Teaching and Assessing Teamwork:
Including a Method (That Works) to Determine Individual Contributions to a Team

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Abstract:

Implementing teamwork has historically been difficult to achieve in an educational setting and hence has often been avoided. With a heavy emphasis on teamwork via industry and accreditation standards, group projects are a high priority.

There are two primary problems to resolve when students work on teams. The first problem is that students are rarely taught how to work on teams. The second problem is the need to assess each individual’s contributions (or lack thereof) to the team.

Assessing teamwork, by its very nature, is usually deemed as a subjective process. Thus, the approach employed to perform the assessment must be structured in a manner that can be objectively and quantitatively measured via a methodology emphasizing the teaching of teamwork and the evaluation of individual contributions to a team. The individual assessments are accomplished predominantly by a highly structured, systematic method of peer evaluation that emphasizes ethical behavior by members of the team. In the past, peer evaluation has been avoided due to the inherent problems of students grading other students. However, the solution provided in this paper is fair and has been proven very successful. Peer evaluation is especially useful and informative because the actual team members themselves know best the contributions of each individual member of the team.

This paper presents a brief review of suggestions for topics to improve the teaching of teamwork. The primary emphasis of the paper is to present a successful method of assessing individual contributions to a team. The basis for implementing the teamwork and associated assessment techniques is an industrial model based on a blend of techniques used by Ford Motor Company, Intel Corporation, IBM Corporation, and The Goodyear Tire and Rubber Company.
Introduction:

Teamwork can be either a successfully rewarding experience or a failingly detrimental experience, depending on the dynamics of the team members. Frequent and measurable expectations of individual team members can help assure a more rewarding experience. Regardless of rewards or detriments, teamwork is required in nearly every technical profession.\(^1\,\!2\,\!3\,\!4\,\!5\) In addition, the Accreditation Board for Engineering and Technology (ABET) mandates teamwork in Criterion 3.d. of the Criteria for Accrediting Engineering Programs.\(^6\)

One common method of implementing teamwork in an academic setting is to assign a project to a group of students. The students complete the project, submit the work for evaluation, and everyone on the team receives the same grade at assessment time. The primary problems with this scenario are twofold. First, the skills required for teamwork are never actually taught. The work of the team is just “expected”. Secondly, everyone on the team receives the same grade even though the work was undoubtedly not accomplished equally by each member of the team.

To resolve these problems, students need to be “taught” teaming skills because these skills are not intuitive.\(^7\,\!8\,\!9\) In addition, a method to determine the participation level of individual members of the team is essential. Students need to be recognized not only for the outcome of the entire team, but also for their individual contributions within a team.

One of the most important aspects of working on a team that needs to be stressed is the knowledge that every individual is responsible for the outcome of the team. From this perspective, it is essential therefore, to fully understand and reward those who are making significant contributions to the team, and to adequately recognize those who are not contributing their fair share. When some team members are not performing their fair share of the work, the rest of the team members must work harder. Because most team members do not work at the same level of expertise or commitment, it is important to distinguish between those who are the top contributors to the team and those who are not the top contributors. Providing a method to distinguish individual contributions to a team can be accomplished utilizing a highly structured peer-to-peer evaluation system that provides a rank for each individual on a team. This is accomplished by establishing benchmarks and evaluating the contributions of each team member toward each particular benchmark.

Ethics is a crucial element of teamwork that must be carefully recognized, considered, and addressed whenever students evaluate each other. However, with the appropriate checks-and-balances as proposed in this paper, the ethical considerations can be minimized.

Teaching Teamwork:

Attempts have been made in the past, to define the best dynamics of a successful team. However,
as is the usual case in nearly every professional settings, teams are formed more as a random selection of employees with the necessary skills, rather than via a cohesive plan for a best fit regarding the dynamics of the individuals or any other criteria for that matter. With this industrial model (or lack of a model) in mind, there has been no attempt in the process presented here to influence the make-up of each team. All of the members of each team are senior level undergraduate students with similar skills.

There are sometimes misperceptions as to whether a student is taught a subject or just required to know the subject. A good example of this is when students are required to give an oral presentation. There is a perception that if a student gives a presentation, then that student has learned the art of verbal presentations, regardless of whether the student was actually taught how to give a good presentation. This same misperception applies to teamwork. The misperception is that if a student is required to work on a team, then that student has learned teamwork regardless of whether the student was actually taught how to work on a team. Teamwork must be learned (taught), as it is not intuitive.

Ultimately, the success of teamwork is considerably dependent on how the methodology of working on a team is taught and orchestrated. The primary topics that must be taught to enable each student to understand and learn about teamwork and to be able to assess each individual’s contribution to a team are many. The following is a list of topics that should be taught to all teams in general. A second list outlines the topics regarding teamwork that must be taught for the successful implementation of the assessment method described later.

Topics Required for a General Discussion of Teamwork:

- Establish a high-level/formal design/construction/test plan.
- Assess strengths and weaknesses of individual team-member skills.
- Utilize those skills to determine the responsibilities of each individual team member.
- Establish a team leader using consensus of the entire team.
- The team leader acts as a facilitator rather than a “boss”. A facilitator works for consensus among team members when decisions are made and monitors and maintains project flow and progression.
- Utilize electronic mail and other on-line communication tools for frequent and consistent communication between all team members.

Topics Required for the Successful Implementation of the Assessment Methods Described Herein (these topics are in addition to the topics listed above):

- Make it very clear that every individual is responsible not only for their individual contributions, but for the outcome of the entire team.
- Set measurable individual and team benchmarks.
• Set completion dates of benchmarks.
• Frequently measure and assess the expectations of each individual and the team.
• Make it very clear that every individual will be expected to work with their team to merge all individual work into a team project.
• Measure and assess each benchmark from both a team and individual perspective.
• Establish a schedule of face-to-face meetings, and allow no exceptions as to attendance at the meetings.
• Individuals must fully prepare work prior to all meetings and benchmarks, and then present that work to the team at the meetings.
• Every member of the team should keep a log of accomplishments of each member of the team.
• All team members assess the contributions of all other members of the team at each face-to-face meeting and/or benchmark.

Evaluating Individual Contributions to a Team:

Peer evaluation is an effective tool to use to determine individual contributions to a team. The team members themselves know best who is making the most significant contributions to the team. According to an article by P. Johnson, the concept of peer evaluation in the professional sector is said to have started in the 1980s as a tool for executive development. Peer evaluation has gained even more popularity in the last ten years and has broadened its scope to include all workers, from top managers to entry-level employees. Numerous articles have been written regarding student teamwork, but few relate to peer review as part of the process. The criteria to use to determine individual contributions must be formal and must be timely.

The characteristics of what constitutes a good team and good team members are open for debate. Some feel that effort is the most important factor, while others feel that only concrete results should be considered, and still others have their own ideas of what constitutes an effective team and team member. However, because a main purpose of team projects is to prepare students for employment (most likely in an industrial setting), it was decided that the basis for implementing the teamwork and associated assessment techniques would be an industrial model based on a blend of techniques used by IBM Corporation, Intel Corporation, The Goodyear Tire and Rubber Company, and Ford Motor Company. At Intel, for example, employees are evaluated based strictly on a review of current accomplishments - not “What are you good at?”, “How well known are you?”, “How many patents did you get two years ago?”, “Hey, how about that Nobel Prize you won in 1994?”. This evaluation method is not “…about researchers whose work may not have visible payoffs every twelve months.” “The best recognition an engineer gets is from his peers…”

At IBM, teams and individual team members are rewarded utilizing a “variable pay” program based on the contributions of the employee, the profits/performance of the specific unit, and the
profits/performance of the company in general. Employees are evaluated as “extraordinary”, “achieved their goals”, “achieved some of their goals”, and “lower levels”.12

As can be concluded from the descriptions of the IBM and Intel evaluation and reward systems, work must actually be accomplished (and measured), because good intentions, being nice, and work you did in the past do not build a company’s current profits. These same types of accomplishments must be expected of students. Only hard work and concrete results get the project completed, while good intentions do not. While any system of evaluation can have both positive and negative arguments, this method was chosen with a goal of introducing students to an actual industrial model, flawed as some feel it may be (see “Ethical behavior and other concerns” below).

The process begins with team members understanding that each member of the team is evaluated by the other members at every team meeting and/or benchmark in two categories, “work done outside of team meetings” and “work done at team meetings”. These measurements assume that benchmarks have been set and that face-to-face meetings are mandatory at benchmarks. Work done outside of the group, in an effort to meet a benchmark, is a crucial endeavor to the well being of the team. Once this outside work is accomplished, the face-to-face meetings are necessary to tie all of the individual work together towards completion of the group project. This peer-evaluation process provides a continuing source of measurement of an individual, namely the work done outside of the group to meet a benchmark and the work done at meetings to assist in the coordination of the entire team project. An evaluation of each team member at each team meeting and/or benchmark will help explain why things are, or are not, going well for the team.

The evaluation of each team member is accomplished by having all other members of the team assign a numeric value to the level of participation of the team member being evaluated (note that all team members evaluate all other members of the team). Assigning a numeric value assists in establishing a consistent and continuous record of evaluation of each member of the team. The numeric ratings that have been chosen range from +4 indicating a “top contributor” to –6 for “not even showing up”. The complete range of numeric values is shown in Figure 1.

<table>
<thead>
<tr>
<th>Quantitative Values for Rating Team Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Contributor</td>
</tr>
<tr>
<td>+4</td>
</tr>
</tbody>
</table>

Figure 1: Team Member Ratings
The individual ratings for all benchmarks and/or team meetings is formalized in a form titled; “Team Members Scoring Form” as shown in Figure 2. This is an evaluation form for assessing

### Team Members Scoring Form

**Name of Team Member being Evaluated:**

<table>
<thead>
<tr>
<th>Work Done By An Individual At Team Meetings:</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meeting:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One of the TOP contributors.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Showed signs of a true leader.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did more than a fair share.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Showed potential as a leader.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did exactly as expected.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A team player.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did less than a fair share.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follows rather than leads.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did far less than a fair share.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not a team player.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did not even show up.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL “at meetings” POINTS:** __________ (total of all scores for meetings 1-5)

<table>
<thead>
<tr>
<th>Work Done by an Individual Outside, In Preparation for Team Meetings:</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meeting:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did more work than almost everyone else.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did more than what was expected.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did exactly as expected.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did less than their share.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did far less than they were asked to provide.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did not do any work.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL “outside preparation” POINTS:** __________(total of all scores for meetings 1-5)

**SUM of BOTH “TOTAL POINTS”:** __________

---

**Your Name (evaluator):**

This name will be removed

Figure 2: Team Members Scoring Form
each team member as benchmarks are achieved. The form is completed by each member of the team, for all other members of the team. Each form is capable of recording information for up to five meetings or benchmarks. Multiple forms can be utilized when the number of meetings and/or benchmarks exceeds five. At a future prescribed time, when it is time for each individual member of the team to see their evaluations, confidentiality is assured by removing the name of the evaluator prior to providing each team member with their evaluations.

Ranking of each Team Member:

Ranking is used by some of the largest corporations in the world to determine employee contributions to the company, which ultimately affects raises, bonuses and promotions. One such example is IBM which uses ranking to determine profit sharing bonuses to employees. Another example is Intel which uses a system called “ranking and rating” to evaluate employees. In addition, ranking is used by the Ford Motor Company, and the Goodyear Tire and Rubber Company.

Ranking is one of the final steps in the peer-review process described in this paper. At a predetermined time, all “Team Members Scoring Forms” are turned in to the instructor. The scores for each individual provided on the forms are totaled by the instructor. Once the grades of each team member are totaled, each student on a team is ranked within that team by the instructor. The top one or two scorers are ranked as “Top”. The lowest scorers with positive totals are ranked “Low”. Those students with scores somewhere between “Top” and “Low” are ranked as either “High” or “Middle”, depending on the value of the totaled scores. Teammates with scores totaling less than zero are ranked “Negative”. Each level in rank is provided bonus or penalty points for the project as shown in Figure 3.

| Bonus and Penalty Points Based on Individual Rank within a Team |
|---------------------------------|-----|-----|------|-----|
| Top                             | High| Middle| Low  | Negative |
| +8                              | +4  | +2   | 0    | -10     |

Figure 3: Bonus/penalty points based on team rank.

At first glance, the point spread between “Low” and “Negative” may seem inaccurate based on the fact that the points jump from 0 to –10 in just one slip in ranking. However, based on many years of experience, it has been observed that students are typically very generous to their teammates. These values for ranking have been adjusted over the years based on experience with student-to-student evaluations. Only when students are truly frustrated with the performance of a teammate are they willing to provide a negative grade. In addition, some students are quite content to let their classmates do their work for them. The threat of “negative” penalties helps unmotivated students to assess the impact on their grade if they receive grades below zero from
their teammates. Experience has shown that even the most poorly performing students are still quite shocked when they realize their classmates grew tired of their lack of contributions and justly gave them negative grades.

One reason why this system functions well is that students are not asked to provide a grade or rank for other students on the team. Experience has shown that direct grading by other students can have many serious problems. However, this system avoids having students directly grade each other. At each benchmark or meeting, the students are required to simply check if a teammate has done what was expected, and to what degree it was done. The students are not performing any kind of ranking at that time. Only when all of the scores for each student are totaled, does the “instructor” perform the ranking.

An example of actual data from a recent team of seven students is shown in Figure 4.

<table>
<thead>
<tr>
<th>Name</th>
<th>Score</th>
<th>Rank</th>
<th>Numeric Rank</th>
<th>Bonus Points</th>
<th>Scores from each team member</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL</td>
<td>176</td>
<td>T</td>
<td>1 +8</td>
<td>12 18 22 34 44 46</td>
<td></td>
</tr>
<tr>
<td>HS</td>
<td>170</td>
<td>T</td>
<td>2 8</td>
<td>6 18 24 32 42 48</td>
<td></td>
</tr>
<tr>
<td>DH</td>
<td>92</td>
<td>H</td>
<td>3 4</td>
<td>2 6 12 22 24 26</td>
<td></td>
</tr>
<tr>
<td>DS</td>
<td>66</td>
<td>M</td>
<td>4 2</td>
<td>4 4 6 8 22 22</td>
<td></td>
</tr>
<tr>
<td>JC</td>
<td>58</td>
<td>M</td>
<td>5 2</td>
<td>0 2 10 12 16 18</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>58</td>
<td>M</td>
<td>6 2</td>
<td>0 4 10 12 12 20</td>
<td></td>
</tr>
<tr>
<td>BN</td>
<td>24</td>
<td>L</td>
<td>7 0</td>
<td>-2 2 2 6 6 10</td>
<td></td>
</tr>
</tbody>
</table>

* T=top, H=high, M=middle, L=low, N=negative

Figure 4: Actual data from a team of seven students.

Fairest Method to Determine Rank within a Team:

Straight Score
Three different techniques were utilized to establish rank using the numerical point system as discussed in this paper. The first technique is to simply total the scores provided by each individual on the team for all other individuals on the team. Averages are not necessary, as the numeric rank will not change from simply using the totals if all scores are divided by the number of members on the team providing evaluations.

Factoring in Ethical Considerations:
Using the total scores could be considered inaccurate because biases can be present in any team.
setting. One solution to help alleviate bias is to disregard both the highest and lowest scores and then to calculate a total. Disregarding the lowest score eliminates at least some negative bias such as race, religion, etc. Disregarding the highest score eliminates at least some positive bias such as when a boyfriend and girlfriend both work on the same team or when good friends work on the same team.

Calculating the Median:
A third technique utilizing the median of all the scores also helps to even out any positive or negative bias.

Sampling of Data:
Further proof that this method of peer-evaluation and ranking is accurate was accomplished via a sampling of data from a recent class involving nine teams of from six to eight student members per team. Each of the three methods explained above was used to determine rank. Interestingly, five of the nine teams resulted in the exact same rankings using all three methods. Even though the numeric scores differed, the overall ranking of the individuals on the five teams remained the same.

Furthermore, three more of the teams had only one teammate’s ranking change (note that this is not the numerical rank, but rather the rank of Top, High, Middle, Low, Negative) when calculated using the three different methods. Only one of the nine teams had significant changes in rankings across the three methods. In this instance, three of the six teammates’ rank changed when using the three different methods.

In a student survey given prior to knowing their rank, 47% of the students felt the method of removing the highest and lowest scores was the best choice. From experience, it was felt that this method of removing the highest and lowest scores would be the most equitable choice to use when the three methods provided different ranking values. The complete information regarding the methods students thought were fairest is shown in Figure 5.

Ethical behavior and other concerns:

In Criterion 3.f. of the Criteria for Accrediting Engineering Programs, ABET requires that students have an understanding of ethical issues facing engineers. Ranking is certainly a topic that provides many opportunities for discussions of unethical behavior. At The Goodyear Tire and Rubber Company, a class-action lawsuit has been filed by employees who lost their jobs or were denied raises or bonuses based on an employee-rating system. At Intel, ranking decisions are full of ethical issues including determining methods of ranking employees on partial leave or employees on long-term projects that do not have the usual payouts. Another ethics concern at Intel revolves around how to keep employee input to peer evaluations confidential.
ethics is certainly behind a comment that states “The rating system …has been very controversial”.\textsuperscript{13} Ford has two lawsuits pending based on the premise that their ranking system discriminates against older workers.\textsuperscript{16} Obviously, ranking is not endorsed by everyone. Ranking is certainly not illegal (yet), but whether it is unethical is open to debate. However, until these ethical issues are resolved, engineering students still need to be taught how to be professional engineers and for now, ranking is certainly part of the profession.

In an academic setting, some of the concerns that arise from this process of peer-evaluation are absences from meetings, not turning in the “Team Members Scoring Forms”, and unethical behavior when completing the forms.

In college, it is not uncommon for students to skip class or to consider skipping team meetings. When a meeting is missed by a teammate, all team members should be provided a full explanation as to the reason the meeting was missed. It is the responsibility of the teammate missing a meeting to be sure that fellow team members are informed as to nature of the reason the meeting was missed. Deciding whether a team member has a legitimate excuse to be absent is sometimes a difficult decision. If it is felt that a team member merely skipped out on a meeting, made no attempt to notify the team in advance, and had no legitimate excuse for the

![Most Equitable Method for Determining Rank within a Team (Student Survey)](image)

**Figure 5: Methods to Determine Rank**

absence, then that team member should receive a score of −6 for that meeting (and another −6 if work was expected) as shown in Figures 1 and 2. Sleeping in, studying, or doing work for

another course are not excusable. However, if a team member notifies the team far in advance, and has a legitimate excuse, then the score should be 0 for that meeting, (and another 0 if work was expected). If a team member did not notify the team members in advance, but had a legitimate excuse (such as a car accident or illness that can be proven) then the score should be a 0 for that meeting rather than a −6 (and another 0 if work was expected). Note that a score of 0 is neither a penalty, nor a bonus.

One hundred percent participation in assessing each member of the team using the “Team Member Scoring Forms” is crucial to the success of this process. A team member not turning in the scores for everyone on the team by the deadline must be removed from the ranking (which could mean a substantial loss of points). In addition, a 10-point penalty should be assessed. This type of penalty usually provides the necessary motivation to insure all teammates participate.

In an academic setting where students evaluate each other, there is certainly room for unethical behavior. There can be positive biases, including having boyfriend/girlfriend on the same team, or good friends on the same team. Negative biases include any of the typical prejudices such as race, religion, sexual orientation, etc. Unethical behavior includes, but is not limited to, providing exceptionally high or low scores to the entire team, providing undeserving exceptionally high or low scores to one individual, providing scores that are inconsistent with other team members, and providing scores that appear to not have been done in the spirit of a true and accurate evaluation. The instructor must review each “Team Members Scoring Form” to determine whether unethical behavior has occurred. In a situation of unethical behavior, the provider of the scores should be removed from the ranking, which could mean a substantial loss of bonus points. In addition, a 10-point penalty (or even a harsher penalty) should be assessed.

Upon casual observation of the scores provided for teammates in Figure 4, it may seem that the scores are inconsistent. For example, the scores for “HS” ranged from a low of 6 to a high of 48. What this shows is not unethical behavior, but rather that each member of a team has a different view of the scale to use to assess other teammates. The reason that this is not a problem, however, is that as long as everyone on the team is honest (consistent), then the scores are accurate. For example, a student providing the top score of 48 for “HS” typically also provided the top score (or close to the top score) of 10 for BN”. Likewise, a second student providing a low score of 6 to “HS” typically provided the low score of 2 (or close to the low score) to “BN”. Because ranking is used, both of the students scored “HS” as “Top” and both students scored BN as “Low” even though the numerical points they assigned were 38 points apart for the “Top” performer. As long as there is honesty and consistency, the rankings are accurate.

Honesty of peer-to-peer evaluations:
At the conclusion of the project, but prior to finding out their own ranking, students were asked to fill out a confidential survey regarding peer-evaluation and ranking. The key to successful peer-to-peer evaluation and ranking to determine individual contributions to a team is honesty. A full 94% reported they had been honest in their assessment of their peers, which is solid proof that this
Empirical Data and Research:

Data used for this research are based on a survey of nine teams, with each team consisting of from six to eight undergraduate students. Highlights of the survey are discussed below. Full information regarding the survey is shown in Figure 6.

<table>
<thead>
<tr>
<th>Student Survey of Peer Evaluation and Ranking</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are you aware that ranking is used in industry?</td>
<td>43 %</td>
<td>57 %</td>
</tr>
<tr>
<td>Are you aware that peer evaluation is used in industry?</td>
<td>45 %</td>
<td>55 %</td>
</tr>
<tr>
<td>Is peer evaluation to determine rank a fair system in college?</td>
<td>49 %</td>
<td>51 %</td>
</tr>
<tr>
<td>Is peer evaluation to determine rank a fair system at the professional level?</td>
<td>71 %</td>
<td>29 %</td>
</tr>
<tr>
<td>Did you fill out the evaluation forms accurately?</td>
<td>94 %</td>
<td>6 %</td>
</tr>
<tr>
<td>Did the scores you provided accurately reflect your true feelings about the contributions of your teammates?</td>
<td>80 %</td>
<td>20 %</td>
</tr>
<tr>
<td>Do you believe that almost all professional work in your field is team based?</td>
<td>82 %</td>
<td>18 %</td>
</tr>
<tr>
<td>Did the teamwork experience in this class help prepare you for professional teamwork?</td>
<td>71 %</td>
<td>29 %</td>
</tr>
<tr>
<td>Did you enjoy the teamwork experience?</td>
<td>80 %</td>
<td>20 %</td>
</tr>
<tr>
<td>Do you think you will enjoy teamwork at the professional level?</td>
<td>71 %</td>
<td>29 %</td>
</tr>
</tbody>
</table>

Figure 6: Student Survey of peer-evaluation and ranking

Information regarding teamwork:
More than half the class was unaware that peer evaluation and ranking were used in industry. In addition, 71% felt that this type of evaluation system was fair in industry, but only 49% felt it was
a fair system in college. However, 80% enjoyed the college teamwork, but only 71% thought they would enjoy teamwork at a professional level.

How individuals ranked:
At the end of the project, but prior to finding out their ranking, students were asked to estimate what their rank would be within their team. A full 63% felt they would be ranked in the “Middle” category, when in actuality only 26% ranked in the middle. Also interesting is that only 4% felt they would rank below “Middle”, when in fact 31% ranked lower than “Middle”. The complete information is provided in Figure 7.

![Individual Rankings within a Team - Actual versus Student Prediction](image)

*Figure 7: Actual versus Prediction of Student Ranking*

The Future:

Further study of the methods described in this paper will continue into the future. Several topics are of particular interest. One of the troubling survey results was that 51% of students responding to the survey felt that team ranking to determine individual contributions to a team was not fair at the college level. The source of this feeling among students needs to be identified and hopefully corrected. Even though the research indicated that 94% of the evaluators said they
were honest, could it be that students felt their teammates would be dishonest and therefore did not trust the system? In the future, an emphasis will have to be made to assure students that peer-to-peer evaluation does work.

Another troubling statistic was that 29% of the student respondents to the survey felt that they would not enjoy teamwork at the professional level. Based on observations that indicate that nearly 100% of the students will work on teams, this is a particularly troubling statistic. Could it be that students already dread the seemingly endless meetings required by teamwork?17

Conclusion:

The assessment techniques described herein are based primarily on the industrial models of Intel and IBM. While any system of evaluation can have both positive and negative arguments, this method was chosen to introduce students to an actual industrial model, flawed as some feel it may be.

Determining the individual contributions of members of a team is a necessity. This can be accomplished by using a peer-to-peer evaluation system that provides a team rank for all individuals on the team. The measurements should consist of work done in preparation for benchmarks and work done to incorporate all individual components into a final product. Students can be trusted to provide an accurate assessment of the work done by teammates, as research has shown that students will be honest using the method provided in this paper.

Whenever assessments are performed, there is room for unethical behavior. However, certain precautions can be undertaken to insure ethical behavior. These precautions include a review of student evaluations, with the prospect of a significant penalty if the assessments are not completed properly.

Survey results indicate that students are typically unaware that peer-to-peer evaluations and ranking take place in industry. However, most students do look forward to working on a team as a professional. As demonstrated here, teamwork can be successfully taught and implemented into an academic environment. Teamwork should be taught and practiced as a prerequisite to professional employment.

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Biography

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