A Multilevel Assessment Process for Student/Faculty Teams in a Project-Based Learning Environment

David DiBiasio[1], Natalie Mello[2], and Fabio Carrera[2]
[1]Department of Chemical Engineering and [2]Interdisciplinary and Global Studies Division
Worcester Polytechnic Institute

Introduction

High tides, sinking buildings, 12 million tourists a year - all contribute to the problems of Venice, Italy. Canals designed to handle limited human-powered boat traffic are now inundated by powerboats. Biological, chemical, and mechanical factors damage centuries-old walls, resulting in annual repair costs of several million euros. *Moto ondoso*, the wall damage caused by the relentless pounding by boat wakes, is a complex problem that involves chemical and other engineering issues, culture, and economics. It is also a political and social problem frequently appearing in the popular press and in public demonstrations (see Figure 1).

(a) from La Nuova Venezia, July 8, 2002

(b)

Figure 1. a) Article describing a protest along the Grand Canal concerning *moto ondoso* policies. b) Anti-wake banners posted along a Venetian canal.

Yet, WPI undergraduate student teams have made contributions toward solving this real problem while receiving academic credit. A key element is effective teamwork at both the student *and* faculty levels. That teamwork results from a multilevel assessment process designed to optimize the learning and teaching experience.

The student team experience is designed and monitored using well-established cooperative learning principles adapted to our unusual academic structure. Instructional design is based on

situated learning theory and the principles of guided participation. The structure allows credit for work integrating social science and engineering. Program success requires four elements: authentic learning environments, authentic student assessments, knowledge integration outside of engineering, and commitment to multidimensional assessment.

In this paper, we briefly describe our academic structure and concentrate on the assessment process. Throughout the paper we'll use one project from our Venice project center as a representative example, specifically one from the summer of 2002 when three students conducted a boat wake energy impact study (1). This was one of six projects completed in Venice that summer, and one of several during the past few years that investigated the *moto ondoso* problem.

Background

For many years WPI has found ways to graduate socially conscious, globally literate engineers. We do this by breaking the barriers of traditional course boundaries and rigid curriculum requirements and placing students in contexts that provide learning opportunities consistent with our mission. Evidence seems to indicate that entering college students do not have an appreciation of their role as engineers in society, as they are most often not involved in solving real problems that have an immediate impact on the world in which they live. Generally, they have a diminished knowledge of their place in the global marketplace as engineers (2). Our experience shows that our students develop a more realistic picture of the world, its needs, its opinions and its sensitivities by participating in our global program.

We desire student-learning outcomes that are not limited to basic comprehension or simple application, but demonstrate analysis, synthesis, and evaluation (3). Our belief is that global perspective outcomes are best achieved through problem and team-based learning in an international setting rather than just in the classroom or through information technology. Off-campus opportunities provide students the means to move from self-knowledge to understanding complex relationships, and to understanding multiple perspectives and cross-cultural issues (4). But, how do we get from these lofty goals and descriptions to the details of earning academic credit while helping in the preservation of Venice?

Instructional Design and Program Structure

Many recent engineering education reform efforts incorporate proven learning strategies like active and cooperative learning (5,6), and project-based learning (7,8). WPI utilizes these strategies, but what distinguishes our program is that we integrate material that is normally taught in a compartmentalized sequence of fundamental courses. This includes both technical and non-technical (general education) courses. Our instructional design combines learning theory with a structure that awards credit for both social science and engineering.

WPI's instructional design is based upon situated learning theory that includes authentic activities, contexts, and assessments. We provide collaborative knowledge construction and opportunities for explicit articulation of knowledge during the learning process (9-11). We place students in authentic learning environments that mimic the way knowledge is used in professional practice. Our learners get access to experts, conduct collaborative activities that

provide multiple roles, and get multiple opportunities to engage material outside of traditional academic settings (12-15). Assessments are employed that are consistent with the instructional design, and are usually performance-based (16,17). In traditional academic settings efforts to provide these elements are usually focused on upper level courses. Providing them at lower levels of the curriculum can be problematic since the traditional assumption is that students must learn fundamentals before they can successfully attack significant open-ended problems. How can students solve difficult open-ended multidisciplinary problems before they've actually learned some of what they need to know in order to solve them? How can they do this in foreign culture when a significant language barrier exists? The answer lies in proper preparation, project and team management, and in providing multidimensional assessments that support the academic enterprise. The assessment network functions at multiple levels, and absence of any one level seriously degrades the student learning process.

Each of WPI's 22 off-campus centers is residential. Prior to their sojourn, students complete 1.5 courses worth of site and project specific preparation work. Students conduct their projects on-site for a 2-month period, with resident faculty advisors. On-site work is full time and equivalent of three courses worth of credit. Local government, industry, nonprofit organizations, and sometimes universities sponsor projects. Each sponsor provides a liaison responsible for overseeing the student team working with the agency. Student preparation for the experience includes formal coursework taught by WPI faculty, and orientation/cultural preparation taught by WPI professional staff. The same staff handles health and travel issues, risk management, and re-entry issues. At the completion of a project, each student team submits a substantial written report to the sponsoring agency and the faculty advisor. In addition, a formal presentation where project methods, results and analyses are defended is made to the agency before the students leave the site.

Primary Assessment: Student Level

Input Control—Team Formation

Although all students at WPI must complete this "technology/society" project, admission to the global program is controlled. For AY 04-05 more than 500 students out of class of 650 applied for 380 positions. "Input" assessment occurs during the application process. Although our process is selective, it is not based solely upon GPA. We look at several other characteristics. Applicants must submit a resume and a personal essay. The essay is a reference letter they write for themselves addressing strengths and weaknesses in the areas of motivation, teamwork, flexibility, creativity, work ethic, and initiative. All applicants are interviewed by faculty and professional staff who are trained and calibrated in conducting a behavioral event interview (18). Grades, application materials, co-curricular activities, and the interview results all factor into acceptance and site placement decisions. We look for evidence that correlates with high probability of success in the global program.

For example, our three students who undertook the *moto ondoso* project in 2002 were not academically outstanding ---they had solid B averages. However, their essays and interviews showed other evidence indicating they were good candidates. One was an accomplished violinist, another a risk-taking athlete, and the third was bilingual (unusual at WPI).

Team assignments occur prior to project initiation. Interview information, student project preference forms, major discipline, gender, cultural background, and learning styles factor into this decision. Required preparation classes include training in teaming and professionalism. Practice in peer and self-evaluation in team situations is included as are proper techniques for conducting meetings.

Process Control—Team Dynamics

During both on-campus preparation and the on-site project phase team progress is monitored by a variety of standard tools. Team performance contracts are created as a team and signed by each member. Periodic contract reviews provide a first assessment of individual contributions. We also use a formative peer evaluation form from several sources measures 21 items within the dimensions standards of integrity, respect for individuals, innovations, goal setting, leadership, and overall work effort. A sample is shown in the appendix. The advisors qualitatively evaluate frequent group meetings with sponsors and advisors. Advisors also provide weekly written feedback on project progress, writing, and oral presentations. An explicit grading guide is distributed early in the project so that students know how they will be graded. That guide specifically explains individual accountability, and how team process is assessed and weighted with the final product.

Output Control—Team Evaluation

Each team must produce a final report and defend its results and analysis in a presentation at the sponsoring agency. Advisor evaluation of these major events is the primary component of the product grade. Students also complete a final peer evaluation form, adopted from R. Felder (19) that provides individual accountability. It also allows, when combined with other evidence, awarding of individual final grades.

Our *moto ondoso* team struggled early in their project with typical team process issues. Frequent contract reviews, peer evaluations, and advisor mentoring eventually moved them to a point where the team recognized individual strengths and weaknesses, and found ways to integrate individual efforts in a productive way. We firmly believe that without these tools and processes in place, this team would have quickly become dysfunctional and would have produced an unacceptable product. Their experience would have been far less successful intellectually, culturally, and personally without this "student level" assessment.

Secondary Assessment: Advisor Level

Typically 24-32 students travel to a project center, accompanied by 2-3 faculty advisors. Only in cases of small student numbers (like 6-7) are teams monitored from a distance by non-resident advisors. The roles and responsibilities of the off-campus project advising team are unlike any other traditional teaching roles. All student work is done outside the classroom; all of it is done in teams; each team has a different, complex, open-ended project; and rarely do the advisors have deep technical expertise in the project topic. Students are also responsible to the sponsoring agency, whose goals may sometimes diverge from WPI's academic goals. The entire global perspective program requires faculty and staff to work in teams, something most academics are

not inclined to do! The advising team's prime academic role is really that of coach and project manager.

In addition to academic roles, advisors must also handle the myriad of problems that arise during any normal study abroad. Advisors might deal with cultural orientation, culture shock, communication issues; and are on-site counselors, disciplinarians, enforcers of university policies, mentors, team process facilitators, social event coordinators, risk managers, health and safety officers, and ultimately evaluators (a final grade is assigned). However, they don't do all this in a vacuum since we have an extensive support system for the program. All off-campus advisors apply for the position and are screened before official appointment. All are also required to attend in-depth workshops that typically focus on developing advising skills in non-academic areas. We also work to use experienced advisors as mentors for new advisors.

Just as classroom teaching evaluation can improve teaching and presumably improve student learning, we have seen anecdotally that good advising results in better student learning and better achievement of academic goals. So, we set out to develop and implement an advisor assessment that could be used for both reward and remediation. Our goal is really to improve the experience for everyone involved, particularly the students. However, there is little or no specific literature for evaluating teaching like that done in our global program. Published work on classroom teaching evaluation provided the basis (20). We contracted an expert in teaching evaluation, formed a committee of students, staff, and faculty and developed an evaluation process.

Table 1 summarizes the overall dimensions (advisor qualities) that we defined important for advisors. Within each dimension are several specific characteristics (not shown here). The table illustrates the most appropriate source for gathering assessment data on each dimension. This is a work-in-progress and over the past year, we developed and pilot-tested an advisor evaluation form that is completed by students at the end of each sojourn (first column). We will initiate formal university approval of the form following the consultant's complete data analysis and report. Work continues on designing evaluation tools for columns two and three.

Table 1. Advisor Dimensions and Assessment Data Source

Source: / Dimension:	**Students**	**Co-Advisor**	**Global Studies Division**
Project Support and Facilitation	***Yes***	---	---
Personal Support and Accessibility	***Yes***	Yes	---
Cultural Guidance and Orientation	***Yes***	Yes	Yes
Policy Compliance	---	---	Yes

Tertiary Assessment: Program Level

Our major program level evaluation tool is that a team of paid faculty reviewers read and evaluate all student reports submitted for grades during a calendar year. Our evaluation form contains 35 questions and probes everything from project objectives, literature review quality, use of appropriate methodologies, data analysis, achievement of educational objectives, and writing/presentation quality. Also evaluated are several EC 2000 outcomes such as: ability to function on multidisciplinary teams, life-long learning, impact of engineering in a global and societal context, knowledge of contemporary issues, and understanding professional and ethical responsibility.

Each spring we recruit a reviewing team. They meet for two half-day training and calibration workshops. During the first half-day the form is reviewed, discussed, and rating rubrics are explained. Each reviewer is then given the same three project reports to evaluate. We convene for a second half-day to debrief everyone's evaluation, attempt to calibrate each other against the rubrics, and minimize variance in rubric application.

Reviewers are randomly assigned about 20 reports to read and evaluate over the summer. The data from about 200 evaluations is analyzed by the Assessment Coordinator who writes a report to the WPI community. Report results inform continuous improvement initiatives led by the Global Division Dean. These may involve changes in the student preparation, advisor training, sponsor consultation, resource allocation, or any other issues identified as problematic from the review process.

As illustrated in Figures 2 and 3, results show that projects conducted by student teams at off-campus sites consistently outrank those done on campus. Average scores are shown for the on-campus projects compared to off-campus projects. The scale is 1=poor, 3=acceptable, to 5=excellent. The rated items shown here are overall report quality, multidisciplinary team function, impact of engineering on society, and use of appropriate methodologies. The on-campus cohort was 119 teams (244 students) and the off-campus cohort was 77 teams (242 students).

Figure 2 shows that on each of the individual dimensions, off-campus teams outrank on-campus teams. The differences shown are representative of results from many of the other rated dimensions (data not shown). Figure 3 shows the percent of reports that were rated unacceptable (rating less than 3) in each of the same items listed above.

The difference in quality is striking. The most likely reason is that on-campus teams do not all receive the same primary and secondary assessments described above. And, we would not have seen such quality differences without the program level assessment. We have taken steps to remedy this by creating a project center within the city of Worcester and structuring it like our global centers. Initial assessments show encouraging improvements in team product quality despite small cohort sizes. For example, overall report quality for the most recent group of "Worcester" student teams (14 teams) was 3.5. Work continues on improving the overall experience for the remaining on-campus student cohort.

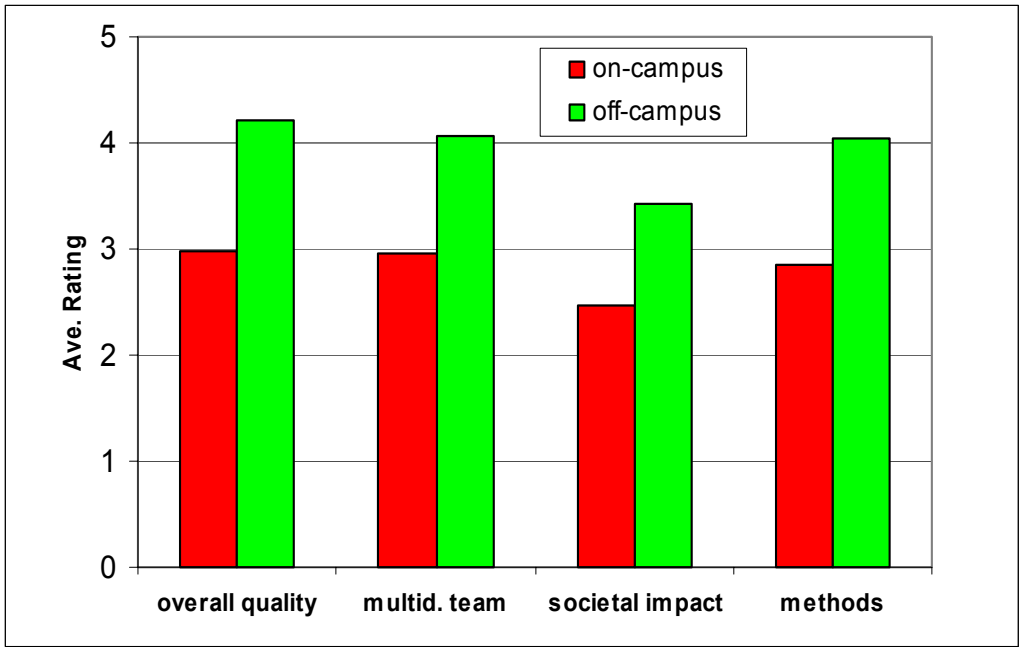

Figure 2: Average ratings on four evaluation items comparing on-campus project teams to off-campus teams (1=poor, 3=acceptable, 5=excellent).

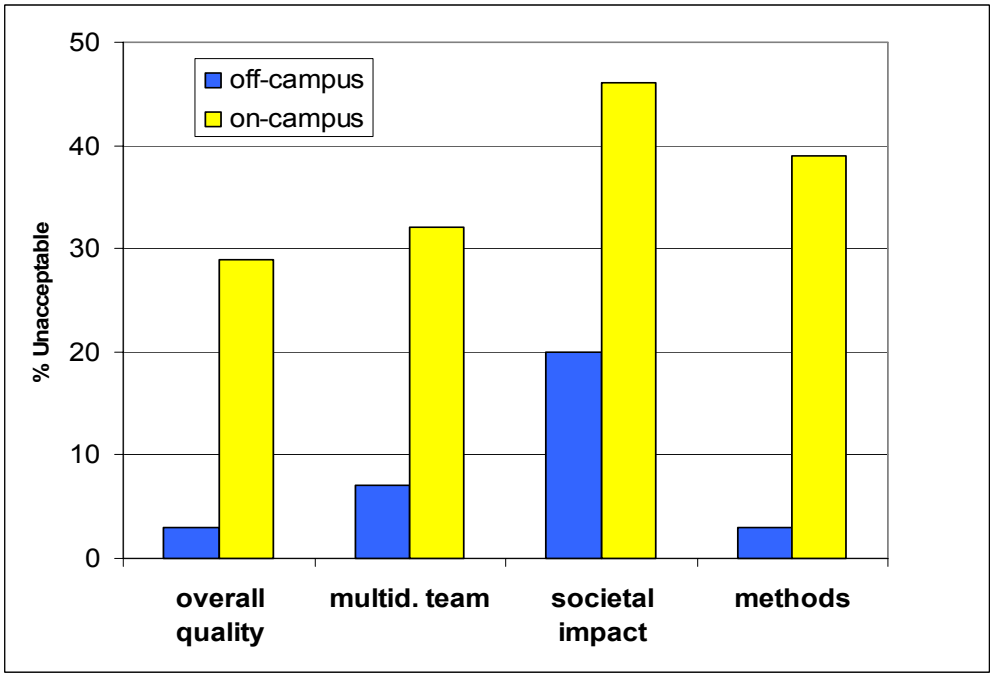

Figure 3: Percent unacceptable ratings on four assessment items comparing on-campus project teams to off-campus teams.

WPI also conducts an annual competition using external judges from industry, government, and academia. It is rare that an on-campus team makes it to the finals of this competition. In the last several years, teams from the Venice Project Center have either won this competition or placed in the top three spots. Our *moto ondoso* example team made it to the semi-finals (one of the top ten teams).

External program review also occurs at the national level and the WPI study abroad program has recently won several awards from organizations such as TIAA-CREFF (Hesburgh award), NAFSA, AAC&U, and IIE (Haiskell award). Also, Venice project team work has been recognized by the Smithsonian and featured National Geographic both in print (see Figure 4) and on television (21-23).

Figure 4. One of the authors (Carrera) and WPI students taking data in Venice (21).

Most importantly, work by student teams results in real positive changes. In Venice, the combined results of student teams from recent years, including the wake impact study (1) and a boat traffic study (24), has helped the city move forward with a new cargo warehousing and distribution system that will radically reduce cargo boat traffic---reducing pollution and the deleterious effects of *moto ondoso*.

Summary

WPI's academic structure requires students to work in multidisciplinary teams on real world open-ended problems outside the classroom. About two-thirds of our students go off-campus with faculty advisors to complete these projects. Because of this unusual structure we developed evaluation and assessment processes that address student learning and professional growth in team contexts that differ from traditional classroom settings. This resulted in a multilevel assessment process:

- Student teams are assessed using standard and readily available cooperative learning tools modified for our context.
- Faculty and staff advising teams are assessed using new tools developed in-house but adopted from those based upon good classroom teaching evaluation principles.
- Program assessment uses a locally developed process and national competitions.

A Venice case study illustrated some assessment process aspects. Undergraduates placed in the middle of the *moto ondoso* controversy made contributions and demonstrated multidimensional learning when the instructional design and the assessment processes are appropriately designed.

The WPI project system may not be easily adaptable by other institutions, and it is not our intent to export it. However, the learning principles upon which it is based can be used to construct locally appropriate team-based learning structures in and out of the classroom. We believe that properly structured, off-campus, authentic learning opportunities (service learning, study abroad, internships) can result in improved multidimensional student learning. Assessing those opportunities to understand them and improve them requires multilevel assessment. The multilevel assessment process and instructional design principles are transferable. Our opinion is that all three assessment levels are necessary to optimize learning. The quality of the entire experience is jeopardized and educational objectives may not be met if any one level is missing.

References

1. Chiu, D., A. Jagannath, E. Nodine, *Assessing the Effects of Boat Traffic in the Canals of Venice*, Interactive Qualifying Project submitted to WPI, August (2002).
2. Davis, P. and N. Mello, *A World-Class Education,* in the Last Word, ASEE Prism, January (2003).
3. Besterfield-Sacre, M., L.J. Shuman, , H. Wolfe, C.J. Atman, J. McGourty, R.L. Miller, B.M. Olds, and G.M. Rogers, *Defining the Outcomes: A Framework for EC 2000*, IEEE Transactions on Education, 43, 2, 100-110, (2000).
4. Alverno College Faculty, *Student Assessment-as-Learning*, Alverno Productions, (1985).
5. Johnson, D. W., R. T. Johnson, and K. A. Smith, *Maximizing Instruction Through Cooperative Learning*, ASEE Prism, 7(6), 20 (1998).
6. Johnson, D. W., Johnson, R. T., and Smith, K. A., *Active Learning: Cooperation in the College Classroom*, Interaction Book Company, Edina, MN (1991).
7. ASEE Prism, *Let Problems Drive the Learning in Your Classroom*, ASEE Prism, 6(2), 30 (1996).
8. Woods, D. R., *Problem-based Learning: How to Gain the Most in PBL*, Waterdown, Ontario (1994).
9. Herrington, J. and Oliver, R. *An Instructional Design Framework for Authentic Learning Environments*, Educ. Tech. Res. and Dev., v. 48(3), 23-48 (2000).
10. Brown, A.L. and A.S. Palinscar, *Guided Cooperative Learning and Individual Knowledge Acquisition*, in Knowing, Learning, and Instruction : Essays in Honor of Robert Glaser, L.B. Resnick, Ed. Hillsdale, N.J. : L. Erlbaum Associates, (1989).
11. Brown, J.S., A. Collins, and P. Duguid, *Situated Cognition and the Culture of Learning*, Educ. Researcher. Jan-Feb, 32-42 (1989).
12. Cognition and Technology Group, Vanderbilt, "Anchored Instruction and Its Relationship to Situated Cognition", Educ. Researcher. v. 19, no. 6, 2-10 (1990).
13. Lave, J. and E. Wenger, "Situated Learning: Legitimate Peripheral Participation", Cambridge University Press (1991).

14. Rogoff, B. and J. Lave, eds, *Everyday Cognition: Its Development in Social Context*, Harvard University Press (1984).
15. Bruer, J.T., *Schools for Thought: A Science of Learning in the Classroom*, MIT Press (1993).
16. Loacker, G. ed. *Self Assessment at Alverno College*, Alverno College Institute (2000).
17. Mentkowski , M. & associates, *Learning That Lasts, Integrating Learning, Development, and Performance in College and Beyond*, Alverno College publications, Milwaukee (2000).
18. McClelland, D. C., *Identifying Competencies with Behavioral-Event Interviews* , Psychological Science, v. 9 no. 5, 331 September (1998).
19. Kaufman, D.B., R.M. Felder, and H. Fuller, *Accounting for Individual Effort in Cooperative Learning Teams*, *J. Engr. Education, 89*(2), 133-140 (2000).
20. Arreola, R., *Developing a Comprehensive Faculty Evaluation System,* 2nd ed., Anker Pub. Boston, (2000).
21. Zwingle, E., *Italy's Endangered Art*, National Geographic Magazine, v. 196, no. 2, August (1999).
22. -----, *Venice Under Siege*, "National Geographic Out There" television show, broadcast May 12, 13, and 19, National Geographic Channel, (2002).
23. Harriss, J., *Turning the Tide*, Smithsonian, v. 33, no. 6, September (2002).
24. Duffy, J., J. Gagliardi, K. Mirtle, and A. Tucker, *Reengineering the City of Venice's Cargo System for Consorzio Trasportatori Veneziani Riuniti*, Interactive Qualifying Project submitted to WPI August (2001).

DAVID DIBIASIO is an associate professor of chemical engineering and Assessment Coordinator for the Interdisciplinary and Global Studies Division. He is also Director of WPI's Washington DC project center. He advised at the Venice Project Center in 2002.

NATALIE MELLO is Director of Global Operations for WPI. She coordinates the student application process, off-campus faculty training, and is in charge of risk management and health and safety for all off-campus project centers. She advised at the Venice Project Center in 2002.

FABIO CARRERA is an adjunct assistant professor in the Interdisciplinary and Global Studies Division. He is Director of the Venice and Boston Project Centers. He has advised at the Venice Project Center for each of the past 12 years.

Appendix: Sample of Formative Peer Evaluation Form

Team Name_____ Date: _____

The purpose of this peer and self-evaluation exercise is to process how your team functions. It will provide you with some concrete feedback on how you are developing as a team member. Please fill out one form for each team member, including yourself. Submit all forms to the instructor by the due date provided. Evaluate each characteristic using the following scale:

Horrible	Much Improvement Needed	Could Use Some Help	Satisfactory	Above Average	Clearly Outstanding
1	2	3	4	5	6

Name of Team Member:	**Please circle rating:**					
Respect for Individuals:						
• Actively values individual differences	1	2	3	4	5	6
• Actively values cultural differences	1	2	3	4	5	6
• Listens attentively to all group members	1	2	3	4	5	6
• Depends on other people	1	2	3	4	5	6
Standards of Integrity:						
• Follows through on commitments to the team	1	2	3	4	5	6
• Admits mistakes	1	2	3	4	5	6
• Actively participates	1	2	3	4	5	6
Innovations:						
• Provides ideas in team discussions	1	2	3	4	5	6
• Seeks opportunities to apply knowledge and skills	1	2	3	4	5	6
• Challenges conventional practices to see improvement of methods	1	2	3	4	5	6
Teamwork:						
• Understands differing viewpoints	1	2	3	4	5	6
• Acknowledges differing viewpoints	1	2	3	4	5	6
• Cooperates in establishing clear goals	1	2	3	4	5	6
• Encourages others to communicate openly	1	2	3	4	5	6
Leadership:						
• Asserts own ideas positively	1	2	3	4	5	6
• Enrolls others in support and commitment	1	2	3	4	5	6
• Shows enthusiasm	1	2	3	4	5	6
• Fosters the development of a common vision	1	2	3	4	5	6
Overall Contributions:						
• Level of effort	1	2	3	4	5	6
• Work quality	1	2	3	4	5	6
***Identify one area of strength**:*						
Identify one area for growth and development:						

Adapted from AT&T's Multi-Source Performance Feedback form by N. Mello.