# Forming Student Engineering Teams

http://www.foundationcoalition.org/teams

## Definition

A team is a small group of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable.[1] Although student teams may not satisfy all the requirements of the definition, the degree to which they do often determines their effectiveness.

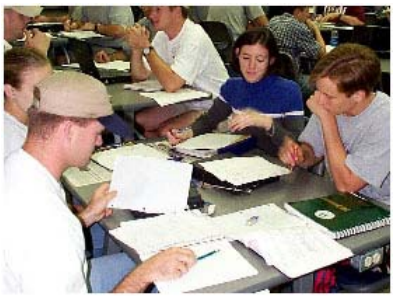
## Decisions in Forming Teams

The first step in working with student teams in engineering courses is forming teams. Although there are many issues connected to forming teams, four will be highlighted.

- **Responsibility for Assignment**: Who should select the teams?
- **Team Size**: What issues are connected with selecting the size of the student teams?
- **Team Composition**: What attributes of the individuals should be considered when composing student teams?
- **Team Schedule**: How might the students' schedules be considered when forming teams? One of the most challenging tasks that team of students faces is finding a satisfactory meeting time.

Guidelines generated through inquiry into these issues will depend on the team's purpose, the team's duration, and the students' maturity. Although there are no set rules for the formation of student teams, thoughtful consideration of these four issues will help provide a better learning experience for the entire class.

## Decision No. 1: Responsibility for Assignment



The first issue that arises in forming teams is who should have the responsibility for composing the teams. There are three alternatives.

1. **Self-selection**: Students decide on the composition of the teams.
2. **Instructor selection**: The instructor assigns each student to a team. An instructor might assign teams randomly, for example, students count off to form teams. This is quick and efficient, and ensures some heterogeneity in the teams. Stratified random may also be used to distribute prior skills or experiences. Or, as described below, the instructor might elect to consider several factors more systematically.
3. **Joint selection**: The instructor and students together decide on the composition of the teams. In one model of joint selection, the instructor might set criteria that team composition must meet, while the students form teams that meet these criteria.

Allowing students to form their own teams helps them accept greater responsibility for configuring their own learning environment or becoming co-conspirators in their own learning.[2] However, research on teams or small groups in the classroom supports either alternative 2 or 3. For example, Feichtner and Davis[3] report "… responses indicated that students are more likely to have positive experiences in classes where groups are either formed by the instructor or by a combination of methods (e.g., one instructor collected data on students' research interests and then group those with similar preferences). Specifically, in recording information concerning their *worst* group experience, 40 percent of the respondents noted that the groups were formed by the students themselves, while in the *best* group experience, only 22 percent reported that the students were responsible for forming the groups." Brickell et al.[4] presented two conclusions from their study that also suggest superiority of the latter two alternatives. "1. Appointed groups with a mixture of homogeneity and heterogeneity perform better (earn higher group grades) when compared with self-selected groups. 2. Allowing students to select their own groups results in the poorest attitudes about the course, their instructors, the projects, their classmates, and other criteria." These results indicate that the instructor must take an active role in forming the teams.

## Decision No. 2: Team Size

The ideal size of the team depends on the nature and duration of the project and the maturity of the team members. For instance, in-class exercises requiring students to use a computer or a limited resource may restrict the working group size to a pair. As another example, the " shorter amount of time available, the smaller the groups should be."[5] In a survey of students in a number of team experiences Fiechtner and Davis[3] found that students have the most positive experiences and perform the best in teams ranging in size from four to seven. Some issues related to team size are summarized in the table below. Finding suggestions in the literature for team sizes of three, four, or five is common.[5-,7]

### Team Size: Issues and Concerns

The table below summarizes issues and concerns with different sizes of teams.

| Smaller Teams | Larger Teams |
|---|---|
| Lack diversity of opinions necessary for a truly high-performance team. | Lead to difficulty arranging meeting times (many different schedules to consider). |
| Tend to be unstable over a semester—one or two absent students make the team inoperable. | Understanding each other and reaching consensus becomes more difficult. |
| Considerable reduction of active participation and learning. | Longer time to develop a trusting/working relationship. Often no relationship is developed. |
| Higher frustration due to lack of people to perform assigned tasks. | More chances of students "slacking" and delegating their work to others in the group. |
| Lack ownership and increase isolation. | Lack of team dialogue. Collaboration is sacrificed. |

## Decision No. 3: Team Composition

Teams are composed of people, with each member contributing a unique blend of attitudes, convictions, beliefs, skills, strengths, and weaknesses to the equation. Some of these elements are known and others are unknowable in advance, perhaps even to the individuals concerned. When these human elements are mixed together, placed under pressure, and have to work together in a concerted way, almost anything can happen. Even a team composed of the very best people has some probability of failure. Nonetheless, the level of heterogeneity plays an important role in team selection by maximizing individual contributions, which ultimately maximize the performance of the team. Homogeneous groups (i.e., groups of individuals with similar characteristics) get answers more quickly and with less fuss, but the answers tend to be unimaginative. Heterogeneous groups, while more diverse, may take more time yet generally produce better results and are more creative in their solutions.[8]

There are several aspects to be considered in team heterogeneity. These include but are not limited to:

1. **Skills** (e.g., computer, writing, presentation)
2. **Previous academic performance**
3. **Gender**
4. **Ethnicity**

### Skills

Matching students with the same skill level tends to generate task completion redundancy. On the other hand, matching students with different skill levels increases team's productivity by having a well-distributed set of tasks and equalizing participation. Measuring skill level takes some time but is always worth the effort.

***How to Measure Skill Level:*** You might measure a student's skill level by conducting a short questionnaire (for an example, see http://www.foundationcoalition.org/home/keycomponents/teamsurvey.html) that asks students to measure their levels of expertise when working with computers or specific software, writing a report, or conducting a presentation. In addition, you can do several in-class exercises in which students draw from a pot a piece of paper outlining a specific theme (e.g., favorite animal, most memorable trip, etc.) and talk for two or three minutes about that topic, which can give you a sense of a student's public speaking skills. This exercise can also be a writing exercise, or you may ask them to write a statement of purpose. By doing this, you will learn more about your student pool and class composition.

***How to Equalize Skill Level:*** Once teams with heterogeneous skill levels are created, it is important to help all team members improve. One way is by having students rotate roles and having members delegate to one another specific tasks that require a certain skill level. For example, a student with lower AutoCAD skills can be responsible for starting the next team graphics assignment with the assistance of the "AutoCAD expert" from his/her team. This way, the person is learning by doing, with guidance from the team's expert. Faculty can also help these students by specifically assigning tasks to these less-skilled students as individual or extra-credit assignments. Faculty may also occasionally give a computer quiz to all team members, but use the lowest grade as the grade for the team. This reinforces individual accountability and encourages students to work toward a common learning goal. However, faculty members should address the resistance that this approach may create in advance.

### Previous Academic Performance

Considering previous academic performance is also an important aspect when forming teams. Avoid matching all the experts or the academically disadvantaged together in one team. The hope is to have the less academically advantageous learn from those students who are considered above average. Again, the goal is to create a well-balanced group with a good blend of skills and learning styles.

### Gender and Ethnicity

Other aspects worth noting are gender and ethnicity. The issues of gender ratio and ethnic ratio have been topics of discussion for many years. Earlier researchers have argued that when women, or any ethnic group, represent a small fraction of a group (i.e., less than 15 percent), the minority member status is considered a token, and this damages general team dynamics.[9] This earlier research suggests that isolating minority students from other minority students or females from other females can in fact be detrimental to the academic success of these individuals because they can become isolated, marginalized, or placed in stereotypical roles and not permitted to flourish. However, later researchers have challenged this theory[10, 11, 12] by suggesting that increasing the number of females in a group will not necessarily lead to positive team dynamics. According to Steele[12], as an individual's minority status becomes more salient in a group, there is an increase in stereotype threat. Hence, increasing the number of women and/or underrepresented minorities in a group could magnify stereotypes and lead to a more hostile environment.

A study at Arizona State University has shown consistency with the second position, in which increasing the number of females and/or minorities can lead to a less stable environment.[13] Females and minorities have reflected on their team arrangements. Most of them agree that team formation should target students' abilities rather than gender or ethnicity. Females and minorities knew that they were placed in a team in pairs, and they also understood why. Nonetheless, students felt that this arrangement didn't impact their individual performances (either positively or negatively).[13] Moreover, underrepresented minorities and women enthusiastically stated that they didn't feel discrimination and were treated as equals by their peers and instructors. Their interest is to be considered individuals with certain academic abilities, knowledge, and personalities instead of being categorized by their gender and/or ethnicity.

## Team Schedule

Most teamwork occurs through face-to-face interaction. Therefore, good teamwork requires effective meetings! When forming teams, approximately 90% of the time, students express a problem with finding a common time to meet. In most cases, finding a meeting time outside the classroom is more a hassle and a frustration to students than any assignment or test you give them.

Arranging meeting times depends on the size of the team. The larger the team size, the more difficult it is to schedule a common meeting time. One approach that helps in scheduling meetings, necessary for team success, is to create a meeting schedule in which students can write the times when they are in class and/or working and their available times to meet (http://www.foundationcoalition.org/home/keycomponents/samplereg.html). If this is done early in the semester (by the second week of classes, when course adding and dropping period ends), the team already commits to a common meeting time prior to getting involved in other extracurricular commitments, which tend to evolve a little later in the semester. This is a suggested method for establishing a common meeting time, but other, simpler methods could be used.

## Examples of Assigning Teams

Many faculty members throughout the Foundation Coalition have been using student teams in their classes for several years. Each has developed his own approach to assigning teams, partly based on published research and partly based on his experience. Hopefully, actual examples of how some faculty members have assigned teams will help others.

### Example No. 1: Bill Moor, Industrial Engineering, Arizona State University

1. My teams in junior/senior industrial engineering courses nominally have 5 members. I never have groups smaller than four or larger than six.
2. I select teams using a semi-random stratified selection. The following factors are explicitly considered. Heterogeneity or homogeneity is sought for the reasons indicated.
    a. Class standing (heterogeneity). The mixture of experiences is positive.
    b. Major (heterogeneity). Most sources indicate interdisciplinary teams are a positive characteristic.
    c. I use GPA as a measure of intellectual attainment (heterogeneity). Most of the sources I have seen say a mixture is a good.
    d. Native language (hetero/homogeneity). On the one hand, I try to have at least two native English speakers in every team but don't worry about the mixture otherwise. Arguably, the non-English speakers suffer a cultural deficit without a compatriot in the team. On the other hand, I often have many single samples of non-English speakers. I feel that it is better to make certain that the team can write reports, homework, term papers, etc. in English.
    e. Typing speed (heterogeneity). I try to assign one moderately skilled typist to every group.
    f. Gender (hetero/homogeneity). If there is one female team member, there will be at least one other (if possible). Colleagues in the Women's Program in Engineering have emphasized the need for mutual support in an atmosphere that is still strongly male dominated.
    g. Distance from campus (homogeneity). Many times this is student requested. We are a commuter campus, and I use the compass (northwest quadrant, southeast quadrant) when it appears necessary.
    h. Special factors. For example, I teach a course in engineering management. I collect "years of management experience" and then try to distribute that experience across teams.
3. I form teams at least twice (and frequently three times) during the course of the semester. I usually use the calendar as a basis (two teams, seven weeks each; three teams, five weeks each) but occasionally use the nature of the projects to be done as a basis (a term project occupying ten weeks would be done by the same team).
4. I typically allow the teams to turn in all forms of class assignment work (homework, laboratory report, plant-tour report, term-project reports), but all quizzes and tests are done individually.
5. At the end of each team assignment period all members of the team evaluate the relative contributions of all team members of the team (including self). This information is consolidated, normalized, and used as a multiplier for the scores received by each student in the team. I do not allow a student to downgrade only one other student, nor do I allow a student to inflate the rankings of only one other student (including self).

### Example No. 2: Jim Morgan, Civil Engineering, Texas A&M University

1. My teams in first-year engineering courses nominally have four members. I never have groups of more than four people.
2. Heterogeneity: I select a success criterion (e.g., GPA) and choose one from each quartile. I pair women and members of any other underrepresented groups. I make a final adjustment to equalize the average "success ranking."
3. I provide team training to help set expectations of team members.
4. I use peer assessment to help teams reach a standard of performance (and an end-of-term peer evaluation that counts toward the grade). In my experience, peer evaluation helps with slackers (and with overachievers). Those who do more get more (up to 110 percent), while those who do less get less (down to 70 percent overall, plus the possibility of zero on individual assignments).

### Example No. 3: Russ Pimmel, Electrical and Computer Engineering, University of Alabama

1. I use teams for a four- or five-week design project in a senior-level course for CompE, CS and EE majors.
2. I form teams of three or four on the basis of a survey of preferred meeting times (MWF, TR, SS -- morning, afternoon, evening) and grades in prerequisite courses. I assign teams so that they have
   - at least two common preferred work times,
   - heterogeneous capabilities, as indicated by prerequisite grades, and
   - a mix of majors
3. Since this is a senior-level course, I don't consider gender and ethnicity.
4. I give a brief training session on teaming, including ideas for effective teamwork.
5. On a weekly basis, team members individually and confidentially assess the team's progress, activity level, and effectiveness using a three-value scale (*adequate, almost adequate, inadequate*). They also report any special problems and any "slackers".
6. I briefly meet with teams with problems and talk to the slackers.
7. At the end of the project:
   - I grade group project reports and individual quizzes
   - Each student evaluates teammates and reports the percent of total effort for each. (Using "effort" allows subjective accommodations.)
   - I "average" peer data to get an individual effort score
   - I use the effort scores to compute individual report grades from the group grade and a team quiz grade from the individual grades. I then average individual and team grades for each student.

### Example No. 4 – Susan Voss, Donna Riley, and Borjana Mikic, Picker Engineering Program, Smith College

1. A major component of our first-year engineering course involves a semester-long design project that is completed by four-member teams that instructors assign during week two of the semester.
2. To assign teams, we qualitatively use results from the Meyer-Briggs Type Indicator (MBTI) so that each team has a mixture of personality types. In-class time is devoted to discussing the four dimensions of personality type and the implications of individual preferences for working successfully with others.
3. To minimize the problem of teams finding common times to meet, the class has an assigned lab period of three hours each week. Teams can choose to meet at anytime, but they are assured to have this common three-hour block.
4. We emphasize to the students the stages of team formation and the importance of communication. Initially, teams are required to develop a set of "ground rules" that all team members agree to. If difficulties arise, we first revisit this document with the team as a starting point for discussion. Additionally, we meet with each team several times throughout the semester. At each meeting, each team member is asked to bring a written list of two things that are going well with the team's function and two suggestions for improvement related to the team's performance. Each team member takes a turn and shares the positive comments, and then each team member states the areas that she has identified that would improve the team's function. These comments often lead to further discussion.
5. For each of several "deliverables" related to the design project, we use peer assessment to assign individual grades from the group grade based on the model presented by Kaufman et al.[14]

### Example No. 5 – Karl Smith, Civil Engineering, University of Minnesota

I use two types of formal teams in my upper division civil engineering classes (project management and economics, and civil engineering systems): Task teams and Base teams.

1. During the first class period I random distribute students to four-person teams. This sends the message that teams will be used during the course, and helps students get to know one another (students typically come from several departments).
2. During the second or third class I ask students to complete a team membership preference card. Several students (up to ¼ of the class) don't express preferences or list the students in their randomly formed team. I then form four-member teams; honoring their preferences (I usually put up to two people who expressed preferences together, and their put two pairs together). This is their base team and first task team.
3. I change task team membership one-to-two more times during the semester but the base team membership remains the same.

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

http://www.foundationcoalition.org or contact: Jeffrey Froyd at froyd@ee.tamu.edu or 979-845-7574.