    - Requires supervision by the instructor.
    - Acceptable at start and/or as part of any of the other problem designs, but otherwise not preferred because it does not motivate teamwork intrinsically (students work together to make instructor happy, not because it is perceived as useful for them).
- Expertise constraint: In order to complete the assignment, teams composed of "experts" in different areas are needed. Each student on a team either is or will become an expert in a given area, and then shares that knowledge with the other team members.
    - A good intermediate level teamwork exercise.
    - Can be used in-class, although it usually requires more than one class period/homework to develop "expertise."
    - Needs significant instructor input to identify/create experts in different fields.
- Complexity constraint: The problem is so complex that a team is required to attack it.
    - Usual method for senior-level design courses.
    - Requires creativity since the solution to the problem needs a diverse set of viewpoints.
    - Needs significant structure (such as combining with "assignment constraint") for use with beginners.

Fostering Interaction

Interaction is separate from cooperation, although they are related. Students, who each take one problem from the homework assignment, solve it by themselves, then copy the solutions from each other are certainly cooperating, but they are not interacting. To get the full benefit from a team homework assignment, they should be working on all of the problems together, discussing them as they go.

The same conditions that encourage cooperation will also encourage interaction as long as positive interdependence has been built into both the problem and the grading

scheme (see Chapter 1). It will also be fostered when the problem solution benefits from multiple viewpoints, which may be expressed by different team members. For problem design, this means that the solution should require creativity and that there should be multiple paths to the solution or multiple answers, and that the students should be aware of this.

Student Feedback: Have you created a "good" problem?

The best way to know if your problem is good is from student feedback. Students are generally not shy about letting you know if a problem was inappropriate for teamwork. You can learn what they think (after the assignment is complete) from a short survey or from student conversations.

Another useful piece of student feedback is the student peer-evaluations that the students turned in as part of their team processing. Reading these forms will allow you to determine if the problem's design did or did not lend itself to shared responsibility, equitably. If the problem was poorly designed, many teams will have members who are rated poorly for not having done enough work. You will also possibly receive notes from these people saying there wasn't enough work for them to do.

You can also assess the goodness of your problems by observing the students at work. They will have an easier time staying on-task and acting in their team roles if the problem is well designed. (While walking through the classroom, one can informally measure the N_{ESPN}, a dimensionless quantity that corresponds to the fraction of students discussing sports rather than the problem.)

Finally, perhaps the most important assessment of the goodness of the problem is to look at the final products produced by the student teams. Are they what you expected? Can you see that the final work was the result of multiple contributions?

Creating good problems is an ongoing process; hopefully what follows will set you on the road towards them, but practice will make the creation process easier!

C. Applications

Exercise 1: Ideas for producing time-constrained problems {Bucket Brigade}

Students are given a problem in four (or number of team members) parts or are given four problems. Each student must complete a part before passing the problem along to the next team member. Each of the parts of the problem tests a different level of Bloom's taxonomy (knowledge, comprehension, application). The exercise repeats at least as many times as there are team members so that each team member gets to do each type of problem.

Example 1: To help memorizing concepts during a class period. Person A is given an abbreviation, for which they must produce the definition. Person B must give an example of the concept defined by Person A, and Person C must give another example.

Finally, Person D must perform a simple calculation based on the concept. For example, Symbol T is shown; Person A states "temperature"; Person B says 30ºC; Person C says 45 K; and Person D converts 30ºC into K.

Example 2: For an in-and-out-of-class activity, four moderately complex problems (equivalent to the more difficult textbook homework problems) are assigned, and a team of students applies a problem-solving methodology to solve them. For example, sophomore students in chemical engineering must learn to apply the principle of material balances to solve well-defined problems. They must distinguish between different types of systems—continuous with no chemical reaction, batch, semi-batch, and continuous with chemical reaction. Starting with the fundamental conservation law of matter, students can write material balances based on mass, moles, or atoms. An instructional strategy is designed to explicitly practice the six steps of a problem solving methodology that results in a conceptual diagram, a mathematical model, a mathematical algorithm, a numerical solution, some heuristic observations, and formal documentation. If a four-member team is assigned a two-week project that contains four problems (P1, P2, P3, P4) to solve the material balances for four different systems, then each lecture period can be devoted to each step in the problem-solving methodology, as illustrated in the following diagram:

Project:	**First Week**			**Second Week**		
Student	**Monday**	**Wednesday**	**Friday**	**Monday**	**Wednesday**	**Friday**
Mary	Diagram, P1	Model, P2	Algorithm, P3	Solution, P4	Heuristics, P1	Document, P2
Mike	Diagram, P2	Model, P3	Algorithm, P4	Solution, P1	Heuristics, P2	Document, P3
Beth	Diagram, P3	Model, P4	Algorithm, P1	Solution, P2	Heuristics, P3	Document, P4
Jack	Diagram, P4	Model, P1	Algorithm, P2	Solution, P3	Heuristics, P4	Document, P1

At each lecture period, all students are focusing on the same step in the problem-solving methodology, but each is doing it on a different problem. Before a lecture period, a team member must develop a draft outside of class and bring it to the lecture period. These drafts are used to focus the discussions and then plan for the next period. When team members move to the next lecture period, they will all have the same focus but on a different problem. At the end of the two weeks, all team members will have worked on all four problems and interacted with each other. In the sixth period, teams can be required to spend time doing self-assessment of their team functioning. Students are told that on the next exam one problem will be on material balancing, and that they must solve it by themselves. This highly-structured instructional strategy incorporates all five tenets of cooperative learning and provides guided practice in the problem-solving methodology. It also allows deep learning to occur; that is, team members learn more collectively than what an individual could learn over the same two-week period.

The benefit of this method is that it is a succinct way to insure students learn about low-level material. It is also a good introduction to teamwork and interdependence, and can be a lot of fun if you run it as a race. The difficulty of this method is that it requires instructor effort to make it work, because it may be too easy for one person to do by himself or herself if he or she is allowed to.

This problem type can be used outside of class as well, on slightly more complex material, however it becomes harder to verify that the students actually shared the work.

Exercise 2: Ideas for producing assignment constrained problems

This can be used with pretty much any problem, from a simple in-class problem to an end of semester project. The goal is to create a grading scheme in which each individual's grade is highly dependent on a given part of the project while, a large portion of his or her grade is still dependent on the work as a whole. For example: in a lab/design report, Person A is responsible for introduction/conclusions; B is responsible for background/motivation; C is responsible for results/discussion. Then, 50% of A's grade is based on A's section, while 25% apiece comes from the other two sections.

The benefits of this method are that it encourages positive interdependence, while automatically creating a well-framed problem for three (or however many) people. It is also easy to grade and assign individual credit. However, it can be tricky to insure that the different tasks are all of approximately equal difficulty. This issue can be mitigated by rotating the different tasks between team members over the course of the semester. It can also generate some resentment among students who see having a part that is assigned to them as "theirs", such that they do not want anyone else to share credit for it and do not want to be graded on other peoples' work (cooperation without interaction).

Exercise 3: Ideas for expertise constraint problems

Jigsaw Method [Millis and Cottell, 1998] {no pre-existing knowledge}

A student from each team becomes part of a larger group that is sent off to learn more about a given topic. They then return to their team and share their new knowledge. This can work as a relatively short in-class exercise or as part of a longer term, out of class, project.

Example 1: In class, students in each group are given a different short article on the topic. The large groups then try to answer specific questions from their article. Students then return to their teams, and share and discuss each group's answers to the questions. Positive interdependence and individual accountability can be created by including questions from each group's area on a homework or quiz.

Example 2: Out of class, students are asked to research or attend a special class on their particular topic. Then teams reassemble to work on their project, which requires experts in each field.

This method as a whole encourages positive interdependence, cooperation, and interaction, and breaks a large problem into individual parts in an obvious manner. It is a good way to cover 3 to 4 times the material that one would in a straight lecture. This method does require significant preparation by the instructor, who needs to be able to coach in all areas of student expertise. Also same size teams are needed; if all teams have

four students except one which has three, special arrangements will have to be made to keep that group from missing a quarter of the material.

Jigsaw Method [Millis and Cottell, 1998] {pre-existing knowledge}

In this scenario, students from different disciplines/backgrounds are brought together to complete a task. The instructor assembles the teams such that each student brings to the table something needed to complete the project.

Example 1: The instructor knows that certain students have taken a class in which they needed to build a web page. In the current class, teams are built with one person having HTML experience per team.

Example 2: Class contains students from mechanical, electrical, and chemical engineering. Each team contains at least one student from each discipline to work on the integrated project.

This method more closely mimics the situation that graduates will find in the work place, and gives them a chance to appreciate the talents of individuals who have studied different topics. However, it can be difficult to obtain exactly the right mix of students in a particular class. Also, scheduling problems for team members outside of class are magnified when interacting across disciplines.

Exercise 4: Ideas for complexity constrained problems

Problems which use their complexity to require teamwork are the easiest to come up with, but can be difficult to implement in such a way that the students are not overwhelmed. To create a problem, use a "real world" situation, and leave the solution open-ended. When introducing the students to this sort of problem, it is helpful if they have been exposed to a problem solving methodology previously.

Example 1: For a lower-level class, or with students not familiar with open-ended problems, you want to put some constraints on the problem statement, and give some hints as to what you want in the solution. "Design a power plant to produce 10 mega-watts. It should meet all applicable regulatory criteria (as discussed in class). The power plant may use water, wind, or nuclear energy as its power source. You may assume that money is not a constraint, and that an appropriate location is available. Your report should include an introduction, your final design and justification, and calculations."

To complement this problem, you should have discussed the "regulatory criteria" as well as the basics of the three different possible designs in class. You might also assign a report section to each team member.

Example 2: For a senior design course, where the students have encountered problems such as those in Example 1 previously, you can be much more general.

"Design a power plant to produce 10 mega-watts. It should meet all applicable regulatory criteria." However, a framework should still be provided for team roles.

The benefit of this type of problem is that students gain practical experience working on the sort of problems that they will encounter in the workplace. Also, students often appreciate the opportunity to tackle something "real" on which they can use their creativity. To prepare for these sorts of problems, it is important for the instructor to do a lot of background work, to insure that the students will have access to the materials they will need to conquer the problem. Maintaining a supportive environment, where the students view the instructor as on the same side, battling the problem, as opposed to an environment where the students see the instructor as all knowing (but just not sharing it), is key to success.

D. References

1. Brian Hoyt, "Problem-Based Learning: How to Get Started," A Project Catalyst PowerPoint Presentation found on the Workshop CD-ROM, College of Engineering, Bucknell University, Lewisburg, PA, 2001.
2. Millis, Barbara J. and Philip G. Cottell, Jr. *Cooperative Learning for Higher Education Faculty*. American Council on Education and The Oryx Press, Phoenix, AZ, 1998, pp.126-132.

Module 2: Assessment and Evaluation

A. Objectives

1. To understand the three levels of evaluations.
2. To illustrate some assessment techniques for these levels.

B. Outcomes

3. Instructors will be able to judge the beginning abilities of students.
4. Students will be able to do self-reflection while working in a team.
5. Instructors will be able to monitor the learning progress of their students.
6. Instructors will be able to evaluate the performance of each student.

C. Discussion

What is assessment? What is evaluation? How do they differ? What roles do they play in a cooperative learning (i.e., a teamwork) environment? One definition for *assess* found in most dictionaries is "to estimate or determine the significance, importance, or value of; evaluate." A definition for *evaluate* is "to judge or determine the worth or quality of; appraise." A synonym for assess is evaluate and vice versa. For our context, we will make a clear distinction between these two terms. Assessment has to do with determining if one has reached his or her goals or outcomes. Evaluation is judging the quality and possibly assigning grades.

Any instrument designed or required by an instructor with the purpose to assess learning and then used or produced by learners will be called an assessment technique. The purpose of this instrument is to assess or determine whether learners have completed a learning outcome or set of learning outcomes. With respect to our definition and use of assessment, nothing is implied about the quality of the student-completed product or the process used to develop it. Exams, homeworks, lab reports, and oral presentations are examples of traditional assessment instruments. Surveys, chat rooms, progress memos, technical journals, and teamwork feedback are other examples.

Once learners have completed assessment products, an instructor may evaluate or judge the quality of those products or the process that led to their development. Evaluation can occur at three levels—diagnostic, formative, and summative. Diagnostic evaluation usually takes place at the beginning of a course, and it usually is a measure of how well the students know the prerequisites. Formative evaluation is done during a learning unit, and it is a measure of how things are going with respect to the specific learning outcomes. Summative evaluation is done at the end of a learning unit such as the first exam or a course, and it is a measure of students' level of performance and their mastery of specified learning outcomes.

Once instructors have designed assessment instruments for specific learning outcomes, they will use those instruments to conduct diagnostic, formative, or summative evaluation, or they may require students to use them to engage in self reflection (i.e., self evaluation). In

either case, the diagnostic and formative evaluations are intended to help plan for enhancement activities, either by the instructor, the students, or both. The summative evaluations usually are used to determine students' grades.

Most of the following material is taken directly from *Cooperative Learning for Higher Education Faculty* by Millis and Cottell [1998]. This material outlines Classroom Assessment Techniques (CATs or assessment instruments in our terminology), which give instructors particularly useful ways to ascertain the effectiveness of what they and the students are doing in a course, particularly if instructors are experimenting with any new method of instruction like cooperative learning. As stated by Millis and Cotell, "these techniques are designed to find out how well students are learning and, based on this information, to make midcourse adjustments in teaching to improve their learning."

Before any diagnostic, formative, and summative evaluations can be done, information must be gathered using Classroom Assessment Techniques (CATs); that is, using assessment instruments. The techniques particularly useful for the cooperative learning environment can be classified into four categories—those for the beginning of the course, those to assess the group processing function for teamwork, those to monitor student learning of specific material or comprehension of learning objectives, and those for doing traditional summative evaluations.

D. CATs Useful for Course Beginnings

An instructor can use the follow techniques in the first couple of classes. They help to break the ice and set the stage for what is to come in the cooperative learning environment. Three techniques are outlined below—goal exercise, knowledge probe, and learning style inventory.

1. Goal Ranking and Matching Exercise [Millis and Cottell, 1998, pp. 44-45]

This technique helps to establish communication between instructors and students with respect to course expectations. The assessment instrument is a form as given by Millis and Cottell and illustrated in Exhibit A. The procedure is as follows:

a. Students work individually to write their individual goals for the course on the form. Then, to reinforce the cooperative-learning process and to further student connections, students discuss their goals with another person and possibly revise them.

b. The instructor shares with students his or her own course-related goals using handouts or slides. At this point, students are asked to determine the degree of match between their goals and the instructor's using the form.

c. Finally, the instructor can initiate a whole-class discussion focused on the shared goals and those student goals that do not match the instructor's.

Exhibit A. Goal Ranking and Matching Exercise

What do you hope to get out of this course? Will it address your needs and expectations? This is a Classroom Assessment Technique designed to help you identify your expectations and share them with the instructor and each other. You will also find out what the professor's goals are for this course, and see how well those goals match yours.

1. On the lines in the left-hand column below, please list three or four goals you hope to achieve—things you hope to learn or questions your hope to raise—through participation in this course.

Your Goals for this Course	Your Ranking of Importance	Do they Match the Professor's	
		YES	NO
		YES	NO
		YES	NO
		YES	NO
		YES	NO

2. Now, using the middle column above, rank your goals in terms of their relative importance to you. Make the most important goal #1, the next most important goal #2, and so on.

3. As you hear the instructor's goals, circle "YES" in the right-hand column next to each of your goals which matches one of those listed. If you end up with goals that the teacher has not mentioned, circle "NO" next to them.

4. Prepare to talk about any important goals you have which are not included in the professor's list of goals and/or to ask questions about these goals.

Reference: Angelo, T. A. and Cross. K. P. Classroom Assessment Techniques: A Handbook for College Teachers, 2nd Edition. San Francisco: Jossey-Bass, 1993, pp. 290-294.

Collecting these anonymous forms helps the instructor to evaluate the needs and desires of the students. This activity also helps students identify and clarify their own learning goals.

2. Background Knowledge Probe

This technique helps to determine the most effective point at which to begin instruction and to provide feedback on the range of preparation among the students in the class. This assessment instrument can take one of two forms—a questionnaire or a test.

Knowledge Questionnaire [Millis and Cottell, 1998, pp. 207-209]

This form of the probe consists of a short questionnaire to which students respond on the first day of class. The following four kinds of questions should be included in the design of this assessment instrument:

a. A personalized "warm-up", such as asking students in their first discipline course to describe what a typical engineer does.

b. Students' preconceptions and misconceptions, such as in what direction does a fluid flow and in what direction does heat flow.

c. Subject-related knowledge at varying levels of difficulty, such as what is the state of a material, what is the ideal gas law, and what is the conservation of mass.

d. Students expectation of the course, such as what do they hope to learn in this course.

The results from this questionnaire help to provide a picture primarily of students' comprehension of conceptual matters. To address students' analytical and rhetorical skills, a knowledge test is required.

Knowledge Test

This form of the probe consists of a short test which students complete in the second week of class. In designing this assessment instrument, an instructor wants to discover how well the students understand the prerequisite skills needed for the course. Some types of questions to include in this assessment instrument address:

a. mathematical and numerical analysis skills,

b. statistical analysis and graphing skills,

c. fundamental skills from the sciences, and

d. composition skills.

Students are told on the first day of class what topics will be covered in the knowledge test, and they are asked to prepare for the test, which is usually given in the second week of the course. For individual accountability, the instructor also informs the

students how the results of the test will count towards their final grade in the course (e.g., as several homework assignments or a percentage of the final grade).

Team Formation [Millis and Cottell, 1998, pp. 208-209]

The results from the knowledge questionnaire or test can be used in the formation of teams. Four piles can be created—erroneous background knowledge, no relevant background knowledge, some relevant background knowledge, and significant background knowledge. The instructor can assign students to heterogeneous structured-learning teams by selecting one completed instrument from each pile. At this point, the instructor may wish to use other factors such as student gender, ethnicity, or other background characteristics to increase diversity in the team membership.

3. Learning Style Inventory and Team Contract

This technique helps students to identify their preferred style of learning and appreciate the fact that students have different learning styles. Several inventory instruments exist—Kolb's Learning Styles, Herrmann's Thinking Styles, and Felder's Index of Learning Styles— that an instructor can choose from. A learning style inventory, team dynamics, and team responsibilities can be coupled to help teams create a contract. The procedure to follow could be:

a. have students take the inventory outside of class and bring printed copies of the results for distribution to their team members and the instructor at the next class period.

b. have students study outside of class the development cycle of a team (i.e., forming, storming, etc.) and require them to complete individually a survey or quiz on the topic before the next class.

c. have students study outside of class the pocket guide for team members called The Team Memory Jogger and require them to complete a survey on the topic before the next class.

d. have an in-class cooperative activity to discuss the above three topics.

e. have the teams generate a contract which each member signs. A signed copy is given to each team member as well as the instructor.

The team contract is an assessment instrument that members can review periodically to evaluate how their team is performing, and instructors can use it to mentor teams when they are having difficulties.

E. CATs Useful for Assessing Group Processing

An instructor can use one or more of the follow techniques to facilitate group processing in a team, the fifth tenant of cooperative learning. As the instructor, you will want to gather from the students their perceptions of how well the team is progressing and how well you are

accomplishing teaching using a team environment. Three techniques are outlined below—group instructional feedback, group processing form, and the team developer.

1. Group Instructional Feedback Technique [Millis and Cottell, 1998, pp. 210-211]

This technique focuses on the effectiveness of the instruction using a team environment. Three simple questions are used for this CAT:

a. What specific things does the instructor do that really helps you learn from teamwork?

b. What specific things does the instructor do that make it more difficult for you to learn from teamwork?

c. What are one or two specific, practical changes that we could make to help you learn better in your team?

This assessment technique not only can provide feedback when there are problems in a class, it also gives students a chance to take more responsibility for suggesting solutions.

2. Group Processing Form [Felder and Brent, 2001, p. E-15]

This form is designed to determine those students who have been active and cooperative members as well as to identify those students who do not participate. Felder has developed this form based on one presented by Millis and Cottell. Each student assesses the performance of each team member, filling out one form per member. A scale of "never, rarely, sometimes, usually, and always" is used by a team member to answer the following questions:

a. Has the student attended your team meetings?

b. Has the student notified a teammate if he/she would not be able to attend a meeting or fulfill a responsibility?

c. Has the student made a serious effort at assigned work before the team meeting?

d. Does the student attempt to make contributions in team meetings when he/she can?

e. Does the student cooperate with the team effort?

This assessment technique then concludes with asking for an overall rating on the student. When a team has worked together for at least a month, the team members fill the forms out and exchange and discuss them with one another. You, the instructor, do not see them; they mainly give students an opportunity to do group processing, in order to enhance the performance of the team as well as each member in the team.

This assessment form is meant to give students an opportunity to practice evaluating one another and then take self-corrective action when need. It is best to have a team do this group assessment several times, before they peer rate their team members on

team projects or homeworks. This peer rating can be used to make individual adjustments to the team grade on a project or set of homeworks.

3. The Team Developer [McGourty and De Meuse, 2001]

This assessment technique takes a holistic approach to group processing. It is a student guidebook for team assessment and interpersonal skill development. McGourty and De Meuse present a model based on four specific behaviors that have an impact on team performance. Special attention is given to defining these behaviors and describing various roles members need to perform to maximize team performance. In support of this model, the authors provide a computer-based survey from which feedback reports can be generated for each team member.

This computer-based survey system called The Team Developer consisting of numerous items, selectable by the instructor, that relate to the four behavioral categories: (a) communication, (b) decision making, (c) collaboration, and (d) self-management. Team members use a 1- to 5-point rating scale to anonymously rate themselves and all of their fellow team members on various team behaviors. Based upon those ratings, each team member receives a confidential feedback report. The report summarizes how each person sees himself or herself, as well as how their team members collectively perceive them.

Based on the feedback students receive from their teammates, they are encourage to prepare a carefully developed plan (i.e., an action plan) to enhance their team skills. Unless they make a concerted effort to understand the feedback results and focus on individual improvement, The Team Developer system will not benefit them. However, those students who are motivated and conscientious would benefit from using this system.

In the spirit of cooperative learning, team members (and consequently the whole team) would benefit greatly by sharing individual Feedback Reports and Action Plans with each other. The feedback provided by The Team Developer enables teams to discuss overall patterns of member results to determine whether various team members are meeting all 10 team roles for effective performance of a team as defined by McGourty and De Meuse. If not, a team might deliberately decide to assign specific roles to certain team members. From a team perspective, it is necessary that all 10 roles be performed. However, it is not necessary that all members of the team individually perform all 10 roles. This evaluation by the team should strength their bond and effectiveness.

F. CATs Useful for Assessing Student Learning [Millis and Cottell, pp. 211-218]

As stated by Millis and Cottell, these assessment instruments are used "to provide faculty and students with the information and insights needed to improve teaching effectiveness and learning quality. Instructors analyze feedback gleaned from CAT's and use it to make adjustments in their teaching. They also share that feedback with the students in order to

help them improve their learning strategies, learning skills, and study habits." Millis and Cottell present nine CATs to assess student learning. They all are particularly useful to do formative evaluations in a cooperative learning environment. Four of them are outlined below:

1. Minute Paper

This technique helps to get written feedback on two or three questions about a specific class session or topic. Instructors typically ask variants to two questions:

a. What was the most important thing you learned today?

b. What questions still remain unanswered?

The Minute Paper usually takes three to five minutes, depending on the difficulty of the learning to be assessed. Instructors should give students the option of responding anonymously on the Minute Papers. Feedback should be provided in two forms—individually for those who provided their name and collectively for those who did not.

As students grow accustomed to the idea that they must identify and express concepts and pinpoint things that remain unclear, they focus more upon their own learning processes. This metacognitive awareness helps them become better learners.

2. Muddiest Point

This technique is a variation of the Minute Paper, and it provides information to the instructor about what students find least clear about a particular lesson or topic. The instructor asks the students to respond to a single question. For example, "What was the most confusing point in the cooperative activity you just completed?" or "What was the most confusing point in the lecture you just heard?"

An instructor can ask this question by itself or possibly include it as one of the questions in the Minute Paper. Feedback from the "muddiest point" helps the instructor to discover which points are most difficult for students to learn and to guide decisions about what topics to emphasize and how much time to spend on each.

3. Feedback/Participation Form

This technique offers instructors the flexibility to probe student understanding of the course content while assessing group processing. It is a more elaborate adaptation of the Minute Paper. An example form is illustrated in Exhibit B. The form has two parts: one for course content where the student can ask a question of the instructor and the other for the group processing of course content where the student can comment on the team's cooperative learning activities.

This form may be easily modified to fit any classroom situation and/or instructor question. Changing the form from time to time discourages students from simply checking the boxes rather than carefully considering the questions.

Exhibit B. Feedback/Participation Form

If you prefer, you may omit your name, section, and team.

Name: _____ Section: _____ Team: _____

1. _____ I have the following question relating to:

   _____ Text Material (page/section _____)

   _____ Lecture Material and/or Class Discussion

   _____ Problem Material (Which one? _____)

   My question is:

   _____ I do no have a question today—I am all set.

2. How well do you understand the material you covered in your team today?

   _____ I understand all of it!

   _____ I understand most of it!

   _____ I am so confused!

   Comments:

This form is adapted from a form developed by Professor Elaine Harwood, as found in her working paper "The Effectiveness of Classroom Assessment Techniques (CATs) in Introductory Accounting Courses: An Empirical Examination of Minute Papers."

4. Directed Paraphrasing

This technique is used to determine the degree to which students have understood and internalized the main point of a learning objective. To initiate this assessment instrument, instructors select a point in the course after the completion of a major reading assignment, an important lecture, or a complex cooperative-learning activity. They identify a realistic, yet challenging audience and also give students time and space limits for the paraphrase. For example, engineering students may be asked in class to paraphrase in fifteen minutes the first law of thermodynamics as though they where explaining it to first graders.

The Directed Paraphrasing usually takes the form of a short written exercise that students turn in to the instructor. The instructors must provide feedback, so that students will know how well they are mastering the material.

This technique is an exercise in "authentic learning", since as professionals they will be involved in the communication of complex ideas to lay persons. To extend the value of a Directed Paraphrase, an instructor can combine it with a Think-Pair-Share activity, enabling students to receive feedback from one another as well.

Also discussed in Millis and Cottel are five other CATs for assessing student learning—"Focused Listing," "Pro and Con Grid," "Self-Diagnostic Learning Logs," "Exam Reflection," and " Quality Circles." The "Focused Listing" directs students to list several ideas or major points concerning a key concept in the course. The "Pro and Con Grid" helps students recognize more than one side of an issue. The "Self-Diagnostic Learning Logs" are tightly focused versions of student journals that encourage students to do self-reflection. The "Exam Reflection" helps students to view a course examination in a fuller context than the typical "What grade did I get?" response. The "Quality Circles" use student representatives to report concerns and comments between the students and the instructors. Millis and Cottell provide excellent explanations of how to use these five assessment instruments.

G. CATs Useful for Summative Evaluation

These techniques are used at the end of a learning unit or semester, and they provide evidence of the students' achievement of specific learning outcomes. Traditional assessment instruments such as homeworks, exams, quizzes, and reports provide the instructor with the data on which to evaluate each student's performance. Student's performances on all such instruments are combined by the instructor to determine a grade assignment for the course. Each of these assessment instruments can be used in an individual or team setting.

1. Individual Work: homeworks, quizzes, exams, and reports

Obviously, these are traditional instruments aim at judging how well a student is performing with respect to the course learning outcomes. Each student completes an instrument independently; that is, without consulting with anyone. Basically, the

instructor evaluates an individual's performance on an instrument and reports it usually on a scale of 0 to 100%.

2. **Teamwork**: homeworks, quizzes, exams, and reports

Johnson, Johnson, and Smith [1998, pp. 8.22 to 8.24] provide twelve techniques for giving grades in cooperative learning situations involving quizzes and exams. They are primarily based on an additive factor ranging from giving bonus points to team members based on individual performances to randomly selecting a team member's individual work, evaluating it, and giving all team members that grade.

Assessment techniques to determine individual performance in team homeworks and projects usually are based on using a multiplicative factor on the team grade. Two such techniques are presented—peer rating factor and professionalism factor. Both incorporate positive interdependence and individual accountability.

Peer Rating Factor [Felder and Brent, 2001, p. E-11]

A "auto-rating" (peer rating) system designed to account for individual performance in cooperative learning team projects has been developed by Professor Rob Brown at the Royal Melbourne Institute of Technology and adapted by Richard Felder for team homeworks. Team members confidentially rate how well they and each of their teammates fulfilled their responsibilities, taking the ratings from a prescribed list of nine terms ranging from "excellent" to "no show." The students are cautioned that they are rating only responsibility of performance and not academic ability or percentage contribution to the project. The instructor assigns numerical values to each rating as follows:

Excellent	100
Very good	87.5
Satisfactory	75.0
Ordinary	62.5
Marginal	50.0
Deficient	37.5
Unsatisfactory	25.0
Superficial	12.5
No show	0

and computes a weighting factor for each student as the student's individual average rating divided by the team average of individual ratings. The square root of that number may be used instead if the instructor wishes to give less weight to the peer ratings. The student's final project grade is the product of the weighting factor and the team project grade.

For example, before the first examination, four-member teams have worked cooperatively to solve and document four, weekly homework assignments. A single team solution was provided for each assignment. The members have rotated through the roles of coordinator, recorder, checker, and group process monitor on each

assignment. The four homework grades are averaged to give a team project grade. After completing the four team assignments, team members confidentially rate how well they and each of their teammates fulfilled their responsibilities. These verbal ratings are entered as numerical ratings into a spreadsheet table like the following:

Team Homework Project Grade = 80								
Team Member	**Rating 1**	**Rating 2**	**Rating 3**	**Rating 4**	**Indiv. Avg.**	**Team Avg.**	**Adjust Factor**	**Indiv. Grade**
Betty	87.5	87.5	75.0	87.5	84.4	82.0	1.02	82
Carlos	87.5	100	87.5	87.5	90.6	82.0	1.10	88
John	62.5	75.0	50.0	75.0	65.6	82.0	0.80	64
Angela	87.5	87.5	87.5	87.5	87.5	82.0	1.07	85
Team Peer Rating Average: 82.0								

The adjustment factors are the individual's average divided by the team average of peer ratings. The individual project grade equals the adjustment factor times the team's homework project grade of 80. If this is done three times during a semester, an individual course average for homework can be calculated.

This "peer rating" assessment technique is often questioned for its validity. Common concerns are that individuals will inflate their self-ratings; team members will agree to give everyone identical ratings to avoid conflict; and gender or racial bias and personal dislikes might influence the ratings. Kaufman, Felder, and Fuller [2000] have reported that most of these concerns about peer ratings in cooperative learning are unfounded, with a possible exception being the potential influence of personal prejudice in assigning ratings.

Professionalism Factor [Hanyak, 1997 p. D-1 to D-12]

This assessment technique expands the adjustment factor to include not only "peer ratings" but also other contributing factors for individual effort in a team project. In this technique, an individual's grade is the product of a professionalism factor and the team's project grade.

This assessment technique is designed for a semester-long project that can be divided into sub-projects equal in number to the number of members in a team. In a chemical engineering design course, three-member teams might be assigned a feasibility study for a manufacturing process to make a chemical product from starting raw materials. This study is sub-divided into a process scope project, process requirements project, and a process profitability project, each taking four weeks to complete. Each project terminates with a written technical report where roles are assigned for project leader, background writer, and discussion writer in the team. The leader is responsible also to write the introduction, conclusions and recommendations for the technical report. These roles are rotated from one project to the next.

While doing a project, technical assignments (about three or four) are given to be done individually and to prepare each team member to complete the technical analyses that are required in the project. These homework assignments, which are graded, can cover material from previous courses and/or introduce new material. In both cases, they are designed to prepare the students to transfer knowledge to the assigned project.

The project terminates with a written report, where sections are drafted and reviewed by team members and the instructor during the four-week period. When the report is submitted, team members must provide a confidential peer rating of themselves and their other members using a supplied form, as illustrated in Exhibit C. Each team member's performance is evaluated on a scale of 1 to 5 for eight criteria. For each team member, his or her peer ratings as expressed by the other two team members are collated and an average rating on scale of 100 is determined for that team member. The formula used to calculate the average favors ratings in the 90's for scores of 4 to 5.

A standardized form, as illustrated in Exhibit D, is used by the instructor to evaluate each section of the written report on a point scale of zero to 100. Each section score is multiplied by a weight factor. The total possible score for the 16-section report is 400 points, with: (a) the introduction, conclusion, and recommendation sections worth 80 points, (b) the background section worth 80 points, and (c) the discussion section worth 80 points. In the three-member team, the leader gets an individual grade for Item (a), the background writer gets an individual grade for Item (b), and the discussion writer gets an individual grade for Item (c). Both the team report grade and the individual section grades are reported on a scale of 100% as indicated in Exhibit D.

A member's grade for the project is calculated as the product of a professionalism factor and the team's report grade, as illustrated in Exhibit E. The report grade is a measure of the team's effort, while the professionalism factor is a measure of a member's effort within the project. For each team member, this factor has three components—the team's peer rating of the member, the member's report section rating, and the member's homework rating. These three rating components are averaged, and this rating average is used in a formula to calculate the initial factor in a range of 0.15 to 1.15. The formula is designed to convert a report grade of 85 to an individual grade of 93.5 for a rating average of 95. To reward outstanding professional behavior (0.0 to +0.2) or to penalize unprofessional behavior (-0.2 to 0.0), a subjective adjustment factor is added to or subtracted from the initial factor by the instructor to get the final professionalism factor, as shown in Exhibit E.

An example is presented to show how students' individual grades would be determined for two members of a three-member team. The team's written report grade would be determined by using Exhibit D, and for this example, the team's report grade was an 86% (344 points out of 400). Using Exhibit D as a guide, Member 2's individual contribution to the report is based on the background (e.g., 68 points out of 80), giving a Member's Work rating of 85%. Member 3's individual contribution to the report is based on the discussion (e.g., 52 points out of 80), giving a Member's Work rating of 65%.

Exhibit C. Team Member Evaluation Form

Team: _____ **Investigation:** _____ **Date:** _____

In the evaluation table below, place the number that corresponds to that descriptive phrase which most nearly describes the person being rated. Evaluate each quality separately. Rate all team members including yourself. Avoid the common tendency to rate nearly everyone as "average" on every trait; instead, be more critical in your judgment. Also avoid another common tendency to rate the same person "excellent" on every trait or "poor" on every trait, based on the overall picture one has of the person being rated. Please total the ratings for each team member. Thank you.

Rating Criteria for a Team Member

ACCURACY is the correctness of work duties being performed. **1** - Made many errors. **2** - Somewhat careless. **3** - Average number of mistakes. **4** - Accurate most of the time. **5** - Exceptionally accurate.	DEPENDABILITY is the ability to do assignments well with minimum supervision. **1** - Quite unreliable. **2** - Sometimes required prompting. **3** - Usually did assignments on time. **4** - Very reliable. **5** - Outstanding in reliability.
ALERTNESS refers to the ability to grasp instructions, to learn from others, and to solve problems. **1** - Slow to catch on. **2** - Needed more than average instruction. **3** - Grasped instructions with average ability. **4** - Quick to understand and learn. **5** - Exceptionally keen and alert.	JOB KNOWLEDGE is the information each member had to know in order to do his/her part of the project. **1** - Poorly informed. **2** - Lacked knowledge of some phases. **3** - Moderately informed. **4** - Understood most phases. **5** - Had mastery of all phases.
FRIENDLINESS refers basically to the ability to get along with the team members. **1** - Distant and aloof. **2** - Friendly once known by others. **3** - Warm, friendly, and sociable. **4** - Very sociable and outgoing. **5** - Excellent.	QUANTITY OF WORK is the amount of work done by the individual throughout the project. **1** - Unacceptable. **2** - Did just enough to get by. **3** - Average volume of work. **4** - Did more than was required. **5** - Superior work production.
PARTICIPATION is being available for and participating in team activities. **1** - Often absent or unavailable. **2** - Lax in availability and participating. **3** - Usually available and participating. **4** - Very prompt and regular. **5** - Outstanding, did more than share.	OVERALL EVALUATION is a comparison with other team members. **1** - Definitely unsatisfactory. **2** - Below average but made an effort. **3** - Did an average job. **4** - Definitely above average. **5** - Outstanding.

Team Member Evaluation Table

	Print team members' last names in alphabetical order, including yourself.			
Criteria				
Accuracy				
Alertness				
Friendliness				
Participation				
Dependability				
Job Knowledge				
Quantity of Work				
Overall Evaluation				
Total				

Team's Rating = $\left(\frac{+}{2} + 32\right) * 1.35 =$

Print your name _____

Your signature _____

Write comments about each member on the reverse side.

Exhibit D. Report Evaluation Form

Team: _____ **Investigation:** _____ **Date:** _____

Member 1: _____ **2:** _____ **3:** _____

	U P F G E†	Score	Initials
Organization	(0 5 6 7 8 9 10) x 1 =	_____	
Clarity and Conciseness	(0 5 6 7 8 9 10) x 2 =	_____	
Appearance and Neatness	(0 5 6 7 8 9 10) x 2 =	_____	
Letter of Transmittal	(0 5 6 7 8 9 10) x 1 =	_____	Member 1
Title Page and Cover Page	(0 5 6 7 8 9 10) x 1 =	_____	Member 2
Summary	(0 5 6 7 8 9 10) x 2 =	_____	Member 1
Table of Contents	(0 5 6 7 8 9 10) x 1 =	_____	Member 2
Lists of Tables and Figures	(0 5 6 7 8 9 10) x 1 =	_____	Member 2
Introduction	(0 5 6 7 8 9 10) x 4 =	_____	_____
Background	(0 5 6 7 8 9 10) x 8 =	_____	_____
Discussion	(0 5 6 7 8 9 10) x 8 =	_____	_____
Conclusions	(0 5 6 7 8 9 10) x 2 =	_____	_____
Recommendations	(0 5 6 7 8 9 10) x 2 =	_____	_____
Bibliography	(0 5 6 7 8 9 10) x 2 =	_____	Member 3
Acknowledgement	(0 5 6 7 8 9 10) x 1 =	_____	Member 3
Appendices	(0 5 6 7 8 9 10) x 2 =	_____	All
	Net Points =	_____	
Grammar	(6 5 4 3 2 1 0) x -4 =	_____	
Spelling	(6 5 4 3 2 1 0) x -4 =	_____	
Punctuation	(6 5 4 3 2 1 0) x -4 =	_____	
	Report Grade =	_____ / 400 =	_____ %

Member's Work. **1:** ____/80 =_____ % **2:** ____/80 =_____ % **3:** ____/80 =_____ %

†Excellent (9.5), Good (8.5), Fair (7.5), Poor (6.5), and Unacceptable (5.5 to 0.0).

Exhibit E. Performance Summary Form

Team: _____ **Investigation:** _____ **Date:** _____

Member's Name: _____

Team's Rating = _____ %

Report Sections Rating = _____ %

Homework Rating = _____ %

Rating Average (RA) = _____ %

Professionalism Factor = _____ = 1.10 - 0.01*(95 - RA)

PF Adjustment (-0.2 to +0.2) = _____

PF Total = _____

Member's Grade = _____ (PF Total) x _____ (Report Grade) = _____

Comments:

Project Supervisor: _____ **Date:** _____
signature

In this example, Member 2 received a "good-to-excellent" evaluation (1.05) for his or her professionalism. This member wrote a good background section in the report (85%), did an excellent job at doing homework (96%), and did excellent work as reported by the other two team members (Member 1 gave 32 points, and Member 3 gave 38 points, each using Exhibit C). Based on Exhibit E, the performance of Member 1 in the project is calculated as follows:

$$\text{Team's Rating} = \left(\frac{32+38}{2}+32\right) * 1.35 = 90$$

Report Sections Rating = 85
Homework Rating = 96

Rating Average (RA) = (90 + 85 + 96) / 3 = 90

Professionalism Factor = 1.10 - 0.01*(95 - RA) = 1.05

Member 2's Grade = 1.05 x 86 = 90.3.

Member 2 would receive a grade of 90 for his or her performance, based on no instructor's adjustment to the performance factor of 1.05.

In this same example, Member 3 received a "poor" evaluation (0.80) for his or her professionalism. This member wrote a poor discussion section in the report (65%), did a fair job at doing homework (70%), and did unacceptable work as reported by the other two team members (Member 1 gave 10 points, and Member 2 gave 15 points, each using Exhibit C). Based on Exhibit E, the performance of Member 3 in the project is calculated as follows:

$$\text{Team's Rating} = \left(\frac{10+15}{2}+32\right) * 1.35 = 60$$

Report Sections Rating = 65
Homework Rating = 70

Rating Average (RA) = (60 + 65 + 70) / 3 = 65

Professionalism Factor = 1.10 - 0.01*(95 - RA) = 0.80

Member 3's Grade = 0.80 x 86 = 68.8.

Member 3 would receive a grade of 69 for his or her performance, based on no instructor's adjustment to the performance factor of 0.80.

Because of the multiplicative effect of the professionalism factor in determining individual performances in the team projects, team members must maintain a high standard of professionalism while doing the engineering project. Any unprofessional behavior upon a team member's part will severely affect his or her performance grade.

When applying any of the above assessment techniques to do summative evaluations, a criterion-referenced grading system must be used instead of a norm-referenced grading system. The former is an absolute system that requires students to either work individualistically or cooperatively. The latter is a relative system that places students in

competition with each other. Basically, you do not curve grades in a criterion-referenced system.

H. References

1. Felder, Richard M. and Rebecca Brent. "Effective Teaching: A Workshop," given at Bucknell University, Lewisburg, PA, May 15-16, 2001.
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3. Johnson, David. W., Roger. T. Johnson, and Karl. A. Smith. *Active Learning: Cooperation in the College Classroom*. Interaction Book Co., Edina, Minnesota, 1998.
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5. McGourty, J. and K. P. De Meuse. *The Team Developer: An Assessment and Skill Building Program*, Student Guidebook. John Wiley & Sons, Inc., New York, 2001.
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Module 3: Instructor Motivation of Teamwork

A. Objectives

To give faculty some tools to turn to when students complain that they do not wish to be in teams (or on *another* team, or on a team they didn't pick, or …).

B. Discussion

There are three progressive goals for students' attitudes towards teamwork:

1. Students should accept that they are going to work in teams.
2. Students should realize that, for the purposes of this assignment, teams are preferable.
3. Students should internalize that teamwork is an efficient and preferable method for tackling complex problems; they should really believe that 1+1=3 (i.e., in the context of teamwork, of course).

As with most attitudinal change, these tasks may be quite difficult to accomplish and also to assess. Instructors should understand this (think of your own reactions to teamwork!) and give the students time to adjust. At a low level, just shoot for the students to accept that they are going to work on teams. After practice (if properly guided by their instructor) students should move from acceptance to an internalized belief in teamwork as an effective means of accomplishing goals. Students will come to believe in the effectiveness of teamwork as they experience working on an effective team. It may take exposure to well-constructed problems involving teamwork across several classes before students reach Goal 3, if at all.

This module provides some quick justifications which you can use to convince students that teams are in their best interests. However, the best argument for teamwork is going to be their own experience; when they accomplish a task which they know would have been impossible to do on their own, then they will begin to move towards endorsing teamwork. Unfortunately, that only happens at the end of the project (or semester!). Therefore, here are some ideas you can use along the way to try to keep the students motivated.

C. Motivation Hints

Hint 1: Stand Firm

In order to encourage students to accept teams as a tool for completing a project, you need to support the idea to the greatest extent. That means that, when students complain, you listen and try to address their concerns, but that you do not eliminate (or change) the teams as a result of complaints (except within the bounds of a "team contract" discussed in Chapter 2). Letting one group split up and go solo (except in the case of irreconcilable problems which have been addressed as well as possible) would be disheartening to the rest of the class.

Hint 2: Reasons for all Seasons

Following the Kolb cycle, here are some teamwork justifications designed to satisfy different types of learners.

Why-Type Preferred Learning Style

- Recruiters want to see evidence that you can work on a team.
- You can't claim to have leadership experience (something recruiters again look for) unless you have been with people who function as a team.
- You will be working on teams in industry, and they will not be composed of your best friends or even (in most cases) people you can choose at all. Therefore it is important to learn how to work effectively with others who are not necessarily your friends.
- It should help you learn the material better (Millis and Cottell, 1998; Felder, 1999)
- Even if you feel you do not need the help that a team provides, you should give others the opportunity to work with you.

How-Type Preferred Learning Style

- Teamwork is a skill, just as the ability to do a force balance is a skill, and therefore students can learn and practice it in class, just like everything else.
- The modules in this practical guide can help students practice their teamwork skills.

What-Type Preferred Learning Style

- Teamwork consists of a coordinated effort by a team of individuals to accomplish a single goal.
- Again, teamwork is something that needs to be practiced in order for students to be successful at it.

What-If-Type Preferred Learning Style

Have the student look at the problem, and observe that it is either too difficult for one person to tackle alone, or too much work for one person to finish in the amount of time allotted to complete the work.

Hint 3: Be aware of History

Students may arrive in your classroom already poisoned by negative teamwork experiences in high school or other college classes. The solution to this problem is to emphasize the components of cooperative learning in your class, and highlight for those students, who are negative on teamwork, how these components might have been missing previously.

D. References

1. Felder, R.M., FAQ. *Chemical Engineering Education*, 1999. 33(1): p. 32-33.
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