Quality Approaches in Higher Education

Driving continuous improvement through the development and assessment of learning outcomes and rubrics.

Learning Outcomes for a Multidisciplinary Undergraduate Honors Program: Development, Measurement, and Continuous Improvement

Kylie Goodell King and Jeffrey W. Herrmann

Abstract

In the University of Maryland's Quality Enhancement Systems and Teams Honors Program, undergraduate students from engineering, science, and business learn to apply quality management tools, improve processes, and design systems. Eight learning outcomes were developed and for each outcome, four elements for assessment. The learning outcomes were mapped to the program's three required courses, and assessments and rubrics were created to measure every element. Faculty, staff, program alumni, and current students participated in the assessment process. This paper describes how learning outcomes and rubrics were developed, how outcomes and elements were assessed, and how these are used to drive continuous improvement. The paper also suggests how other programs can develop a learning outcomes assessment process.

Keywords

Assessment, Learning Outcomes, Continuous Improvement, STEM

Introduction

The Quality Enhancement Systems and Teams (QUEST) Honors Program ("the program"), which began in 1993 as part of an initiative to apply quality management to higher education, is a multidisciplinary honors program for undergraduate students at the University of Maryland. Students are selected from three units: the Robert H. Smith School of Business, the A. James Clark School of Engineering, and the College of Computer, Mathematical, and Natural Sciences. Approximately 90 students are admitted each year, and students are in the program for three years. We use the term multidisciplinary engineering, technology, and management (METM) to describe our program and similar programs that provide students with the opportunity for multidisciplinary collaboration and complex problem solving that requires knowledge from science, technology, engineering, and mathematics (STEM) as well as management disciplines. Moreover, students must integrate knowledge and skills from multiple courses. Multidisciplinary programs like QUEST increase personal and professional development in students (Holley, 2009; Hotaling, Hermann, Fasse, Bost, & Foresta, 2012). Additionally, the program addresses industry needs by giving students real-world experiences in which they see the relevance of their coursework, apply their skills, and practice professional behavior (National Research Council, 2012).

The development and assessment of learning outcomes can benefit a METM program, its students, and industry. It helps program directors understand how well students are learning, and it is a critical component in a data-driven quality management process for guiding curriculum changes. Students benefit from the improvements that help them learn more and from knowing specifically what they should be and are learning. Industry benefits not only from hiring better-prepared students but also from reducing the uncertainty associated with hiring a program's graduates.

This article describes how, since 2010, we have developed learning outcomes and rubrics, how we assess outcomes and elements, and how we use these to drive continuous

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improvement. It lists our program learning outcomes, includes the rubrics for assessing the relevant elements, describes our assessment process, and presents the results of recent assessments. This includes a novel two-dimensional plot for visualizing and comparing the performance of different elements. The article also suggests how other programs can develop and apply relevant learning outcomes and rubrics. Elements of this article appeared in Goodell and Herrmann (2014); that article provides more background and information about our assessment process and its role in continuous improvement.

Literature Review

Developing and using learning outcomes and assessment tools can help an educational program determine what and how well its students are learning and can be used to guide curriculum improvement efforts. Rogers and Sando (1996) and Maki (2002) provide insight and guidance into the process of developing learning outcomes, which should begin with identifying program goals and educational objectives (Davis, Gentili, Trevisan, & Calkins, 2002). One can also use research-based evidence to improve a curriculum (Finelli et al., 2012).

Learning outcome assessment tools that are especially relevant to METM programs include those for project management skills, communication skills, teamwork, and other professional skills. Pinelli, Hall, and Brush (2013) described an assessment of professional skills in an internship program, but these can be difficult to assess in general (Atif, Ibrahim, & Shuaib, 2012; Palmer, 2002; Palmer, 2003; Shuman, Besterfield-Sacre, & McGourty, 2005; Thambyah, 2011).

Efforts to improve our program are related to other efforts to transform engineering education, which include, for example, studies of admissions policies (Holloway, Reed, Imbrie, & Reid, 2014), faculty motivation (Matusovich, Paretti, McNair, & Hixson, 2014), how teaching improvements are adopted (Finelli, Daly, & Richardson, 2014), and perceptions about curriculum changes (Besterfield-Sacre, Cox, Borrego, Beddoes, & Zhu, 2014). In general, faculty is responsible for curriculum change, and learning outcomes and assessment are essential elements (Jamieson & Lohmann, 2009). As a focused program that has enthusiastic faculty, we wanted to develop a data-driven quality management process for guiding curriculum changes.

The following question naturally arises: how can one develop learning outcomes, use them to assess student learning, and drive continuous improvement in project-oriented METM programs? This article presents a case study that describes how our program did this. From the perspective of change categories and strategies (Borrego & Henderson, 2014), one can view these learning outcomes as the products of reflective teachers who, as a faculty learning community, have created a quality assurance strategy.

Background

Undergraduate students in the three participating units apply to the program in their freshman year. Students must have a 3.0 GPA after their first semester to be eligible. After an initial screening and a group interview for the most qualified applicants, approximately 90 students (two cohorts of 45 students) are admitted to the program. Overall, in the Spring 2014 semester, the program had 212 students: 59 seniors, 66 juniors, and 87 sophomores. The two cohorts of freshmen admitted that semester included 38 students from engineering, 35 from business, and 14 from science; 53 students were men and 34 were women.

Students begin the program in their sophomore year and take three required courses (one each year) and two electives in which they learn to apply quality management tools, improve processes, and design systems. (Students typically take one course per semester.) The required courses, Introduction to Design and Quality (IDQ), Systems Thinking for Managerial Decision Making (STMDM), and QUEST Consulting and Innovation Practicum (QCIP), incorporate a variety of learning activities, including multidisciplinary team projects in which the students generate, evaluate, and recommend solutions to real-world problems from industry and government clients (an important practice for engineering education (National Research Council, 2012). QUEST juniors and seniors (from the three participating units) mentor the teams of sophomores in IDQ. Faculty advisors from the three participating units guide the teams of seniors in QCIP. In IDQ, teams are formed to have a variety of majors and diverse demographics. In QCIP, teams are formed by selecting the interested students who are best qualified to tackle the client's problem. In both courses, teams usually have five students from multiple majors.

In the taxonomy described by Jamison, Kolmos, and Holgaard (2014), the QUEST program could be classified as a "market-driven approach" in which the students learn problem-solving skills that will be useful in their professions. Because the students are also in traditional academic majors, their aggregate experience is one of hybrid learning.

In 2010, the program developed learning outcomes during a workshop with other METM programs (the workshop was sponsored by the National Science Foundation and hosted by the program). Additional discussion and editing led to the eight outcomes listed in Table 1 (end of article). These include the four Accreditation Board for Engineering and Technology (ABET) competencies that engineering graduates identified as the most important: ability to function on a team, ability to analyze and interpret data, engineering problem-solving skills, and communication skills (Passow, 2012). These outcomes were also influenced by Bloom's taxonomy (1956) and Anderson and Krathwohl's revised taxonomy (2001).

For each learning outcome, we identified four elements that correspond to specific skills that the students should be able to do when they complete the program. For each element, we developed rubrics to describe four levels of performance: advanced, proficient, developing, and unacceptable. These are the same levels used in the Valid Assessment of Learning in Undergraduate Education rubrics (Rhodes & Finley, 2013) and by our university's general education program (University of Maryland, n.d.).

After considering the content of the program's three required courses, we mapped the learning outcomes to these courses; that is, we identified the course(s) in which the students learned the elements associated with the learning outcomes. This map enabled us to determine the courses in which elements can be assessed and shows where the curriculum can be changed to improve our students' performance on an element. This map was then enhanced by identifying which activities and assignments in these courses would be used to assess which elements. Five of these learning outcomes are assessed in more than one course (Table 1), and seven are assessed by more than one instance of assessment (more than one exam, paper, or presentation). Most of the assessments are completed by faculty, staff, and students within the program, but some are completed by the mentors, the faculty advisors, or the clients' project champions because they can best evaluate how the IDQ and QCIP student teams perform outside the classroom while completing their projects.

Learning Outcomes and Assessment Mechanisms

The eight learning outcomes, 32 elements, and associated assessment mechanisms that were conducted in the 2012-2013 and 2013-2014 academic years are described in Table 1. An evaluation is an instance of one evaluator considering the performance of one student or team on one learning outcome. The number of evaluations conducted during the Fall 2013 semester is provided. Other semesters noticed similar numbers of evaluations for each learning outcome. The number of evaluations per learning outcome varies for a variety of reasons. Some learning outcomes are relevant to many activities, which allow more evaluations. Some evaluations consider individual students, while others consider teams. There are also differences in the number of teams in each course, the number of evaluators who are available, and the response rates of the evaluators. Table 2 (end of article) lists the rubrics for the elements of all eight learning outcomes.

The learning outcomes reflect the program goals, which include developing students who have specific "hard" skills in quality management, process improvement, and system design. Moreover, the program uses active learning and authentic design projects in which students work on clients' real-world problems. Learning outcomes 1, 2, and 4 describe these specific skills, and learning outcome 3 describes more general skills that support the elements of these learning outcomes.

The program also prepares students to be effective professionals and have successful careers using the hard skills they learn. Learning outcomes 5 to 8 describe professional skills (teamwork, communication, project management, and ethical, professional behavior) that are generally recognized as important for workplace success (Shuman, Besterfield-Sacre, & McGourty, 2005).

The learning outcomes assessment (LOA) process is designed to support continuous improvement of the curriculum. The process involves a variety of individuals, some of whom play multiple roles. The program's Curriculum Review Committee (CRC) plays a major role. In the Spring 2014 semester, the CRC had 13 members, including seven members of the faculty (one from computer science, one from engineering, and five from business, the administrative home of the program), one program alumna, four students from the program, and one member of the program staff. The CRC includes the program leadership and the instructors of the core courses. Some (but not all) of the QCIP teams' faculty advisors are members of the CRC; those who are not are from the three participating units. Each QCIP project has a project champion representing the client who is sponsoring the project. (In the Fall 2013 semester, there were 13 QCIP projects.) Each IDQ team has a mentor, a student who has already taken the course. In the Spring 2014 semester, there were nine teams in IDQ, and three engineering students and six business students were mentors.

Before the semester starts, the program leadership and course instructors meet to review the LOA plan and determine the timing of assessments in each course. Assessments are assigned to members of the CRC, the QCIP faculty advisors, and the QCIP project champions. At the beginning of the semester, the CRC meets to review the LOA plan and assignments. During the semester, the CRC members complete the assessments. The program leadership and course instructors meet monthly to discuss the completed assessments and identify opportunities to address areas where overall student performance is weak by including additional reviews or practice that semester. At the semester's end, the CRC reviews the assessment data and discusses opportunities to enhance the courses and the LOA plan. The program leadership also discusses the results with university administrators (the dean of undergraduate studies and the associate deans from the three participating units).

With this process, we can see changes in the performance of the elements over time, which, like a process control chart, can indicate when something is undesirable and an improvement is needed (such as new activities in a course). Thus, the LOA process drives continuous performance.

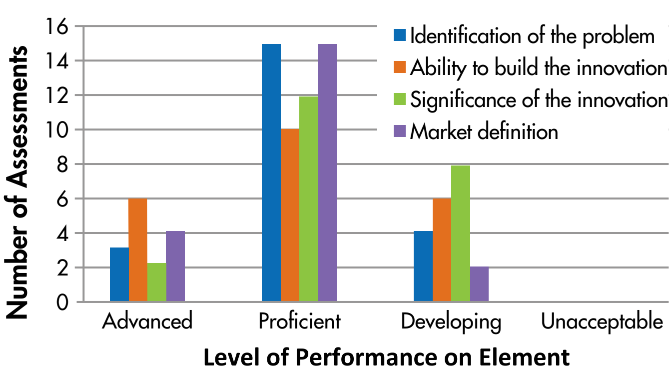
We can also use the record of performance to verify whether a curriculum change is making a difference. If so, then we have evidence that the improvement is working and can continue. (If not, then we need to reconsider our approach.) For instance, increasing the emphasis on using quality management tools (learning outcome 1) in IDQ has increased the students' performance on those elements.

In the 2014-2015 academic year, we will implement an online system for reporting, storing, and analyzing assessment results. This system will reduce the effort needed to generate reports and thus enable prompt feedback and more specific results, which can accelerate the continuous improvement cycle.

Results

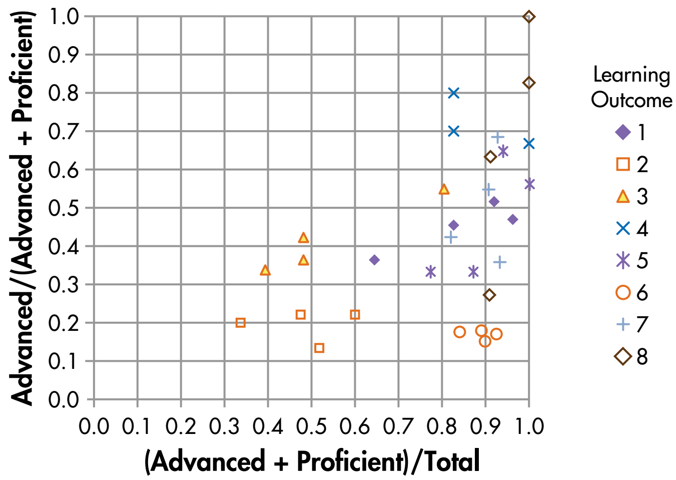
The collection of LOA data began in the Spring 2013 semester. Because this article is about our LOA process, some recent results are presented to illustrate the way that we summarized the data.

In the Spring 2014 semester, the program learning outcomes were evaluated using the rubrics, and, for each type of document or presentation, we created a histogram that shows, for each element, the number of evaluations at each level of performance: advanced, proficient, developing, and unacceptable. Because these evaluations use an ordinal scale, we summarized the data



The evaluations of the final presentations in IDQ during the Spring 2014 semester based on the level of performance in each of the 32 elements. This is one example of how data was summarized using counts instead of means.

Figure 1: Assessment of the Elements of Learning Outcome 1 From the IDQ Final Presentation



Each of the 32 elements were evaluated based on the fraction of all evaluations that were advanced or proficient and the fraction of the advanced and proficient elements that were advanced.

Figure 2: Relative Performance of the 32 Elements of the Learning Outcomes Based on Assessments Collected During the Spring 2014 Semester

using counts instead of means. Due to space constraints, we cannot include all of these in this article. Figure 1 displays one such chart, which summarizes the evaluations of the final presentations in IDQ during the Spring 2014 semester.

The relative performance on the 32 elements was determined by first aggregating all of the assessments on each element to determine, for each element, the number of evaluations in which performance was advanced (which we denote as N_a), the number of evaluations in which performance was proficient (N_p), and the total number of evaluations (N_t). Note that the total number of evaluations also includes the evaluations in which performance was developing or unacceptable.

To normalize the results (because the number of evaluations varied), for each element we computed the following two fractions: $p_1 = (N_a + N_p) / N_t$ and $p_2 = N_a / (N_a + N_p)$. The first indicates the fraction of all evaluations (on that element) that were advanced or proficient. The second indicates the fraction of the advanced and proficient elements that were advanced if $N_a + N_p > 0$. For example, if, for some element, all of the evaluations were advanced, then $p_1 = p_2 = 1$. If, for some element, all of the evaluations were proficient, then $p_1 = 1$ but $p_2 = 0$. If, for some element, one-fourth of the evaluations were advanced, another one-fourth were proficient, and the remainder were developing or unacceptable, then $p_1 = p_2 = ½$.

Figure 2 depicts the performance of all 32 elements using these two fractions. The abscissa (horizontal axis) measures p_1, and the ordinate (vertical axis) measures p_2. The symbols represent the different learning outcomes. This figure indicates which outcomes and elements need more investigation, while the detailed assessments describe specifically where student performance can improve. The results show that the elements for learning outcomes 2 and 3 had the lowest values of p_1, which means fewer evaluations (as a proportion of those evaluated) were advanced or proficient. The elements for learning outcome 6 had large values of p_1 but low values of p_2, which indicate that most evaluations were proficient but not advanced. Some elements for learning outcome 8 had large values of both p_1 and p_2, which indicates that most evaluations were advanced. Our improvement efforts after that semester focused on improving the product development and data analysis activities in IDQ, the course in which students learn these skills.

Limitations

These results and the experiences of conducting these assessments have indicated some opportunities for improving the assessment process. The number of assessments for each learning outcome was not consistent (min = 4, max = 84) due to the variety of assessment techniques and operational constraints. Some evaluators may have assessed students relative to their expected performance in each course (that is, a reviewer may hold lower standards for sophomores in IDQ than for seniors in QCIP). The evaluators need to understand the purpose of program learning outcome assessment and how it differs from grading student work. The evaluators need to have a common understanding of what level of performance corresponds to the different levels on each element. More precise rubrics would allow consistent evaluations to be obtained from a number of different evaluators. In addition, this process, designed for evaluating program learning outcomes, does not provide feedback to individual students about their performance (although the grades on assignments do).

Summary and Conclusions

By comprehensively assessing its learning outcomes a program can identify shortcomings and improve curricula and other activities (Nitko & Brookhart, 2007; Royse, Thyer, & Padgett, 2006). Because students in the QUEST program learn about quality management and process improvement, it is particularly appropriate that the program has a quality management system to guide its curriculum improvement. The results also help the program demonstrate its effectiveness to administrators and potential sponsors.

We recommend that a higher education program interested in improving its curriculum work to develop a data-driven, continuous improvement process as follows:

- Identify program learning outcomes and elements which define the skills that graduates should possess.
- Create rubrics for assessing performance on the elements of the learning outcomes.
- Identify course assignments and activities across the entire curriculum that are relevant to the elements of the learning outcomes.
- Appoint and train faculty, staff, students, alumni, and other interested parties to conduct evaluations.
- Complete assessments throughout the academic year and analyze the results without delay.
- Consider the results, identify opportunities for improvement, and initiate changes.
- Use the results of future assessments to verify whether the changes are having the desired impact.

Evaluating course assignments avoids requiring students to do more work. Using rubrics can improve the consistency of evaluations (Rhodes & Finley, 2013) and make it possible for students and other participants to perform some evaluations with minimal training on the LOA process, how to use the rubrics, and examples that illustrate the different levels of performance for the elements of the learning outcomes.

Future research on instructional design would be useful to identify and compare methods for designing a course to support program learning outcomes with detailed task-specific guides (Diefes-Dux, Hjalmarson, & Zawojewski, 2013). Successful examples of using assignment grades directly as program learning outcomes assessments and collecting portfolios of student work would be useful as well.

The assessment process used material from all three required courses and involved a variety of evaluators, including students, alumni, faculty, and staff. We have developed assessment techniques that can be enhanced and used again, and we have selected ways for analyzing and reporting the results. The process and assessment techniques described here should be useful to other METM programs and to engineering programs (including those that are not honors programs) that, like the QUEST program, help students learn to integrate knowledge and skills from multiple courses to solve real-world problems in multidisciplinary teams.

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Table 1: Learning Outcomes, Elements, Numbers of Evaluations, and Assessment Mechanisms

Learning Outcome	Element 1	Element 2	Element 3	Element 4	Number of Evaluations	Assessment Mechanisms
1. Apply quality management tools, improve processes, and design systems.	Tool selection	Fit	Tool use	Solution evaluation	32	IDQ: Final presentations; final paper QCIP: Faculty advisor evaluation; final presentation
2. Manage the new product development process and market a new product or technology working on a multidisciplinary team.	Problem identification	Ability to build the innovation	Significance of the innovation	Market definition	16	IDQ: Final presentations; final papers
3. Ability to use quantitative and qualitative data analysis techniques.	Qualitative analysis	Quantitative analysis	Multi-methods synthesis	Methodology	52	IDQ: Final presentations; final papers QCIP: Faculty advisor evaluations; final papers
4. Work in multidisciplinary teams to evaluate, analyze, and recommend solutions to real-world problems provided by corporate sponsors.	Problem identification	Methodology	Analysis	Recommendations	27	QCIP: Faculty advisor evaluations; final presentations
5. Work in multi-disciplinary teams with an understanding of different roles and how to negotiate conflict in these situations.	Role identification and delegation	Coordination of tasks	Conflict resolution	Coherence around mission	14	IDQ: Mentor evaluations QCIP: Faculty advisor evaluations
6. Communicate ideas effectively in business environments through written, visual, and oral methods.	Articulation	Enthusiasm	Clarity	Ability to convey difficult concepts	84	IDQ: Self evaluations QCIP: Final presentations; final papers
7. Manage projects and people using effective project management tools.	Parsing complex tasks	Project definition	Resource allocation	Risk management	25	IDQ: Mentor evaluations STMDM: Teaching assistant evaluations QCIP: Faculty advisor evaluations
8. Use business etiquette skills to network and communicate in diverse professional settings and behave in a professional and ethical manner.	Listening	Communication	Attire	Ethics	4	QCIP: Faculty advisor evaluations

Table 2: Rubrics for Elements of Learning Outcomes 1 to 8

Learning Outcome and Element Name	Advanced	Proficient	Developing	Unacceptable
1. Tool selection	Selects the most appropriate tool or approach for the problem situation after thorough consideration of alternatives.	Selects a tool or approach after considering some alternatives.	Selects a tool or approach without considering any alternatives.	Arbitrarily selects a tool or approach.
1. Fit	The selected tool or approach is the most appropriate one for the problem.	The selected tool or approach is appropriate for the problem; however, some of the tool's assumptions do not hold.	The selected tool or approach is relevant to the problem; however, other tools would have been a more natural fit; many of the selected tool's assumptions do not hold.	The selected tool or approach is inappropriate for the problem.
1. Tool use	The tool or approach was used appropriately, correctly, and effectively.	The tool or approach was used in a reasonable manner with few mistakes.	Some steps of the tool or approach were performed incorrectly or inappropriately.	The tool or approach was used inappropriately, incorrectly, and ineffectively.
1. Solution evaluation	The proposed solution was evaluated correctly on all relevant criteria.	The proposed solution was evaluated correctly using some relevant criteria.	The proposed solution was evaluated appropriately but incorrectly.	The proposed solution was not evaluated or was evaluated using inappropriate criteria.
2. Identification of the problem that the innovation is solving	Clearly defines problem; does not assume the source of the problem; able to articulate and consider the problem from multiple disciplines and perspectives; able to understand the root causes of the problem.	Defines problem; does not assume the source of the problem; mostly able to articulate and consider the problem from multiple disciplines and perspectives; mostly able to understand the root causes of the problem.	Problem definition is unclear; assumes the source of the problem; unable to consider the problem from multiple disciplines and perspectives; able to understand some root causes of the problem.	No problem definition or evidence of considering problem source or root causes.
2. Ability to build the innovation	Demonstrates a prototype that accurately reflects the innovation.	Demonstrates a prototype that mostly reflects most elements of the innovation.	Demonstrates a prototype that reflects some elements of the innovation; however, prototype is not entirely clear.	No demonstration of a prototype.
2. Significance of the innovation	The innovation is novel and demonstrates unique and distinguishing features.	The innovation has many distinguishing features but is similar to previous innovations.	The innovation has some unique features but is closely related to previous innovations.	The innovation is indistinguishable from other products.
2. Market definition	Clearly defines the market in which the product will be diffused including a quantification of the size of the market and how customers in this market demand the product.	Mostly defines the market including a discussion of potential customers.	Loosely defines the market but does not discuss potential customers.	Does not define the market or potential customers.

Table 2: Rubrics for Elements of Learning Outcomes 1 to 8 (Continued)

3. Qualitative data analysis	Synthesizes data from interviews, observations, focus groups, or other appropriate qualitative techniques to accurately analyze the problem.	Uses interviews, observations, focus groups, or other appropriate qualitative techniques to generally analyze the problem.	Demonstrates limited ability to use interviews, observations, focus groups, or other qualitative techniques.	Does not employ qualitative data analysis techniques.
3. Quantitative data analysis	Evaluates several sources of quantitative data and synthesizes information from quantitative data using sophisticated statistical analysis to provide recommendations to the problem.	Evaluates some sources of quantitative data and synthesizes information from quantitative data using basic statistical analysis to provide recommendations to the problem.	Evaluates a limited number of sources of quantitative data and synthesizes some information from quantitative data using elementary statistical analysis.	Does not employ quantitative data analysis techniques.
3. Multi-methods synthesis	Synthesizes qualitative and quantitative research techniques to develop a more detailed insight into the problem; use of multi-methods strengthens analysis.	Synthesizes most qualitative and quantitative research techniques; use of multi-methods complements analysis.	Synthesizes a few qualitative and quantitative research techniques; unclear how use of multi-methods benefits analysis.	Does not provide a synthesis of qualitative and quantitative analyses.
3. Methodology choice	Appropriate choice of methodology to evaluate the problem; proper application of methodology; methodological assumptions conform to the context of the problem.	Methodology is adequate to address the problem; mostly appropriate application of methodology; some methodological assumptions conform to the context of the problem.	Methodology is not appropriate to address the problem; methodological assumptions do not conform to the context of the problem.	No discussion of methodology.
4. Problem identification	Fully considers client needs in identifying a significant organizational problem.	Considers most client needs in identifying a somewhat significant organizational problem.	Considers some client needs in identifying an organizational problem with limited significance.	Does not consider client needs; identified problem is not significant to organization.
4. Methodology	Properly identifies and applies the most appropriate methodology to address the problem or opportunity.	Identifies and applies a usable methodology to address the problem or opportunity.	Addresses some aspects of the problem or opportunity; however, the methodology is not fully appropriate for this project.	The methodology applied is not appropriate to address the problem or opportunity.
4. Analysis	Fully analyzes several sources of data including quantitative and qualitative measures in an objective way.	Analyzes quantitative and qualitative data in an objective way; analysis could be more in-depth.	Analyzes a limited amount of data; insufficient use of either quantitative or qualitative data; analysis is somewhat objective.	Analysis is unclear or subjective.

Table 2: Rubrics for Elements of Learning Outcomes 1 to 8 (Continued)

4. Recommendations	Prioritizes and precisely defines and justifies feasible and desirable recommendations that are actionable by a client.	Prioritizes and generally defines and justifies mostly feasible and desirable recommendations that may be actionable by a client.	Loosely defines somewhat feasible recommendations that may be actionable by a client.	Provides weak recommendations that are unlikely to be actionable by a client.
5. Role identification and delegation	Team clearly defines their roles; these roles are interdependent but not overlapping or redundant; team members are accountable for the completion of all team tasks.	Team mostly defines roles; roles have some interdependence but some overlap and redundancies; team members are accountable for the completion of tasks within their individual roles.	Team defines some of their roles; roles are not interdependent and overlap and redundancies are present; team members are somewhat accountable for the completion of tasks within their individual roles.	Team does not define roles and is not accountable.
5. Coordination of tasks	Tasks are well documented and clear interfaces are used for the successful transfer of information between team members.	Tasks are generally well documented and reasonably clear interfaces are used to transfer information between team members.	Tasks are documented; however, documentation could be clearer; information transfer between team members is poorly structured.	Tasks are not documented; information transfer has no coordination.
5. Conflict resolution	Team is able to identify and address conflict in a timely manner; team develops appropriate methods to resolve conflict.	Team is able to identify and address conflict; however, conflict remains unresolved.	Team is able to identify conflict but is unable to appropriately address or resolve the conflict.	Team has conflict but is unable to identify, address, or resolve the conflict.
5. Coherence around common mission	Clear and consistent definition of a common mission or objective by all team members; commitment by team members to help accomplish this shared goal.	Mostly clear definition of team's mission with consistency from most team members; commitment by most team members to accomplish this shared goal.	Vague definition of team's mission with inconsistent views amongst team members; varying levels of commitment to mission within team.	Team does not have a common mission or objective.
6. Articulation	Team members clearly articulate thoughts and ideas with no spelling, grammatical, or language issues.	Team members articulate thoughts and ideas with limited spelling, grammatical, or language issues.	Team members articulate thoughts and ideas; however, spelling, grammatical, and language issues are frequent.	Spelling, grammatical and language issues are a severe detriment to team's presentation.
6. Enthusiasm	The team consistently communicates all concepts in a way that presents their ideas in a positive light and conveys enthusiasm.	The team generally communicates in a positive manner which presents the project in a positive light and conveys enthusiasm; however, enthusiasm wanes at some points during presentation.	The team shows some level of enthusiasm; however, communication conveys some degree of frustration or boredom with the project.	The team is not enthusiastic and appears to be frustrated and/ or bored with the project.

Table 2: Rubrics for Elements of Learning Outcomes 1 to 8 (Continued)

6. Clarity	Communication is concise and direct, and the logic of the presentation is straightforward.	For the most part, communication is concise and direct and the logic of the presentation is relatively easy to follow.	Communication varies between direct and concise and difficult to follow.	Communication is overly abrupt or long-winded; the logic of the presentation is difficult to follow.
6. Ability to convey difficult concepts	The team clearly communicates difficult-to-understand concepts and specialized knowledge such that a diverse audience may easily understand the project and its results.	The team communicates difficult-to-understand concepts and specialized knowledge such that a diverse audience understands most elements of the project and its results.	The team is able to convey some technical concepts to a diverse audience; however, many concepts may be unclear to those without specialized knowledge.	The team does not attempt to, or succeed in, conveying difficult technical concepts to a diverse audience.
7. Parsing complex tasks	The team fully understands a complex task, divides it into appropriate subtasks, orders the subtasks logically, and correctly identifies dependencies.	The team understands most elements of a complex task, divides it into appropriate subtasks, orders most of the subtasks logically, and correctly identifies most of the dependencies.	The team fully understands some components of a complex task, divides it into some subtasks, orders some of the subtasks logically, and identifies some dependencies.	The team demonstrates minimal understanding of a complex task and does not develop appropriate subtasks.
7. Project definition	The team precisely defines the project scope and develops clear definitions of project success.	The team generally defines the project scope and develops appropriate definitions of project success.	The team defines some of the project scope and develops vague definitions of project success.	The team does not define the project scope and does not develop definitions of project success.
7. Project resource allocation	The team allocates its resources optimally and identifies and thoroughly learns all of the skills that it needs but does not have.	The team allocates its resources efficiently and identifies and learns most of the skills that it needs but does not have.	The team allocates its resources inefficiently and identifies and attempts to learn some of the skills that it needs but does not have.	The team allocates its resources ineffectively and does not attempt to learn any of the skills that it needs but does not have.
7. Risk management	The team anticipates all project risks, develops effective risk mitigation plans, and successfully implements their strategy.	The team anticipates most of the project risks, develops appropriate risk mitigation plans, and implements most of their strategy.	The team anticipates some of the project risks, develops some risk mitigation plans, and successfully implements some of their strategy.	The team does not anticipate project risks and does not develop risk mitigation plans.
8. Listening	Listens to verbal and visual communication to fully understand a message and reflect the message back to the speaker with 100% agreement.	Listens to verbal and visual communication to mostly comprehend a message; is able to reflect the message back to the speaker with general agreement.	Listens to verbal and visual communication to comprehend some elements of a message; attempts to reflect the message back to the speaker with some difficulty.	Does not listen to verbal or visual communication to sufficiently understand most messages; does not attempt to reflect messages back to speaker.

Table 2: Rubrics for Elements of Learning Outcomes 1 to 8 (Continued)

8. Communication	Verbal and non-verbal communication skills in one-on-one, group, and professional settings demonstrate respect for an audience and convey content so that the audience may fully understand the message.	Verbal and non-verbal communication skills in one-on-one, group, and professional settings mostly demonstrate respect for an audience; content is conveyed so that the audience understands the main points of the message.	Verbal and non-verbal communication skills in one-on-one, group, and professional settings demonstrate some respect for an audience; content is conveyed so that the audience understands some of the main points of the message.	Verbal and non-verbal communication skills in one-on-one, group, and professional settings do not demonstrate respect for an audience and do not convey content so that the audience may understand the message.
8. Attire	Personal appearance is appropriate for the setting and demonstrates care and respect for others.	Personal appearance is mostly appropriate for the setting and demonstrates respect for others.	Personal appearance is somewhat appropriate for the setting and demonstrates consideration of others.	Personal appearance is inappropriate for the setting.
8. Ethics	Ability to fully recognize ethical issues; clear understanding of one's personal ethics and values; clear ability to act on ethical principles.	Ability to recognize most ethical issues; general understanding of one's personal ethics and values; ability to act on ethical principles in most situations.	Ability to recognize some, but not all, ethical issues; some understanding of one's personal ethics and values; ability to act on ethical principles in some situations.	Unable to recognize most ethical issues; limited understanding of one's personal ethics and values; unable to act on ethical principles in most situations.