Abstract - Although industry and academia alike place high value on teamwork, how do we actually develop and assess those skills in our students and ourselves? How do we evaluate whether our efforts have had a measurable impact on the students so that we can adjust our approach for maximum benefit? In October 2004, the authors presented initial work on a program-embedded process designed to help students (1) learn critical teambuilding skills, (2) identify their strengths and weaknesses when working in teams, and (3) improve their team skills. The process involves data collection, exit interviews, and student feedback in five program-specific courses taken over three semesters and with two different faculty. Data has been collected on 100 students to provide evidence of student development in the three areas indicated. Although data analysis did not always indicate student development, the exit interviews conducted at the end of the three semester sequence of courses consistently revealed improved skill. This paper summarizes the program-embedded process and provides results based on data collected from Spring 2003 through Spring 2007.

Index Terms – teamwork, assessment.

INTRODUCTION

The importance of teamwork in today’s workplace is essential. Teamwork in educational programs is expected by many accreditation agencies such as the Accreditation Board of Engineering and Technology (ABET) as defined in the Engineering Criteria 2000 (EC-2000). Many publications, generally from psychology roots [1] – [5], can be found on the subject of teams and team assessments. These often discuss processes for creating and managing effective teams as well as the assessment of the team and, to a lesser degree, the individual. Engineering faculty at Bucknell University provide a comprehensive look at teaching and developing teambuilding skills, as part of their NSF funded “How to Engineer Engineering Education Workshop” [6], that often employs simple classroom assessment techniques, such as those offered by Angelo and Cross [7]. Imbrie, et al. [8,9] developed a self-assessment instrument, to facilitate the identification of effective student teams. In their work, team effectiveness was operationalized in terms of a 24-item self-report requiring students to indicate the degree to which their team worked together across a range of domains, including: interdependency, learning, potency and goal-setting.

A large-scale project, reported on by McGourty, focused on developing engineering students’ teambuilding skills [10] utilizing a computer-based survey system called Team Developer [11] in which responses are supplied using a Likert scale. Teams consisted of 4-6 students working on semester-long projects. Thousands of students at various universities participated in this project which reinforced the importance of repeated multisource feedback for student development [12]. Since the assessment using Team Developer is lengthy and in depth, its application is best suited for large teams working on semester-long projects. However, the feedback supplied is limited to quantitative data although qualitative data could be added. These factors restrict the types of courses Team Developer can be applied in as well as how often, what type, and how much feedback is supplied. Still, there are many similarities between McGourty’s work and the work presented here in terms of rationale, benefits, implementation strategies, and even conclusions. The contribution of our work is a program-embedded process that is readily implemented in any course in which group work takes place regularly. Group work involves 2-3 students working on short-term activities. The result is a multisource feedback process that draws information from different courses over several semesters within the student’s program of study.

The objective of the Team Assessment process was to provide a simple and quick method of evaluating and improving individual team building skills that could be applied regularly to classroom and lab group activities. The process should raise awareness of the importance of working effectively in teams and provide personal insight for each individual leading to their self-development.

The students in this study included first and second year community college technology students. An earlier study [13,14] of data collected between Fall 2003 and Spring 2005 provided significant evidence that the process met its objective. This paper provides an overview of the team assessment process and data analyses from Spring 2003 through Spring 2007 supplying further evidence of the process’ efficacy.

TEAM ASSESSMENT PROCESS OVERVIEW

To implement Team Assessment in the classroom including providing evidence of its impact, the following steps are applied:

- Introduce team assessment process to students

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I. Introducing Team Assessment Process to Students

The key instrument in the process is the student Team Assessment (TA) form. The front side of the form (see Figure 1) is quick to complete and highlights fundamental aspects of teamwork: preparation, active participation, involvement in reporting results from the team, and leadership. The back side (see Figure 2) typically provides deeper insight than a rating system as students are asked to comment on (1) the main task each student took on, (2) behavior that was supportive of the team, (3) suggestion for improvement, and (4) leadership skills. All feedback is supplied for themselves and for their peers. The questions on the form were derived from multiple sources including technician level peer review forms used at IBM and Intel and work on functional behaviors in teams [15].

Students are required to submit a TA form for each group activity in their lab-based program-specific courses. Students are invested in the process from the beginning by encouragement and discussion facilitated by the instructors as well as a grade for completing the assessment form for every team activity. Since student teams were formed by random draw and regrouped for each activity, student comments originate from a variety of classmates. Student ratings and comments are compiled by course in a student feedback summary that protects anonymity of the source. These ratings and comments are supplied to the student at mid-term and end-of-semester for each course providing opportunities for the student to self-reflect. Furthermore, for each course the instructor writes a summary of the student’s current team building skill and suggestions for improvement.

In implementation, it is important that students are aware of the preparation required for a particular group task. For example, pre-lab work could be assigned in advance of the activity. Using this approach, students readily identify their preparation level. From five years of observing student responses it was noted that students generally judge themselves honestly when completing the self-assessment portion of the form (Figure 1).

Other material supplied to students [14] along with the TA form includes the ‘TA – Student Supplement’ and ‘Functional Group Roles Summary’. These documents help students fill out the TA form and develop a vocabulary for assessment. The Student Supplement includes a variety of appropriate comments students may select for the back side of the TA form (Figure 2). The Functional Group Roles Summary explains what functional group roles are and also provides a vocabulary for assessment. Students are encouraged to use the Supplement as well as the Functional Group Roles Summary, however, if students can articulate what they want to say without those two documents, they are encouraged to do so. A sample of student feedback is also provided which helps students envision the feedback they will be given and why it provides them with useful information (refer to Figure 3).

The following section provides details of the process steps.

Please recognize that this assessment is for positive reinforcement of excellent team practices and not serves in that capacity with your honest responses.

<table>
<thead>
<tr>
<th>Team Member</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Which team member is taking responsibility for submitting assigned materials by the specified deadline?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In a successful team, each individual team member comes prepared for and actively participates in the activity and is actively involved in any reporting or requirements. Reflect on the three statements below as they pertain to you and that activity. For each statement, circle the response that best represents your opinion:

4 = strongly agree 3 = agree somewhat 2 = disagree somewhat 1 = strongly disagree

- I came prepared for this activity by performing all pre-activity assignments such as pre-read homework, reading in the textbook, and thoroughly reading the activity instructions.
- I fully participated in this activity by determining how to support the team. Teams of support include organizing personnel, providing team analysis, coordination, including, and measurement.
- I fully participated in meeting all reporting or requirements. I have worked with team members in regard to these. I collaborated to produce materials required for submission by the team.

For each team member, circle the response that most closely represents your opinion.

4 = strongly agree 3 = agree somewhat 2 = disagree somewhat 1 = strongly disagree

- I really enjoyed working with this person. This person is a good asset to the team, and would like to be on a team with her/him again.
- This team member has strong leadership potential and I would like to see them take on more of a leadership role in the team.
- I really enjoyed working with this person. This person is a good asset to the team, and would like to be on a team with her/him again.
- This team member has strong leadership potential and I would like to see them take on more of a leadership role in the team.
- I really enjoyed working with this person. This person is a good asset to the team, and would like to be on a team with her/him again.
- This team member has strong leadership potential and I would like to see them take on more of a leadership role in the team.

FIGURE 1
FRONT SIDE OF TEAM ASSESSMENT FORM.

All the materials described above as well as the Team Assessment process is presented to students on the first day of class so they can be prepared to participate in the process early in the semester. In order to get maximum benefit from these tools, students should practice their team building skills with a wide variety of their classmates. This can be accomplished by grouping students using a random process for each activity. Random selection is critical to the process because students tend to group themselves based on who they know and are comfortable with which limits team building skill development. Furthermore, if allowed to select their own groups and stay in that configuration all semester, they tend to fall into roles, limiting opportunities to try other roles unless assigned to them. Assigning roles
II. Data Collection, Analysis, and Multisource Feedback

Although past study [10] indicated that the act of the student completing the Team Assessment form would help the student identify positive behaviors, regular feedback is important in gaining student buy-in and teambuilding development. The team assessment data from the forms is collected from each group activity, periodically compiled from multiple courses and instructors into a single spreadsheet for each student, and analyzed by program faculty and advisory board members. A discussion of analysis methodology is provided in the subsequent section. The analyses listed below are undertaken for each student’s spreadsheet and are used to identify trends in behavior that may indicate improved teamwork skills.

1. The numerical responses to the team assessment questions are analyzed to note deficiencies and improvement from semester to semester.

2. The short answer responses to the team assessment questions are analyzed with a holistic approach.
responses are read by the instructor of the course, and an overall statement is made about the teamwork skills displayed by the student according to the data (Figure 3). The statement has some level of subjectivity, since the instructor knows the student and their classmates.

3. In the final semester of the program, the student feedback collected over the prior program courses is reviewed by faculty and members of the program’s industry advisory board. For this review, all identifying information is removed. An overall statement is made by each reviewer for each student and then added to the student’s feedback form.

The results of these analyses are given to the student as feedback at midterm and the end of each semester as well as discussed during the exit interview at the end of the program. Faculty work from a shared file so that feedback for a student in multiple courses is collected on a single spreadsheet. This practice produces a growing record of feedback for student consideration from a variety of courses and for multiple semesters. Each feedback point provides an opportunity for students to reflect on their teamwork skills; how they have improved and strategies for continued improvement.

In addition to feedback from each course, as shown in Figure 3, a final feedback summary is given to the students in the capstone course which includes the overall reviews from program faculty and advisory board members.

III. Written Assessments and Exit Interviews

In the capstone course, written assessments and exit interviews are conducted with graduating students. The written assessments provide students a final opportunity to demonstrate their competency in specific program outcomes. The exit interviews offer a unique opportunity to determine the level of a student’s competency that may not be otherwise apparent. For example, it was determined in exit interviews that some high-achieving students who were not demonstrating significant development in their team building skills based on the feedback summary, had in fact developed these skills but didn’t necessarily demonstrate the expected behavior if they felt their team effort would diminish their lab grade.

Questions requiring a written response are:
1. Thoroughly describe the characteristics of an excellent team member.
2. Thoroughly describe the characteristics of an excellent leader.
3. Describe your leadership skills. Do you feel you have developed leadership skills as part of your college education? If yes, explain (what skills and how you developed them).

Exit interview questions related to the team assessment process are:
1. Describe your strengths as a team member, include your strongest contributions and what you need to work on to be a better team member.

2. Do you feel your contributions to teams and your team building skills have changed over your time in this program? If yes, how and why? Provide examples of what you were like when you first started the program and what is different now. Please indicate if any of these changes came about due to feedback from the team assessment process.

ANALYSIS METHODOLOGY

In the first years of the study, raw data analysis was performed using two different approaches. The results were compared to each other and to the exit interview results. The raw data analyses were performed individually by two different instructors on student feedback data that had been collected in a 2nd semester Electronics I course and the subsequent 3rd semester Electronics II course. The purpose of each analysis was to locate student progress – a trend in the improvement of their team work skills. The first method involved summarizing students’ progress from a holistic perspective by reviewing the collection of student feedback over the two semesters. The second method categorized the responses and calculated the difference in the number of comments in each category over progressive semesters.

The summaries of the two approaches to analyzing the data resulted in a depiction of each student’s strengths, weaknesses, and changes. The two faculty involved performed their analysis without consultation and then the results were compared. The categorization method was shown to quantify the holistic method but did not add significant meaning or context to the summary. The interviews confirmed that the summaries from analyzing the data were on target with the student’s own thinking and feelings about the tasks they performed for their teams, the support roles they fulfilled, and how those changed over the year. During the exit interview, students were shown the comments from the Advisory Board, and they concurred that the comments were representative of their behaviors.

The accurate snapshot of the student’s progress provided by the overall summaries written by advisory board members after reading raw data for each student, as verified by the students themselves in the exit interviews, provided strong justification to use the holistic method only when analyzing the data. Additionally, the exceedingly time-consuming method of categorizing student responses added little value to the data summaries. Therefore, the current analysis practice is as described in the previous section.

STUDY RESULTS

The results reported here are derived from team assessment data collected in four Electrical Technology (ELT) courses since Spring 2003. The team assessment data was collected in two required second semester ELT courses and in two required third semester ELT courses. Written assessments and exit interviews conducted in the ELT capstone course since Fall 2004 provided additional data. The capstone course is required in the fourth semester.
The preliminary study [14] applied a multi-pronged approach using data from multiple sources and an exit interview with each student to determine if the team assessment process was having the desired impact. Specifically, did the students who had been provided feedback demonstrate better team building skills? The preliminary study involved 27 students that were categorized as follows:

- Group A consisted of ten students engaged fully in the team assessment process by completing assessment forms and receiving feedback in four of their classes over two semesters.
- Group B consisted of 17 students that had not consistently been required to fill out the assessment form and had not received any feedback from the forms or from their instructors. Also, all of the members of Group B were non-traditional students currently employed in the semiconductor industry which was paying for their education.

The results indicated that 80% of the students from Group A and 59% from Group B recognized a change in their team building skills over the course of the program. However, 80% of the students from Group A and only 24% from Group B were able to clearly articulate their teambuilding skills and what changes had occurred. This trend is worthy of further comment since Group B consisted exclusively of non-traditional students already employed as technicians. The adult learners typically come to college with more developed team building skills than the traditional student and often do not identify significant further development in this area. However, although a majority of the non-traditional students did not strongly identify a change in their team building skills during their exit interviews, they were significantly less capable of articulating their team building skills compared to a twenty-year old with little to no work experience. The inability to articulate team building skills is a hindrance to further development, especially in team support and leadership development. Except for a highly developed team member, the use of the TA form and associated feedback helps the participant be a more effective team member and leader. In fact, only one student interviewed already had excellent team building and leadership skills and was readily able to articulate strengths and weaknesses. This was an ex-marine with substantial training in both teamwork and leadership; training that places a high value on excellent teams and leaders. If we want a similar outcome for our students, we may need to also place a high value on these skills by dedicating more class time and a higher percent of the grade to this competency development.

Table I provides a summary of results from analyzing data derived from the written assessments and exit interviews of 63 students conducted between Fall 2004 and Spring 2007. For the first two years of the study, the exit interviews were conducted by the faculty member teaching the capstone course. In the subsequent years, exit interviews were conducted by members of the program’s advisory board who have no prior contact with the students they interviewed. Little variation was noted between results collected by faculty or advisory board members.

The analysis strongly indicates that students who took part in the team assessment process and received periodic feedback were dramatically more likely to clearly articulate their strengths and weaknesses as a team member than students who had not participated in the process (74% vs 25%). Furthermore, students who received feedback were much more likely to be able to identify how their team building skills had changed and developed over the course of the two year program than students who had not received the feedback (96% vs 54%).

Table I

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Limited</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did student get feedback from team assessment?</td>
<td>41%</td>
<td>44%</td>
<td>14%</td>
<td>0%</td>
</tr>
<tr>
<td>If yes or limited, could student clearly articulate their strengths and weaknesses as team member?</td>
<td>74%</td>
<td>26%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>If yes or limited, did student indicate changes in their team building skills as a result of the feedback?</td>
<td>94%</td>
<td>6%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>If no, could student clearly articulate their strengths and weaknesses as team member?</td>
<td>25%</td>
<td>75%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>If no, did student indicate changes in their team building skills?</td>
<td>54%</td>
<td>39%</td>
<td>0%</td>
<td>7%</td>
</tr>
</tbody>
</table>
feedback of their performance in group activities are dramatically more likely to articulate their own strengths and weaknesses and how they developed those skills.

Input from students during the exit interviews illuminated the fact that comments from their peers had the most impact on their development. The comments drew student attention much more than the peer ratings. Typical comments from students during the exit interviews were:

“This [the feedback] is very good for looking at myself”.

“I saw that I needed to stop worrying about my grade and trust my peers”.

“Team assessment feedback helped me figure out what to do. ...Comments like ‘speak up’ and ‘give input’ helped”.

Students took the feedback seriously as there was so much data from multiple sources to consider. Not all students took completing the form seriously, as indicated by some students during their exit interview, but since there was so much data from so many different students, the overall impact was significant and taken seriously by nearly everyone as validated by the 94% of students indicating that they had changed due to the feedback supplied.

The fact that students are receiving quantitative and qualitative feedback from multiple sources over three semesters as well as the exit interview process which closes the feedback loop distinguishes this work from other similar studies. A conclusion from the large-scale study using the Team Developer software reported on by McGourty [10] stated that “when the process is administered several times over a period of time, individual team members improve on learning outcomes significantly after peer feedback.” The improvements McGourty reported were less than 5% of the five point Likert scale applied which was similar to the quantitative results using the categorization method reported here. However, the qualitative data collected from the team assessment forms and exit interviews provide deeper insight than quantitative data into how students are motivated to improve and the depth of their improvement. Data analysis indicated that students did not demonstrate remarkable behavioral changes, but the interviews revealed that other academic pressures may have affected behavior. Many students indicated that they better understood what they needed to do to support team work by going through this process but the data would not necessarily show how much they had learned. In the exit interviews it became apparent that other factors, such as competing priorities and personal expectations for grades, would often result in the student choosing not to adjust their behavior according to what they had learned from the feedback. Most students felt they would behave differently in a workplace setting where external factors tend to be more supportive of team work than in an academic setting.

CONCLUSIONS AND FUTURE WORK

The results over the four-year study indicate that active participation in the team assessment process, including regular feedback to students and an exit interview, is beneficial in developing team building skills in college students. Unique features of the process are its utility for assessment of small-scale, group activities, such as weekly lab work, and the use of a simple and short team assessment form. During the study, students’ behaviors indicative of improved team building skills were observed and documented in the data analysis. Students indicated that without the Team Assessment process described, they would not have been able to identify some of their specific strengths and weaknesses. Thus, clear outcomes of the team assessment process are; student ability to clearly articulate their own skills, student’s self-assessment of a positive change in team building skills, and to a lesser degree, a change in student behavior reflecting improved teambuilding skills.

We continue to collect and analyze data from the team assessment process which provides solid documentation for assessment purposes. The analysis is used to report on one of the program level student learning outcomes which is that students should be able to define and demonstrate effective team building skills. With this process, we are able to provide evidence to support our claim of success in this outcome.

The Team Assessment booklet [14] will be updated to reflect recent improvements and additions to the process. A web application is intended to be written that will further simplify the Team Assessment process through automation of compiling and randomizing the student feedback, and calculating results of numerical data.

REFERENCES


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