Triangulating Assessments: Multi-Source Feedback Systems and Closed Form Surveys

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Triangulation is becoming an important factor as more engineering programs begin to prepare for accreditation under ABET's EC 2000 criteria.. In general, the purpose of triangulation in assessment and evaluation is to provide multiple measures for a particular outcome. For example, the 'ability to work on multi-disciplinary teams' may be assessed through: (1) the student's self assessment of their enjoyment for working on teams via closed-form questionnaires, (2) ratings by a student's peers on the team, or (3) the direct observation of a team by a trained evaluator. Triangulation may also involve using similar metrics across two or more institutions so that results may be compared. Because many of the methods and instruments currently begin used in engineering education have not been fully validated in terms of content or construct, triangulation provides one means for increasing the validity of the outcome's measurements, or, conversely, increasing the validity of the methodology used to obtain the measurement. Further, it is also possible that a metric/method that adequately measures a particular outcome in question does not exist. In this case, by triangulating different methods and metrics, one obtains multiple surrogates for the real measure of the outcome, thus providing a much needed anchor measure where none exists.

Once results from triangulation have been obtained, statistical methods may be used to determine the relationships among the various metrics. If there is strong correlation among the metrics, then the use of multiple measures may be reduced. Those metrics/measures that are more efficient and cost effective could then be used to routinely assess students' progress on an outcome(s). The more in-depth, and often more costly metrics could then be used only periodically or with samples of the students. This approach helps to minimize costs, and provides a streamlined approach towards program evaluation.

This work-in-progress paper discusses and compares a triangulation experiment comparing two forms of assessment – multi-source feedback systems and closed form (attitudinal) surveys. Specifically, we are conducting a longitudinal triangulation experiment involving students from the University of Pittsburgh, Department of Industrial Engineering. Our experiment began in the fall 1999 semester when the students were in their first semester, sophomore year and will continue through the fall of 2000 when the students complete the first semester of their junior year. This experiment is part of a larger research project, in which we are evaluating the information obtained when multiple methods are used on a cohort of industrial engineering students who are being tracked from the beginning of their sophomore year until graduation. Overall, we are investigating four different methods for measuring outcomes: questionnaires, multi-source feedback, concept maps, and intellectual development. The purpose of the study discussed here is two-fold: 1) to triangulate and verify two or more different methods for measuring outcomes in order to determine the extent that these methods yield consistent, corroborative results, and 2) to investigate how students improve over time particular abilities in selected EC 2000 outcomes.

Specifically, the experiment involves following a cohort of approximately 50 students through a three-course sequence in industrial engineering. The first course, *Modeling with Computer Applications*, was taken the fall 1999 and provided an introduction to mathematical modeling, problem solving, and teamwork. The second course, *Productivity Analysis*, is taken in the second semester of the sophomore year (spring 2000) and provides an introduction to industrial engineering concepts and thought processes. The last course, *Human Factors Engineering*, is taken the first semester junior year (fall 2000) and focuses on the study of human abilities, characteristics, and behavior in the development and operation of systems designed for human use. Each course requires the use of open-ended problem solving (outcome "e"), oral and written communication skills (outcome "g"), and relies heavily on teamwork (outcome "d") in and out of the classroom. Thus, these three outcomes were chosen for the study: problem solving abilities, teamwork, and communication skills. To measure these outcomes, two assessment methods were selected: multi-source feedback using the Team Developer™ and closed-form questionnaires using the *Pittsburgh Sophomore/Junior Engineering Learning and Curriculum Evaluation Instruments*© and the *Pittsburgh Senior Exit Survey*©. The validated questionnaires elicit students' confidence for all eleven EC-2000 outcomes. Each method is briefly described below.

<u>Multi-Source Feedback [1,2,3,4].</u> The increasing introduction of cooperative learning and teaming techniques into the engineering classroom are placing the students themselves in the best position to provide one another with meaningful, *multi-source feedback* about their technical and interpersonal performances. Yet, the applications of multi-source feedback processes in the classroom have been limited, in part, due to large time and resource requirements for development and implementation. A formal multi-source, peer feedback approach should provide students and educators with important benefits including: help in reinforcing key learning objectives and sending strong messages to students when and where performance should be improved. 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. When student have been properly trained, their self and peer ratings are consistent with faculty perceptions of their performance. In addition, when the process is repeated, learning outcomes have improved significantly after peer feedback. To measure multi-source assessments, the Team Developer™ is used. Not only does this allow for measurements from multiple sources (e.g., student, peers and faculty) to be obtained, but it provides a system for feedbacking assessments to the students and thus providing each team member with meaningful feedback about his/her technical and interpersonal performances.

<u>Closed-form Questionnaires (Attitudinal Surveys) [5,6,7].</u> Questionnaires are a practical method for evaluating student attitudes about engineering, aspects of their education, and their self-assessed abilities and competencies. Closed-form questionnaires are less costly to develop, administer and analyze than other types of assessment methodologies, particularly if a large data set is being collected and if statistically reliable conclusions are desired. By limiting the response choices,

data collection can be repeated in order to obtain a time series of data points. Thus, we can examine how attitudes are affected by particular interventions, change over time, or vary among groups of individuals. Like other assessment methods, a good closed-form questionnaire design requires considerable knowledge and skill if results are to be valid. We have developed and used closed-form questionnaires to measure the attitudes students have about engineering and their self-assessed abilities and observe how these measures change as a result of their educational experiences. Our current assessment research uses questionnaires to track students' attitudes and competencies at a number of points in the educational process – from when they enter the engineering education system as freshmen, during the sophomore and junior years, at graduation and as alumni. These surveys will be used in conjunction with the multi-source feedback system.

If valid measurements are to be obtained from the methods used, careful selection of a pertinent set of attributes describing each outcome to be measured is necessary. Obtaining a metric or method that adequately measures the outcome in question may be difficult. To measure the mentioned outcomes, a well-researched outcome/attribute list [8] was used to select the items (attributes) for the Team Developer™. Each attribute is entered into the Team Developer in the form of a statement. For each statement, the student evaluates him/herself and each of his/her peers on the team using a five-point Lickert scale. The three instructors teaching the courses collectively selected attributes that they felt were pertinent to the objectives of the courses. For outcome "e," ("an ability to identify, formulate, and solve engineering problems"), 17 attributes were selected; for outcome "d," ("an ability to function on multi-disciplinary teams"), 32 attributes were selected; and for outcome "g," ("an ability to communicate effectively"), 12 attributes were selected as applicable to the three courses. The outcomes were also mapped to sophomore and junior attitude instruments that had been developed previously. The Team Developer was given to students twice during the semester and the questionnaires were administered on the last day of class.

The first set of data from the TeamDeveloper™ and the questionnaires is currently being analyzed. In analyzing the data, the differences in self-assessment ratings versus ratings of peers and faculty for the group projects are being investigated. In addition, differences between in-depth assessment methods like the multi-source Team Developer and more general assessment tools, such as the sophomore and junior attitude instruments will be explored. Finally, differences in the rating scales used in the two methods will be examined. Preliminary results will be presented at the ASEE conference; additional results will be presented at FIE 2000 in Kansas City.

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