Incorporating Student Peer Review and Feedback into the Assessment Process.

Jack McGourty
Fu Foundation School of Engineering and Applied Science
Columbia University

Peter Dominick
NSF Gateway Coalition for Undergraduate Engineering Education
Drexel University

Richard R. Reilly
Wesley J. Howe School of Technology Management
Stevens Institute of Technology

Abstract *- The paper provides a detailed discussion of the design, application, and results of a computer-based approach used to solicit student self and peer assessment and feedback on nine learning outcomes linked to ABET 2000. Several issues will be addressed including: the efficacy of student self and peer review, correlation with faculty ratings, faculty and student acceptance, and process management.*

Introduction

In spite of the growing number of team-based projects being used in colleges and universities, the application of student peer review processes to support assessment activities has been limited. Furthermore, qualified and systematic methods for peer evaluation and feedback are either non-existent or require additional resources, which are commonly unavailable. This paper will discuss the application and results of a simple, automated and quantified approach to an assessment and feedback methodology successfully used with hundreds of engineering students in several programs including New Jersey Institute of Technology, Ohio State University, and Stevens Institute of Technology.

Rationale

Student outcome assessment has become a primary focus for higher education institutions in today's competitive environment. There is a great deal of pressure from both industry and academic accreditation entities to incorporate a broader set of student learning outcomes and sound assessment techniques into new courses and other educational programs. For example, the Accreditation Board of Engineering and Technology (ABET) has incorporated eleven student learning outcomes and assessment as a key criterion in its Engineering Criteria 2000. According to the ABET criteria, the focus of an institution's assessment efforts should be on the measurement of student learning outcomes in a systematic and valid manner.

In general, an outcome-driven measurement system provides critical information to educators on the effectiveness of the design, delivery, and directing of an educational project, activity, or program. Few educational institutions have a comprehensive system for measuring program results in terms of student learning outcomes. And of those that do, the focus has been on the traditional set of student outcomes in specific technical and basic science areas. However, the movement in industry for practicing engineers and supported by ABET, is the drive to prepare students for the professional work environment they will encounter post graduation. Newly graduated engineers will need competencies beyond the traditional knowledge of science and basic engineering principles. As professionals, they will require skills to help them function in multidisciplinary teams, work with complex systems of products and services, and strive towards continuous self-learning.

To accomplish this skill development, faculty have increasingly turned to the use of cooperative learning techniques in the classroom. [1,2,3] These techniques promote interdependence amongst students, encourage interaction, require information sharing and typically include the use of team-based projects as cornerstones of the learning process. One of the keys to making cooperative learning successful is the shifting of the student's role from a passive receiver of information into an active participant. In a cooperative learning environment, students themselves are often in the best position to provide one another with meaningful feedback regarding both their technical and interpersonal performance. In spite of this fact, the applications of peer review processes in the classroom are limited. Furthermore, qualified and systematic methods of peer evaluation and feedback are almost never used and typically require time and resources that are not easily available.

How does a Formal Peer Feedback System Impact Students' Performance?

A formal peer feedback approach provides students and educators with many important benefits. First, introducing a systematic peer review system helps to reinforce key learning objectives. The behaviorally specific information contained in the survey helps to define and make salient to the student what is required in order to perform effectively. [4] This is especially important when considering the eleven ABET EC 2000 student learning outcomes . Second, the fact that the information is presented as part of a formal feedback system sends a strong message to students that performance should be improved. This message in and of itself, can often encourage people to evaluate their own performance and establish improvement goals. [5] Recent research on the use of peer feedback systems suggests that students are likely to demonstrate changes in behavior and skill acquisition simply by completing the feedback instrument. For instance, Dominick, Reilly & McGourty found that students who completed a peer feedback instrument, but did not actually receive feedback, were just as likely to improve their performance as students who actually received feedback. [6]

This is not to suggest that feedback does not add value. Providing feedback to the student is a critical component of the peer review process. The students that receive timely and detailed feedback are in a better position to have meaningful performance improvement discussions with their instructor and peers. They will also have a valuable performance record that makes it easier to track their performance over longer periods of time. Finally, the feedback can be of great value to the instructor for teaching and assessing course outcomes. By reviewing feedback results, instructors can better tailor their teaching activities to specific needs identified for individual students and the total class. Doing so is likely to promote even greater learning and improvement by students.

The Team Developer™

One approach that has been successfully used in the class-room is a behavior-oriented survey called the Team Developer. [7] Team Developer is designed to provide each student with developmental feedback regarding his or her effectiveness on several specific cognitive and behavioral skills. Student team members rate both themselves and their teammates on items designed to identify skills based on behaviors that have been found to be important for practicing engineers. Each student receives a developmental feedback report that presents self and team ratings on each survey item and highlights overall strengths and areas for development. Gaps between self-perceptions and the perceptions of others are clearly shown. Specific suggestions for development, keyed to the behavioral areas, are provided to assist team members in developing action plans based on their personal feedback.

The Team Developer approach provides students and educators with many important benefits. First, feedback is based on the observation of specific behaviors rather than subjective overall impressions. Thus, the student can act on the information more readily. Second, students can use the reports to plan their own development activities and monitor progress over time. Third, the feedback reports allow educators to tailor their teaching activities to specific needs identified for individual students and the total class.

Development of Competency Based Assessment Items

One of the keys to the successful use of a peer feedback system, such as Team Developer, is the clear articulation of the competencies and behaviors that are to be assessed. A competency is a bundle of knowledge, skills and abilities that relate to successful performance. Another way to think of a competency is as a learning outcome associated with a course or a program. Therefore, when designing a peer assessment instrument, one of the first questions to answer is, "What are the main competencies that relate to effective performance in this course and or program?" For instance, the competency, Analytical Skills could be defined as follows:

> *Applies logic in solving problems and analyzes problems from different points of views. Translates academic theory into practical applications and recognizes interrelationships among problems and issues.*

Once a definition of the competency is established, the next step is to further define it with illustrative and specific behavioral examples. It is these behaviors that will form the content of the peer feedback instrument. Defining competencies in behavioral terms makes it far more likely that people will be able to provide valid assessments and also increases the likelihood that feedback will be actionable. For our Analytical Skills competency, some sample behaviors include:

- Analyzes problems from different points of view
- Recognizes interrelationships among problems and issues
- Applies logic in solving problems
- Scales down information to what is important

While breaking competencies down into specific behavioral examples is essential, it is also important to take a broader strategic perspective as well. Ideally, one should be able to identify the ways in which competencies for a particular course or program relate back to broader institutional objectives and also to outside accreditation criteria such as ABET EC 2000. Doing so helps to ensure that the instrument provides meaningful feedback to students and is an integrated part of an institution's overall assessment strategy and program.

Using the Computer for Instrument Administration

One of the biggest challenges many faculty faces when attempting to implement peer feedback process is finding the time to collect, tabulate and then disseminate information. A computerized format like Team Developer's helps to eliminate many of these obstacles. Using a computerized survey means that data can be collected and analyzed quickly and that there can be a fast turnaround time for providing feedback. This also means that more time can be spent reviewing information and ensuring that the feedback process is a meaningful one for students and instructors.

Of course using a computerized survey assumes that students have access to computers and the appropriate level of computer literacy. While these issues are not likely to be problems for most of today's students it is a factor to consider when implementing the feedback process. Another factor to consider is that while an automated system is ultimately a time-saver, there is usually an initial need for more up-front time to ensure that the process operates smoothly and efficiently. A peer evaluation process will be more effective if the instructor takes the time to discuss the process with the students. Students need to be aware of the rationale for receiving feedback from peers. Additionally, they must understand how the competencies being measured are linked to the course objectives.

Implementing a Feedback Process

Even a well designed and automated peer feedback process will fail to produce meaningful results if it is not implemented with care. To begin with, feedback providers and recipients should be made aware of how the instrument was developed and most importantly, how the information they provide will be used (for example, developmental versus evaluative). One of the advantages of Team Developer is that feedback can be collected and provided in ways that ensure confidentiality. Ensuring confidentiality is often an important factor, especially for people who are new to the peer feedback process.

In terms of encouraging improvement, there should ideally be more than one administration of the instrument during the time that peers are working with one another. Two administrations of the instrument (at the midpoint and end of a semester) has worked best with Team Developer. The midpoint assessment should be conducted after the students have had sufficient time to observe skills and behaviors of their fellow team members. By the end of the semester, the students have adequate opportunity to react to the peer feedback they receive and to implement improvement efforts.

Another factor that can help to make the most out of the peer feedback process is instructor involvement. For instance, at Stevens Institute of Technology, instructors typically make themselves available to students who wish to discuss the feedback they have received. [7] In some cases, instructors have facilitated discussions amongst peers in order to help them better understand the feedback they have provided to one another. Another way to strengthen the impact of a peer feedback process is requiring students to prepare development plans based upon their feedback.

Using Peer Feedback to Reinforce and Assess ABET 2000 Learning Outcomes

Several undergraduate and graduate engineering programs have incorporated the Team Developer into their curriculum. For example, New Jersey Institute of Technology (NJIT) used the Team Developer process to assess undergraduate engineering students working on team design projects. [8] The process at NJIT involved students rating self and peers on 48 behaviorally specific items relating to nine core learning outcomes: Analytical Thinking; Communication Skills; Creative Problem Solving; Project Management; Research Skills; Self-Learning; Systems Thinking; Teamwork; and Technical Competence. Each of these outcomes was linked to ABET 2000 Criteria 3 (a-k).

In another example, Team Developer was incorporated into capstone graduate classes at Stevens Institute of Technology. In these classes, students worked in teams of six to seven members to solve business cases and make decisions regarding a simulated technology-based organization. Students rated themselves and their peers in four learning outcome areas - Collaboration, Communication, Decision Making, and Project Management.

In both cases, self and peer assessments were based on the observations of specific behaviors of students working on classroom projects throughout the semester. Students engaged in frequent interaction while working on these projects, thus providing good opportunity to observe specific skills and behaviors of each other. Students were provided with feedback on how they were rated by their peers on each of the nine learning outcomes. Students were encouraged to use the reports to plan their own development activities and monitor progress over time. Faculty also received information regarding how their classes faired in the aggregate ratings of the nine learning outcomes as perceived by their students.

Results

At NJIT, data was gathered from three separate sections with a total of 158 students participating. Results from the Team Developer were correlated with faculty ratings on the nine learning outcomes and grades given at the end of class. [9] Faculty rated student teams on each of the nine learning outcomes. These team ratings, given by the faculty, were significantly correlated with students' average team peer-ratings across all learning outcomes. Results clearly demonstrate that student peer ratings are consistent with he overall perceptions of faculty.

One interesting finding is the variation found among correlations between self and peer ratings and students' grades in freshman engineering design classes (Table 1.). There are several potential reasons for the low relationships between grades and self and peer ratings, especially in communication and teamwork. Through interviews, we found that faculty were still generating the majority of their grading on technical competency, with less attention on the cognitive and behavioral skills measured by the Team Developer. This finding was substantiated through student course surveys in which students rated the extent to which the nine learning outcomes were emphasized during the course.

Table 1. Correlations Peer/Self & Grades by Learning Outcomes

Learning Outcomes	Peer-Grade	Self-Grade
Analytical Thinking	.32*	.35*
Communication	.22	.38*
Creative Problem Solving	.32*	.35*
Project Management	.39**	.31*
Research Skills	.59**	.41**
Self-Learning	.60**	.54**
Teamwork	.22	.21
Technical Competence	.35*	.23
Systems Thinking	.38*	.28

(* p<.05, **p<.01)

In the Stevens example, data was gathered from six separate classes with a total of 178 students involved in the Team Developer process. The Team Developer was administered twice in each class. The first administration occurred during the middle of the semester and was used to provide developmental feedback to class participants on four team-related learning outcomes: Collaboration, Communication, Decision Making, and Project Management. The second administration occurred during the final week of class and feedback was delivered to students during their final presentations.

The results demonstrated that students improved in all four areas (Table 2.). Specifically, a series of paired t-tests found significant differences between the means for the first administration versus the second administration for learning outcomes measured as well as the overall average across the four areas combined.

Table 2. Average Peer Ratings for Students by Learning Outcome (Rating Scale 1=Never to 5= Always)

Learning Outcome	Time 1	Time 2	t value
Collaboration	3.71	3.83	2.68**
Communication	3.55	3.74	4.67**
Decision Making	3.46	3.65	5.31**
Proj. Management	3.51	3.72	4.62**
Overall	3.55	3.74	6.64**

(** p< .01)

Conclusions

As engineering educators increase their attention to developing and assessing student learning outcomes, peer evaluation processes will play an integral part in the education process. First, our studies show that student can play an active role in their own development and assessment. However, these self-assessment skills need to be developed by providing a structured process to facilitate their learning. Secondly, peer feedback processes can have an impact on developing student learning outcomes as prescribed by ABET EC 2000. An educational tool, as the Team Developer can support an institution's objectives in the development and assessment of these critical student learning outcomes. Team Developer data on hundreds of students has been collected. This data shows student self and peer ratings can be consistent with faculty perceptions of student performance. Additionally, when the process is administered multiple times, individual team members improve on learning outcomes significantly after peer feedback.

References

1. McGourty, J. (1994). Designing & Teaching Team Courses for Technology-Based Students. Paper published in *American Society of Engineering Education Proceedings*,Edmonton, Canada.
2. Hillborn, RB. (1994). Team learning for engineering students. *IEEE Transactions on Engineering Management, 37,* 207-211.
3. Kernaghan JA, Cooke, RA (1986). The contribution of the group process to successful project planning in R&D settings. *IEEE Transactions on Engineering Management, 33,* 134-140.
4. London M, Smither, JW. (1995). Can multi-source feedback change perceptions of goal accomplishment, self-evaluations, and performance related outcomes? Theory-based applications and directions for research. *Personnel Psychology,* 48, 803-839.
5. Locke EA., Latham GP. (1990). *A theory of goal setting and task performance.* Prentice Hall, NJ.
6. Dominick PG, Reilly, RR., McGourty J. (1997). The effects of peer feedback on team member behavior. *Group and Organization Management,* 22, 508-520.
7. McGourty, J. (1996). Promoting collaborative behavior in the classroom: A field investigation (1996). Paper presented at the Eleventh Annual Conference of the Society for Industrial and Organizational Psychology, San Diego, California.

8. McGourty, J, Sebastian, C., & Swart, W. (1998). Developing a comprehensive assessment program for engineering education. *Journal of Engineering Education* (in press).
9. McGourty, J, Sebastian, C., & Reilly, R. (1997). Incorporating student peer review and feedback into the assessment process. Paper presented to the Best Assessment Processes in Engineering Education: A Working Symposium sponsored by National Science Foundation, ABET, and Rose-Hulman Institute of Technology, April 1997, Terre Haute, Indiana.