STUDENT TEAMS IN THE ENGINEERING CLASSROOM AND BEYOND: SETTING UP STUDENTS FOR SUCCESS

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There is wide demand for engineering graduates to be capable of working well in teams. The National Academy of Engineering's 2004 report *The Engineer of 2020: Visions of Engineering in the New Century* notes that "the engineering profession recognizes that engineers need to work in teams" (p. 43) and that "the challenge of working effectively with multicultural teams will continue to grow" (p. 35). Engineering employers and graduates also see the value of strong teamwork skills, but both observe that the undergraduate experience does not adequately prepare graduates in this regard. Only 39% of employers rated graduates as "very well prepared" for teamwork in a survey conducted on behalf of the Association of American Colleges and Universities (Peter D. Hart Research Associates, 2008). Similarly, results of a 2009-2010 U-M College of Engineering survey found that 72% of recent undergraduate alumni rated "ability to function on a team" as *extremely important* in their professional experience, but only 47% felt that U-M provided *excellent preparation* in this regard (Office of Student Affairs, 2010). Clearly, there is a strong need for higher education to better prepare students for the team interaction they will encounter after graduation.

The engineering accreditation body (ABET, www.abet.org) has responded to this need by requiring engineering programs to demonstrate that their graduates have "an ability to function on multidisciplinary teams" (Haag, Froyd, Coleman, & Caso, n.d.), and many engineering instructors have integrated the use of student teams into their courses. When done well, there are a number of advantages to using teams. Research has demonstrated that regardless of subject matter, students who engage with course material by working in teams tend to learn more of what is taught and to retain it longer than when the same content is presented in other instructional formats, such as lecture (Davis, 1993; Johnson, Johnson, & Smith, 1998a; Springer, Donovan, & Stanne, 1999). There is also plentiful evidence that students who work together on teams outperform even the highest achieving individual students (Hsiung, 2010; Johnson & Johnson, 1999; Johnson, Johnson, & Smith, 1998b; Springer, Donovan, & Stanne, 1999) and are more likely to attain higher-order thinking skills such as analysis, synthesis, evaluation, and problem solving (Johnson & Johnson, 2002; Springer, Donovan, & Stanne, 1999; Wankat & Oreovicz, 1993). Effective use of student teams also has powerful positive impacts on minorities and women in

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terms of achievement and attitudes (Copper & Robinson, 1998; Drane, Smith, Light, Pinto, & Swarat, 2005), and the benefits for students who interact on *diverse* teams are many. For example, problem-solving teams comprised of diverse members consistently perform better than teams of members who approach problems in a similar way (Page, 2007), and students' ability to engage in active thinking, their level of intellectual engagement, and their self-rated academic ability are all enhanced by experiences with diversity (Gurin, Dey, Hurtado, & Gurin, 2002; Watson, Johnson, & Zgourides, 2002).

The characteristics of effective student teams have been widely studied, and there is ample research on what makes student teams succeed. Johnson, Johnson, and Smith (2007), for example, define five traits of effective student teams, and they note that each one is critical for success. The first trait is *positive interdependence*: students work together to accomplish a shared learning goal, and each student can achieve his or her learning goal if and only if the other team members achieve theirs. The sense of accomplishment must come from the knowledge that every person on the team succeeded. Second is *individual accountability*, which suggests that each member should be accountable for his or her learning, and every person must do a fair share of work. This can improve student motivation and improve the overall energy level of the team. The third trait, *face-to-face interaction*, is crucial for building interpersonal skills, as teams work best when members are physically present to interact with the others on the team. Fourth, team members should learn *interpersonal and small-group skills* and should use these skills as the team works together. Last, but not least, the team should periodically *assess its performance* as a team, reflecting on what has been useful or problematic in ensuring effective working relationships and making decisions about what behaviors should continue and which ones should change.

Our purpose in this Occasional Paper is to provide instructors with a framework for ensuring that student teams possess these five traits and are set up for success. The framework consists of four related components shown in Figure 1: designing good team assignments, constructing student teams carefully, teaching teamwork skills, and assessing student teams. We advocate that instructors reflect on this framework and practical aspects related to it as they plan and use student teams in the classroom. In the next sections we separately address each of the four components and offer suggestions for instructors to create environments that are conducive to teamwork and are rewarding for all involved. We emphasize the importance of considering all four components collectively: individually, none of the four will ensure successful student teams and disregarding one or more of the components may result in an unproductive experience for both students and teachers. We also highlight some of the many U-M faculty who have successfully integrated these components into their teaching. Though the examples come from engineering, the ideas described herein can be applied in a variety of college contexts and can be adopted by instructors with any level of experience.

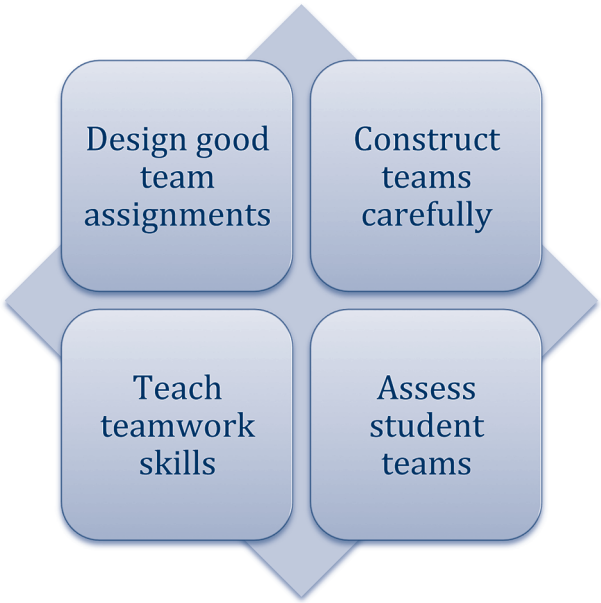

Figure 1. Four components of using student teams successfully

Design Good Team Assignments

Well-planned team assignments are crucial to using student teams well. Michaelsen, Knight, and Fink (2004) observe that most problems of poor student behavior during teamwork "are the result of bad assignments, not bad groups" (p. 71). As with any class assignment, team assignments should have a clear purpose and function and should align with course goals and grading criteria (e.g., Piontek, 2008; Svinicki & McKeachie, 2011), but they also should require individual accountability as well as positive interdependence (Johnson, Johnson, & Smith, 2007; Michaelsen, Knight, & Fink, 2004). Planning a team activity that fits these characteristics requires the instructor to consider the content of the assignment, the academic expectations for the task, the level of preparation required of the students, the way in which the work will be assessed, and the reasons why a team is needed to accomplish the activity. In order to ensure that activities will be suitable for teamwork and that students will have the tools and time to complete the assignment successfully, instructors should

also think through practical aspects of having students work in teams (e.g., when teamwork will take place, whether students will have time to report to the class, and how and when feedback will be given to students). The list of suggestions that follows expands on some of the key points for developing good team assignments.

Begin with simple, well-defined tasks, then increase their difficulty

Team assignments early in the term should include relatively simple, well-defined tasks that require a specific product so students can concentrate on the mechanics of teamwork (Michaelson & Sweet, 2008). For example, a good first-time task may require teams to collaboratively complete a table of definitions and reflect on their team interaction during the process, allowing the instructor to award points based on how well the students worked together to accomplish the goal. As the term progresses, the instructor should assign more complex and ambiguous tasks that promote higher-level thinking skills. (Of course, regardless of complexity, assignments should always be relevant, solvable within a reasonable time frame, and intrinsically interesting.) For example, instead of having students make a list or choose among a few alternatives, students could be asked to "make multiple comparisons and discriminations, analyze content information, and verify rule application" (Michaelsen, Knight, & Fink, 2004, p. 65).

Define individual versus team accountability

A common student complaint about team assignments is that unclear instructions about student roles and division of work allow individuals on a team to contribute unequally without penalty, especially if a single assignment is to be submitted by the team. One strategy to overcome these issues is to require students to rotate through well-specified roles (e.g., scribe/note-taker, time-keeper, clarifier, reporter, and manager) during the term to ensure that each student has the opportunity to take on different responsibilities (Hansen, 2006; Stein & Hurd, 2000). Rotating the leadership role has been shown to result in higher levels of cooperation and performance on student teams (Erez, Lepine, & Elms, 2002) by helping students understand expectations, encouraging individuals to contribute fairly, and enabling students to experience group work as more rewarding and productive (Hansen, 2006; Page & Donelan, 2003). The number and types of roles will depend on the number of people on the team, the length of time the team will be together, and the complexity of the task.

In addition, the assignments should define individual versus team accountability (Cooper, 2009) and provide guidance about expected student contributions to the project. For example, an assignment that does *not* do this might be the following: "Research the impact of the 2010 Gulf Oil Spill on the environment. Then give a presentation based on your findings." Without careful structure, this simple approach to team assignments may result in students completing the task via a divide-and-conquer method. A better example that more clearly defines individual versus team accountability is the following:

> As a team, research the impact of the 2010 Gulf Oil Spill on the environment, prepare a 10-page written report, and present your findings to the class. Collectively, your team should identify important areas to study (e.g., biological impact on plants and fish, how oil settles or disperses in the water, impact on shorelines), and then each team member should research a different area, prepare a two-page overview, and describe the impact to the rest of the team. Your written report should include the two-page overviews as well as a cohesive introduction and a summary that describes the overall impact on the environment. Each team member should participate equally in preparing the class presentation, and one member of the team will be chosen randomly to make the presentation. The team will be graded on both

A Note on Academic Integrity: Designing assignments that require interdependence without conveying expectations about student collaboration can be confusing for students. The U-M College of Engineering honor code states, "It is dishonorable for students to receive credit for work that is not the result of their own efforts," yet because team assignments require students to work together, students may feel they are receiving mixed messages when asked to work in teams. Instructors should strive to be explicit—from the beginning of the term—about which types of collaboration are and are not acceptable, and guidelines for balancing teamwork with an honor code should be clearly stated in a syllabus (Meizlish, 2005). This is especially important when the instructor expects some of the class assignments to be completed individually and other assignments to be completed as a team. Helping students understand your expectations will avoid misunderstandings and encourage an appropriate balance between independence and collaboration.

the written report and the presentation, and individual scores will be adjusted based on the quality of the two-page research overview.

This second set of instructions clarifies how the work should be distributed among individuals, and it conveys the expectation that the team should work together to create the final cohesive report and presentation.

Develop assignments that require interdependence

As Michaelsen and Sweet (2008) write, "the most fundamental aspect of designing team assignments that promote both learning and team development is ensuring that they truly require group interaction" (p. 12). That is, assignments should require teams to make complex decisions together and allow all team members to contribute and participate in the decision making process. In the Gulf Oil Spill example described previously, team members must distribute work in a way that will result in a cohesive presentation about the overall impact on the environment. This requires complex reasoning and a lot of teamwork, but because it can result in a relatively simple presentation, it can allow the team to focus on interacting and content-related decision making, thus further promoting interdependence.

Construct Teams Carefully

Creating student teams that will work well is another critical aspect of using student teams in the classroom. Important considerations in this regard include the number of students per team, the level of diversity on student teams, and whether or not the instructor determines the membership. Here we present some practical, research-based guidelines for creating effective teams.

Form teams of three to five members

Smaller teams better facilitate individual accountability and allow for more flexible scheduling when out-of-class activities are required. On the other hand, larger teams have the potential for more resources, ideas, and points of view to be brought to the problem. In general, teams of three to five students work best, with smaller teams recommended for short-term activities or simple tasks and larger teams for long-term, complex activities (Birmingham & McCord, 2004; Johnson, Johnson, & Smith, 1998c).

Form heterogeneous teams

Heterogeneity is an important characteristic for effective teams. Students on heterogeneous teams bring diverse perspectives and problem-solving approaches, but they may require more time and effort to develop strategies to work efficiently as a team (Birmingham & McCord, 2004). The benefits, though, outweigh these issues for long-term teams, and research finds that "although diverse groups typically have more initial difficulties, after forty hours of working together they are typically more effective than homogeneous groups" (p. 75).

What types of diversity are good for teams? First, teams that have a broad range of abilities and problem-solving perspectives among members tend to be more successful than those that are homogeneous in this regard (Brewer & Mendelson, 2003; Heller & Hollabaugh, 1992). Hong and Page (2004) suggest that such *functional* diversity, or "differences in how people represent problems and how they go about solving them" can be an important attribute of high-performing teams (p. 16385). Other researchers have also demonstrated that working with others of different abilities offers benefits to students at all levels—the more capable students become more aware of their thinking processes, while the less capable student learns from an advanced peer (Oakley, Felder, Brent, & Elhajj, 2004; Wankat & Oreovicz, 1993).

Teams should be heterogeneous in other respects as well—they should include men and women, as well as majority students and minority students whenever possible (Tonso, 2006). Research suggests that when women or minorities are outnumbered in engineering teams, their team participation can be negatively affected because their

Steve Skerlos of Mechanical Engineering regularly uses teams in *ME 450: Capstone Design and Manufacturing*, and he knows that creating diverse student teams and rotating the roles are important for their success. He assigns teams by selecting students with diverse characteristics, assessed at the beginning of the class with a short survey. The team project is complex enough that an individual would be unable to complete it successfully, and students are required to especially focus on a subpart of the project (e.g., the software, the robotic arm control, or the mechanical structure). Team roles such as industry liaison, meeting facilitator, and treasurer rotate during the term (to the extent possible), and he relies on peer assessment to ensure that all students are doing their fair share of the work.

opinions may not be considered valid by their teammates, or they may be assigned unimportant tasks (Ingram & Parker, 2002; Michaelsen & Sweet, 2008). Therefore, it is critical that whenever possible, teams be formed in ways that avoid isolating individual women or minorities. This is especially important in introductory courses when students are new to the field and have not yet established support mechanisms like study groups or academic networks.

Use instructor-assigned teams

Team membership can be selected by students, determined randomly, or assigned by the instructor based upon individual student characteristics. Of these three methods, teams chosen by students tend to be the most homogeneous, while instructor-assigned teams that are balanced in terms of race, gender, ability, and problem-solving approach are more likely to be heterogeneous (Oakley, Felder, Brent, & Elhajj, 2004). Instructor-assigned teams also offer control over the ways in which resources are distributed among teams and result in a stronger sense of fairness.

Consider practical issues when creating teams

The length of the team project and expectations for meetings outside class should be considered when forming teams, because even the best heterogeneous team is likely to fail if the team cannot find a common meeting time. Thus, when students need to work together outside class, instructors should consider out-of-class availability when forming the teams. One way to do this is to query the students about their schedules and use this information in conjunction with other criteria in forming teams (Oakley, Felder, Brent, & Elhajj, 2004). There are on-line automated systems that simplify this process. For example, Team-Maker© is a free, web-based tool (www.catme.org) that collects data from students and automatically creates teams according to criteria specified by the instructor.

Teach Teamwork Skills

The ability of team members to work effectively together can evolve over time as students acquire important skills. The four stages of forming, storming, norming, and performing are commonly used to describe this evolution. *Forming* is characterized by orientation to the team and dependence on others, while *storming* is often marked by conflict and resistance to group influence (Hansen, 2006). This resistance is overcome in the *norming* stage, during which cohesiveness develops, and new roles are adopted. Finally, in the *performing* stage the team is focused on the task, and "structure can now become supportive of task performance" (Tuckman, 1965, p. 396). It is important for students to know that their teams are likely to experience conflict as they work together and for instructors to provide students with ways to deal with those conflicts. The suggestions offered in this section highlight good practices for teaching teamwork skills – other resources may also be helpful (e.g., Michaelsen, Knight, & Fink, 2004; Millis, 2009; Stein & Hurd, 2000).

Pauline Khan of the Technical Communications Program in the College of Engineering relies on teamwork in *ENGR 100: Introduction to Engineering* to help first-year students learn to communicate as a team, complete written and oral team reports, and help each other master technical material. From her 22 terms of teaching experience, she knows that creating the right teams is a critical element for success, and she has devised the following system for assigning student teams. She administers a survey to identify certain characteristics, including where students live; availability for out-of-class meetings; self-assessed computer skills, oral presentation skills, writing skills and teamwork skills; gender/ethnicity; and names of classmates with whom students prefer not to work. She then creates teams of four to five students, guided by the following criteria:

- Members of each team have complementary skill sets,
- Minority or women students are paired on a team so those students have social support mechanisms,
- Members of teams do not have conflicting evening schedules,
- First-year students who live off campus are placed on the same team because they often empathize with one another and understand each other's meeting time limitations,
- Students on a given team live near each other for ease of meeting, and
- Students who clearly state a preference to NOT work with a particular class member are not placed on the same team.

She has refined this system over time and has found it to be successful because it reduces the potential for common teamwork problems.

Have students talk about important team behaviors

Students typically have not received specific guidance on how to be a good team member, and they lack strategies for addressing common team dilemmas. It is the instructor's responsibility to explain to students why teamwork is being used in the class and to help students develop the skills needed to be good team contributors. Johnson, Johnson, and Smith (2007) explain that students not only need to learn practical skills for working in a team, but they also need to learn "civic values," including

> commitment to the common good and to the well being of other members, a sense of responsibility to contribute one's fair share of the work, respect for the efforts of others and for them as people, behaving with integrity, caring for other members, compassion when other members are in need, and appreciation of diversity. (p. 21)

To impart these values and offer resources for resolving some of the challenges of working on a diverse team, instructors might devote a portion of the first class meeting to team building activities (see Kapp, 2009, for a description of successful activities) or develop an initial assignment to help the team work together. For example, having students complete a learning style questionnaire and then reflect on their team's results (e.g., by writing a team essay that describes differences in members' learning styles that could affect collaboration, as well as possible ways of using the differences to their advantage) has been shown to increase students' team skills (Finelli, 2001). Similarly, instructors can create simple scripts depicting common team dilemmas and invite students to role play the situation or give a class assignment asking teams to reflect on characteristics of successful teams, discuss challenges they have encountered, and list strategies for resolving conflict.

The College of Engineering has used variations on both of these ideas by introducing an interactive theater sketch in *ENGR 100: Introduction to Engineering* to provide students with strategies for resolving common team dilemmas and to enhance students' perceptions of the value of diversity on student teams. Performed by the U-M Educational Theater Company, the sketch has resulted in statistically significant benefits for first-year engineering students. After seeing the performance, students reported being better able to resolve common team problems than they could at the beginning of the term, and they placed greater value on diversity, compared to students in a control group who did not see the performance (Finelli & Kendall-Brown, 2009). One explanation for these benefits may be the interactive segment of the sketch during which students generate a list of strategies for having a successful teamwork experience. The director of the theater company has compiled the strategies from several performances into the following list of seven suggestions (McKee, 2010):

1. Think about the roles you tend to play within teams, and make a conscious effort to be open-minded about how these roles will play out in teams. For example, if you usually lead, take time to step back and listen.
2. Be aware of how gender, cultural backgrounds, socio-economic status and life experiences could affect your team members' performance.
3. Assume that your team members are doing their best and want the team to succeed.
4. In meetings, communicate clearly, directly, and respectfully. If a team member's behavior is inhibiting progress, address the issue in a timely, professional manner.
5. Communicate expectations, schedules, and goals for the project at the onset of working together.
6. Be prepared to make sacrifices and be considerate of each other's schedules. Team members may have to rearrange their schedules to get everyone in a meeting, and they may have to hand over part of the project or make changes in plans to accommodate everyone's unique situation.
7. Organize and use time carefully. Set agendas for meetings, be clear about the action items for each team member before leaving each meeting, leave time to work as a team, and make use of each team member's skills and interests in order to take advantage of working with a diverse team of students.

Instructors might consider sharing the list with students who will be asked to work in teams.

Have teams develop contracts

Another way to foster teamwork skills is to have each team develop a contract, which involves discussing the team's purpose or mission, defining appropriate roles for each team member, and setting norms for conduct. Having – and using – a contract gives students ways to mediate team conflict and negotiate agreements on their own, enhancing team productivity (Johnson, Johnson, & Smith, 2007). Several faculty who teach *ENGR 100* require the student teams to develop a team charter (i.e., a shared set of team rules) as one of the first course assignments. The charter is intended to help the team plan for managing cases in which

a team member does not do his or her fair share of the work, doesn't attend team meetings or shows up late, exhibits disrespectful or unprofessional behavior, is excessively demanding, or is overly reserved. The team drafts a charter that everyone signs (indicating agreement with the principles) and gives a signed copy to the instructor. Then, when conflicts arise, the instructor can remind students about the contract, asking them to work together to define the source of the conflict, communicate feelings and positions, take the other person's perspective, and reach an agreement that is satisfactory to all team members (Smith & Imbrie, 2007). If the team needs it, the instructor can intervene to address unresolved conflicts.

Observe and guide teams

In some cases, teams need a great deal of support while individuals learn to interact with diverse peers. Observing the teams is fundamental to detecting and correcting problematic dynamics in a timely way (Fredrick, 2008). Instructors should periodically check in with the teams, perhaps by scheduling times to meet with each team during office hours or being present when the team works together. During these meetings, the instructor should determine the extent to which the team is on track and observe the team dynamics. As needed, the instructor can ask refocusing questions such as, "Kathy, please summarize what the team has done thus far," or "Tim, please describe the team's plan for completing the task," and reiterate expectations about both individual accountability and interdependent work.

When monitoring team interaction, it is important for instructors to be mindful that team dynamics may vary based on the backgrounds of team members. For example, teams composed of students from cultural backgrounds that value the *collective* perspective display more cooperative behavior than teams composed of students from *individualistic* backgrounds (Cox, Lobel, & McLeod, 1991). And in traditional U.S. culture, women have often been socialized to develop group rapport and to seek interaction, while men have been socialized to seek independence (Ingram & Parker, 2002). Furthermore, gender-typical dynamics often exhibited by women students on teams (e.g., willingness to admit vulnerabilities or conceding one's own weaknesses in order to help a teammate "save face") also have an impact on perceptions of student ability. As such, coaching students to understand the value of collaboration, take ownership of and speak confidently about their ideas, and accept (or even demand) technical roles on projects might help students of varied backgrounds achieve success in an engineering community (Wolfe & Powell, 2008).

Other student characteristics can also impact dynamics. Students who are outspoken in class, for instance, may dominate their team, while other students may tend to avoid conflict and simply refrain from participating in the team (Heller & Hollabaugh, 1992). Being mindful of these dynamics, coaching the students through common team dilemmas, and intervening in ways that promote team awareness and encourage change (e.g., praising the class for exceptional behaviors or talking about ways to handle a particular situation) can lead to more successful team interaction.

Matt Collette of Naval Architecture and Marine Engineering infuses his team-based class, *NA 570: Advanced Marine Design*, with a variety of team training activities. The activities include a team-based reflection on individual personality characteristics and their impact on team dynamics, class discussions about common team problems and ways to overcome them (such as consensus building and other conflict resolution strategies), and a unit in which the class generates a list of "norms" for how members on teams should operate. Students are required to use a textbook on teamwork for the class (Parker, 2008), and Dr. Collette supplements the text with his personal experience as a practicing engineer and consultant. After students complete the module, he creates teams that include students of varied personality types, academic ability levels, and backgrounds and then assigns them a large team project. He reminds students to draw on their team training throughout the project and suggests they review the team norms from the training module.

Assess Student Teams

The fourth component of successful student teams in the classroom involves assessment, both of overall teamwork and of individual contributions. This section provides guidance on evaluating the success of team interactions and using peer evaluation to assess individual contributions.

Encourage and allow time for team processing

It is important to provide time and guidance for teams to examine how they are working together (Cooper, 2009). Because students may not know how to reflect on their teamwork behaviors, instructors should periodically ask

individual students questions such as, “What are the things that your team is doing that work well and what things would you like to change?” Such questions allow students to reflect on their own and their peers’ contributions to the team and, when shared with others, illustrate the kind of responses that are useful. Instructors should build in time for in-class team processing throughout the term, debrief the class afterwards when appropriate, and discuss issues that arise with the whole class so students are informed of potential problems and given opportunities to brainstorm possible solutions. The small time investment required upfront for this has the potential to save time later in the course by preventing the escalation of conflicts or confusion.

Use peer evaluations

Because students have the most knowledge about individual contributions to the team, peer evaluations are an important method of team assessment (Cestone, Levine, & Lane, 2008; Loughry, Ohland, & Moore, 2007; Williams, Foster, Green, Lakey, Lakey, Mills, & Williams, 2002). A simple peer evaluation form commonly used in engineering is shown in the Appendix. This form allows the instructor to solicit self- and peer-evaluations about team contributions. The Comprehensive Assessment of Team Member Effectiveness (Figure 2) is a free, web-based version of the form that produces automatically-generated instructor reports, compiling student ratings and alerting faculty to potential team problems. It was developed through rigorous research and has been shown to be valid and statistically reliable (Ohland, Layton, Loughry, & Yuhasz, 2005).

When effectively facilitated, the benefits of peer evaluation are many. Soliciting students’ perspectives of their peers can help an instructor identify “free riders” who fail to contribute to the team and rely on others to get the work done (Glenn, 2009; Slavin, 1995). Students are challenged to think more critically about the process of teamwork (Fredrick, 2008), they reflect on the goals and objectives of a course (Cestone, Levine, & Lane, 2008), and they are more motivated to produce high-quality work when their peers evaluate them than when their instructor does (Searby & Ewers, 1997). Research also shows that students who participate in peer evaluation have an increased awareness of the quality of their own work and increased

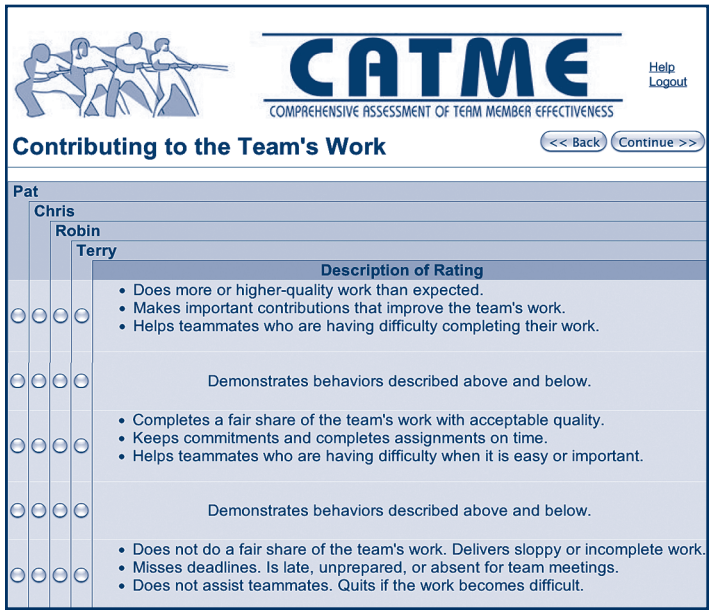

Figure 2. Portion of CATME instrument for peer evaluation (adapted from www.catme.org)

Susan Montgomery of Chemical Engineering builds regular peer evaluations into both *ENGR 100: Introduction to Engineering* and the *Chemical Engineering* courses that she teaches in order to reinforce the message that she believes strongly in the value of teamwork. Using evaluations, students provide valuable feedback in a timely and professional manner, learn to raise and address issues as they emerge, and become skilled at receiving and acting on feedback from their peers. She has found that students take the process seriously when they know their comments will be acted on by others; only rarely has she encountered unprofessional comments.

The peer evaluations also allow Dr. Montgomery to monitor teams, identify problems early, and deal with issues that arise. When they reveal matters requiring her intervention, she meets with the team as a whole to help get them back on track. Though she sometimes meets with individual students before the team meeting to get a better sense of the situation, she stresses the importance of beginning with a “clean slate” during a team discussion and giving everyone a chance to speak their mind. Individual meetings can sometimes uncover other personal issues that are affecting a student’s performance (in which case appropriate university resources can be mobilized), but having a team meeting makes the whole team (and not the instructor) responsible for working on the solution, and ensures that everyone will be satisfied with the agreed upon actions.

confidence in their abilities (Dochy, Segers, & Sluijsmans, 1999). On the whole, students find peer evaluation to be a fair method of assessment (Gatfield, 1999) and are generally very satisfied with the process (Cestone, Levine, & Lane, 2008).

Peer evaluation can be useful both to provide feedback to improve team interactions while the teamwork is in progress and to measure individual accountability in students' course grades. To accomplish the first objective, instructors should distribute peer evaluations at multiple points during the term so students can learn how to score their teammates and get used to sharing their (anonymous) ratings with teammates. And at the end of the term, the instructor can factor the students' ratings into the overall grade or adjust each student's team score by a multiplier based on the ratings to reflect their team contributions (Kaufman, Felder, & Fuller, 2000). Though it is important to make peer ratings count, if the course becomes overly dependent on them, students may start to feel as if they have not received appropriate credit for their individual efforts, and the peer feedback may become counterproductive.

Michael Flynn of Electrical Engineering also relies on peer evaluation in his senior- and graduate-level EECS classes, and he uses the automated CATME system. He relies on both the instructor's report, which summarizes student scores and flags potentially problematic ratings (e.g., under/overconfident students, individuals rated poorly by all teammates, and cliques) and the open-ended comments written by students. He finds the overall peer evaluation score to be a useful metric for student contribution to the project, and he uses it to adjust the students' grades. He notes that the system is fairly easy to set up, the students appreciate the safe way to provide feedback to their peers, and the process is valuable both for getting early project feedback to diagnose problems in groups and for assessing team contribution at the end of the term.

Conclusion

Ample research highlights the benefits to students of effective teamwork, including increased retention of material, acquisition of higher-order thinking skills, and the potential to perform at a higher level than students would individually. Coupled with the critically important need for graduates to be able to work well in teams in professional settings, these benefits provide incentive for incorporating effective student teams into the engineering classroom. In this Occasional Paper, we have offered practical suggestions for designing good team assignments, constructing teams carefully, teaching teamwork skills, and assessing student teams. These suggestions are meant to guide instructors who are interested in using student teams in their classrooms so that their students benefit from more powerful learning experiences and become better prepared for careers in an increasingly team-oriented workplace. For further support on student teams, instructors can contact the Center for Research on Learning and Teaching, which offers individual consultations and programs to help improve teaching effectiveness.

Appendix. Sample Peer Evaluation Form

Peer Evaluation Form

Please write the names of all of your team members, INCLUDING YOURSELF, and rate the degree to which each member fulfilled his/her responsibilities in completing the team assignments. Use the following rating system:

Excellent	Consistently went above and beyond the call of duty, tutored teammates, carried more than his/her fair share of the load
Very good	Consistently did what he/she was supposed to do, was very well prepared and cooperative
Satisfactory	Usually did what he/she was supposed to do, was acceptably prepared and cooperative
Ordinary	Often did what he/she was supposed to do, was minimally prepared and cooperative
Marginal	Sometimes failed to show up or complete assignments, was rarely prepared
Deficient	Often failed to show up or complete assignments, was rarely prepared
Unsatisfactory	Consistently failed to show up or complete assignments, was unprepared
Superficial	Had practically no participation
No show	Had no participation at all

These ratings should reflect each individual's level of participation and effort and sense of responsibility, not his/her academic ability.

Name of team member	Rating
_____	_____
_____	_____
_____	_____
_____	_____

Your signature _____

Adapted from Kaufman, Felder, and Fuller (2000).

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