A Student Outcomes Assessment Methodology for Technology-Based and Hands-On Intensive Curricula

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Abstract

It is desirable to educators, and important for students, that a sound outcomes assessment methodology be employed in technology-based and hands-on intensive courses to measure and ensure that requisite competencies are obtained by students. It is expected that a working knowledge of these important competencies can help a two-year college graduate more effectively demonstrate mastery of the necessary skills and knowledge, and therefore add more value to a potential employer's operations. While assessment of student learning can be straightforward for general education courses, meaningful measurement of student learning within the context of technology-based and hands-on curricula are often more difficult. Furthermore, continuous improvement efforts as a result of assessment, whether or not the defined criteria for success have been met, often involve very detailed and specific adjustments to the curriculum and instructional delivery. However, several elements of an assessment methodology can be employed that are helpful in measuring student learning according to preset benchmarks, when student learning is demonstrated in such environments. Important assessment elements include a sound understanding of the relevant competencies to be gained, the formulation of descriptive outcome statements, the setting of realistic benchmarks, and the implementation of repeatable measurement techniques. A feedback mechanism, for the purpose of continuous improvement whether or not the predetermined benchmark is met, is also a key element. The effective use of these elements are outlined and developed within the context of technology-based and hands-on course delivery in two-year colleges, and with a strong focus on measuring and reporting student learning.

Assessment Philosophy

Trends in higher education outcomes assessment over the last decade have moved from a simple question of whether or not assessment (i.e. a measurement of student learning) is being conducted to the larger question of what is being done with the assessments, especially in terms of continuous improvement. These assessments are being required by regional accreditors, by program accreditors, and by the performance-based funding approaches of local, state, and the federal government.

The assessment process in educational endeavors focuses on outcomes, or the outputs, of the educational process rather than on the inputs. For example, the number of faculty, the availability and amount of financial resources, and the procurement of equipment are all necessary to the success of an academic program, but do not speak directly to a measurement of what students have gained in knowledge, and can apply on completion of a program. The particular measurements sought must clearly display what students have gained in terms of competencies, with a resolution more significant than that of simply noting course grades. For example, in a typical course grading scheme, students earning between 90 and 100% can expect a grade of 'A'. However, students who reach this highest grade may actually have failed to master up to 10% of the course content, and topical areas representing this lack of mastery may involve competencies that have been deemed critical by employers, transfer institutions, and regional and program accreditors. It soon becomes clear that a much more detailed means of measurement is required. It is due to this requirement that current assessments efforts are borne.

Assessment then allows a systematic approach to probing the competencies gained on a much more granular level, which can in fact allow the measurement of a particular competency or skill. Learning outcomes can be predefined with inputs from a variety of sources, standardized across a curriculum to give meaningful and representative results, and the assessment of which can then become an input to an institution's continuous improvement process. True measurement of student learning is the goal.

An additional and somewhat unique feature of assessment is the means by which competencies within technology-based and hands-on courses, such as group design and technology laboratories are defined and measured. For these types of courses, solid rubrics and well-defined outcomes involving both hard and soft skills must be predetermined and then measured.

Assessment Requirements

The influence of accreditors on assessment and continuous improvement efforts is apparent within many institutions. At Rowan College at Burlington County (RCBC), much attention is given to the Middle States Commission on Higher Education requirements around both institutional and educational assessment. Guidance is given by Middle States through Standard 7 (Institutional Assessment) and Standard 14 (Assessment of Student Learning) in the obsolete 'Characteristics of Excellence', now being phased out as transition to a new set of standards occurs. The new standards contain a strong focus on assessment as well through Standard V (Educational Effectiveness Assessment), a condensed summary of which is presented in Table I[1].

Table I. Middle States New Standard V. Educational Effectiveness Assessment

New Standard V. Educational Effectiveness Assessment	Condensed Summary
1.	Clearly stated educational goals
2.	Organized and systematic assessments
a.	Meaningful curricular goals with defensible standards for evaluation
b.	Demonstrate how goals prepare for success
c.	Support and sustain assessment and communicate results to stakeholders
3.	Use of assessment results to improve educational effectiveness
4.	Institution-level review of assessment services
5.	Periodic Assessment of effectiveness of assessment processes

Program accreditation is also a focus at RCBC, especially for the Electrical Engineering Technology program accreditation by ABET, known under the corporate name of the

Accreditation Board for Engineering and Technology. For Engineering Technology programs, under the Engineering Technology Accreditation Commission, ABET requires that accredited Associate degree programs measure and meet requirements for specific Student Outcomes (SO's), with additional program criteria (j and k) as outlined in Table II[2].

Table II. ABET TAC Associates Degree expected Student Outcomes (SO's)

ABET Designation	Requirement
Student Outcomes	
a	an ability to apply the knowledge, techniques, skills, and modern tools of the discipline to narrowly defined engineering technology activities
b	an ability to apply a knowledge of mathematics, science, engineering, and technology to engineering technology problems that require limited application of principles but extensive practical knowledge
c	an ability to conduct standard tests and measurements, and to conduct, analyze, and interpret experiments
d	an ability to function effectively as a member of a technical team
e	an ability to identify, analyze, and solve narrowly defined engineering technology problems
f	an ability to apply written, oral, and graphical communication in both technical and nontechnical environments; and an ability to identify and use appropriate technical literature
g	an understanding of the need for and an ability to engage in self-directed continuing professional development
h	an understanding of and a commitment to address professional and ethical responsibilities, including a respect for diversity
i	a commitment to quality, timeliness, and continuous improvement.
Program Criteria	
j	apply circuit analysis and design, computer programming, associated software, analog and digital electronics, and microcomputers, and engineering standards to the building, testing, operation, and maintenance of electrical or electronic(s) systems
k	apply principles of physics or chemistry to electrical/electronic(s) circuits in a rigorous mathematical environment at or above the level of algebra and trigonometry

These examples of the assessment requirements of a regional and program accreditor outline the framework for a general and a more specific collection of imperatives regarding the measurement of student learning. Both, however, have the same end goal which is to effectively measure the degree of student learning for the purposes of clarification and continuous improvement.

Another reason to assess and demonstrate the effectiveness of academic programs in meeting predefined student learning outcomes is to meet existing and emerging performance-based benchmarks. As the local, state, and federal focus on higher education shifts from an enrollment-based funding model (inputs) to that of a success or performance-based model (outputs), a sound assessment strategy will become even more necessary.

Furthermore, sound assessment strategies will aid a student's ability to succeed in their pursuit of transfer to a baccalaureate degree granting institution, as well as in their quest to find gainful employment. When learning outcomes are aligned well with transfer institution requirements and employer needs, and when attainment of those outcomes can be readily demonstrated, an institution can make great strides toward contributing to the success of its students.

Assessment Approach

RCBC has made efforts to formalize the assessment process and to strengthen it within the culture and environment of the College. In doing so, a Mission Statement for Assessment as well as Assessment Goals have been created and are outlined below.

Mission Statement for Assessment:
Rowan College at Burlington County is committed to student outcomes assessment. Results of assessment are used to support the college mission, improve teaching and learning, plan for resource allocation, and provide
validation to internal and external constituencies.

Assessment Goals:
1. Create a sustainable college climate for assessing student learning outcomes.
2. Support and encourage flexible approaches to assessment.
3. Provide training for the assessment process to all full-time and part-time faculty members.
4. Use assessment results to support the college mission, improve teaching and learning, plan for resource allocation, and provide validation to internal and external constituencies.

At RCBC, all academic programs must complete student outcomes assessments on an annual basis. The College has been diligent in its efforts to collect assessment data and create new opportunities to assess curricular processes and products along with a strong emphasis on academic trends and issues. The final outcome of these processes is verifiable evidence of student
achievement in knowledge, skills and critical thinking. The results of this assessment process are used to improve program quality, provide validation to internal and external audiences about program vitality and quality, and aid in achieving the College's mission and goals. The learning outcomes assessment loop is illustrated in Figure 1[3] and outlines the following assessment process:

1. Set goals to be assessed using internal and external benchmarks.
2. Develop two varied assessments for each outcome assessed and a criterion for success for each.
3. Conduct assessment and collect data using qualitative and quantitative analysis.

4. Develop an improvement plan to address weaknesses and strengths.
5. Implement improvement plan into operations.

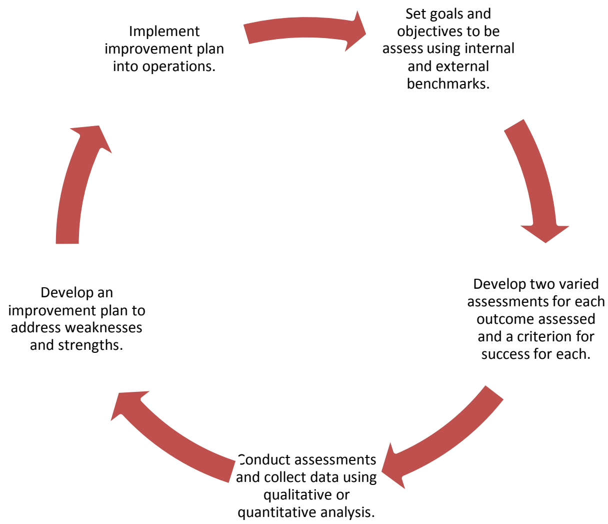

Figure 1. RCBC Assessment Cycle

Within the assessment process, a RCBC faculty is assigned to chair an assessment project (i.e., a specific course) for each academic year and, working collaboratively with the assessment coordinator, the assessment chair determines how to measure the intended learning outcomes for each assessment project. The chairperson creates the assessment device(s) and accompanying rubric(s), reviews them with the assessment coordinator, and meets with, trains, and collects completed assessments from all instructors who teach the course. The assessment chair also meets with and receives feedback from the instructors and constructs a reflective summary for the course. The chair then compiles all of the assessment results, including the reflective summary, and transmits them to the assessment coordinator.

At the discretion of the assessment chair (and approved by the assessment coordinator), assessment devices may include qualitative, quantitative, and/or mixed direct and indirect measures. Rubrics are used to assess essay questions, projects, portfolios and presentations, and they are provided to the instructors who conduct and score the assessment. For each outcome assessed, the assessment chair develops two different assessment tools (i.e., test questions, project or portfolio, and/or essay). Next, an assessment plan is established using the Student Learning Outcomes Assessment Annual Report. At the end of each semester, the data results are submitted in the following format: "__ of __students or __% of participating students scored or were able to …." As noted above, the assessment chairs prepare a reflective summary, which describes what outcomes were achieved (or not achieved) and what was learned by conducting the assessments for that academic year. If the criterion for success was not achieved, a meeting is scheduled with the appropriate dean, faculty, and the assessment coordinator to create an improvement plan that includes tangible and measureable improvement.

The last step in the assessment process is "closing the loop" or the "analysis of the evidence" from the data that are collected. This step in the assessment process facilitates reflection upon what was learned from the assessment. A team of faculty carefully reviews the success and usefulness of the assessments (as well as the assessment tools) and what the results demonstrate. Discussions are then developed regarding the validity of the assessment, the value of the current course materials (including texts) and the core course content. The assessments provide opportunities to assess the strengths and weaknesses within a course or program.

Assessment of Technology-Based and Hands-On Courses

In demonstrating the application of the assessment process described above to technology-based and hands-on courses and competencies, three examples will be presented. Detail will be discussed that relate particularly to the technology and experiential instruction experienced by students. Continuous improvement efforts, as a result of the assessments, will be outlined in specific detail.

CIS-165 Network and Systems Administration

Course Description

This course provides an advanced knowledge of networking as well as related equipment and terminologies. The course will cover local area network, wide area network, managing enterprise level networks using Active Directory and remote access. Advanced network management and environment customization techniques will be explored, including creating users/groups, managing file permissions, configuring server roles, using group policies to configure and secure the network, routine system maintenance and troubleshooting

Course Learning Outcomes

Upon completion of the course, students will be able to:

1. Install, configure and manage enterprise systems/networks, including hardware/software.
2. Implement and administer desktop and server operating systems (client/server), switching and routing devices.
3. Implement and configure active directory
4. Create user/group accounts and configure server roles.
5. Administer permissions for users, files and network resources.
6. Use group policies to configure and secure the network.
7. Manage desktops and server computers using remote access.
8. Install and configure TCP/IP for network and Internet connectivity.
9. Maintain and troubleshoot enterprise networks.

RCBC’s Network and Systems Administration course is a required program course in the Computer Servicing and Networking Technology option to the ABET accredited Electronics Engineering Technology program, as well as in the Computer Management Information Systems Associate degree. The assessment of this technology-based course follows the standard five step assessment outline as described above. The selected course-level outcome is that students should be able to maintain and troubleshoot enterprise networks, specifically to implement and administer desktop and server operating systems (client/server), as well as switching and routing devices.

The first assessment conducted entailed that all students enrolled in Network/Systems Administration (CIS165) were required to complete one (1) project on Network Systems Administration between week 10 and week 14 of the Spring 2014 semester. A benchmark of a minimum of 70% of students answering at least 70% of the project questions correctly was targeted. The resultant measurement was that 13 out of 14 or 92.9% of participating students answered at least 70% of the project questions correctly.

The second assessment was defined as all students enrolled in Network/Systems Administration (CIS165) will be required to complete a final exam between weeks 15 and 16 of the Spring 2014 semester. A benchmark of a minimum of 70% of students answering at least 70% of the final exam questions correctly was targeted as a measure of success. The resultant measurement was that 17 out of 17 or 100% of participating students answered at least 70% of the final exam questions correctly.

The criteria for success were met for both assessments and no corrective action was required. The instructor, on reflective analysis, determined to continue to emphasize the real world application of the course concepts. This approach has been proven to be successful and appears to enable students to remember what was taught, as demonstrated by first-hand accounts of student interns working in industry.

EET-232 Analog Integrated Circuits

Course Description
This course focuses on the characteristics and applications of analog integrated circuits including operational amplifiers and specialized linear integrated circuits. It investigates circuits including inverting, non-inverting and differential amplifiers, non-linear circuits, active filters, equalizers, oscillators, timers, and power supply regulator IC’s. Laboratory experiments cover the above topics and verify lecture theory. Circuit analysis software is used to simulate and verify the laboratory analysis where appropriate.

Course Learning Outcomes
Upon completion of the course, students will be able to:
1. For Analog Integrated Circuits: Identify the characteristics of, analyze and solve problems
2. Use test equipment to perform measurements
3. Use electronic circuit analysis software (Electronic Workbench) to draw schematics and / or analyze circuits.
4. Build circuits on a Protoboard from a schematic
5. Demonstrate a proficiency in soldering printed circuit boards
6. Given circuit specifications, apply knowledge learned in the course to design and build a circuit
7. Communicate effectively through written report

RCBC’s Analog Integrated Circuits course is a required program course in the ABET accredited Associate of Applied Science Degree in Electronics Engineering Technology program and an optional elective in the Computer Servicing and Networking option. The selected course-level outcome is that students will be able to use electronic circuit analysis software (i.e. Electronic Workbench) to draw schematics and/or analyze circuits.

The first assessment involved Test #5, which was based on a group analysis of an assigned active filter. The target benchmark was that at least 70% of students would score above 70% on the test. The resultant measurement was that 17 out of 17 or 100% of students scored above 70% on Test #5.

The second assessment involved Test #6, which was the capstone design project module. The target benchmark was again that at least 70% of students would score above 70% on the test. The resultant measurement demonstrated that 17 out of 17 or 100% of students scored above 70% on Test 6.

Even though the intended benchmarks were met, indicating achievement of a minimum level of competency acquisition by students, the reflective summary approach by faculty yielded improvements to the course delivery.

Specifically, even though for Test #5 the criteria for success was met, the active filter used, a notch filter, had poor performance and was replaced in future offerings. Similarly, for Test #6, the criteria for success was met. However, the test was improved with revisions including temperature sensor input specifications changed for more reliable operation, and an LED circuit connected to the correct output of the RS Latch, so it will light up when the low temperature alarm circuit is activated.

These improvements demonstrate the feedback and continuous improvement possible after assessment, even when criteria for success are met, as a result of critical analysis of the skills imparted to students, and the relevancy of the manner in which the competencies are gained.

EGR-103 Fundamentals of Engineering Design

Course Description
This course involves interdisciplinary teams of students working on engineering design projects. Electronic and mechanical topics along with schematic drawing software are incorporated in lecture and lab modules, and are designed to give students the skills to design, build, document, and present a working project. Projects have elements of Electronic and Mechanical Engineering design. Each team prepares a written report, gives an oral presentation, and demonstrates their project.

Course Learning Outcomes
Upon completion of the course, students will be able to:
1. Explain the operation of electrical and basic electronic circuits.
2. Analyze and solve problems of the mechanical part of a project.
3. Use Visio and Electronic Workbench (EWB) software to draw schematics.
4. Apply knowledge learned in the course and physics to creatively design and build an electronic/mechanical project.
5. Function effectively as a member of a technical team.

6. Communicate effectively through a written report and oral presentation.
7. Make improvements to the project with a quality that it works reliably and complete project on time.

RCBC's Fundamentals of Engineering Design course is an optional elective course in the ABET accredited Associate of Applied Science Degree in Electronics Engineering Technology program as well as in the Computer Servicing and Networking option. The selected course-level outcome is that students will be able to make improvements to guarantee reliability of a project within certain time restraints.

Assessments are done through a Team Capstone Design Project including a Mechanical Report, a team Design Project Oral Presentation, and a Project Demonstration. Students will also use Visio & Electronic Workbench (EWB) software to draw schematics.

The first assessment involved the team capstone design project mechanical report. The target benchmark was that at least 70% of students would score above 70% based on the established rubric for the report. The resultant measurement was that 37 out of 37 or 100% of students scored above 70% on the report according to the established rubric.

The second assessment involved the team Design Project Oral Presentation and Project Construction Analysis and Demonstration. The target benchmark was that at least 70% of students would score above 70% based on the established rubric for the report. The resultant measurement indicated that 37 out of 37 or 100% of students scored at least 7 out of 10 points according to the established rubric, thereby meeting the established criteria for success.

Even though the intended benchmarks were met in this and previous terms, indicating successful attainment of student learning outcomes, the reflective summary approach again yielded course improvements. For example, the standardized photo gate used by all student teams was changed to prevent burn out of the transistor when a delay capacitor was increased to maximize circuit delay time. Also, an additional mechanical lecture was added to address pneumatic components such as solenoids, pistons, and air valves, to increase student's mechanical capabilities in project design.

Summary

While the assessment methods outlined above, for the assessment of the technology-based and hands-on courses described, are useful in viably measuring student learning under these specific circumstances, there are a number of considerations that must be taken into account to gain the maximum benefit of such a process.

First, as demonstrated, the approach to assessment must include a reflective summary and opportunity for continuous improvement even when the predefined criteria for success are met. Critical analysis of course delivery methods, and implementing constructive changes when appropriate, will ensure the robustness of future assessment techniques, and that critical competencies are obtained by students.

Additionally, a predefined rubric must be employed in the measurement of student learning outcomes especially when assessments have several parts, such as in detailed projects, and when students are working in teams but learning outcomes need to be measured on an individual student basis.

The relatively small number of students registered for these technology-based and hands-on courses who are assessed also need to be taken into account when comparisons are to be made institution-wide with courses that have many more students enrolled and assessed.

Finally, assessments are best aligned with industry partner employer needs, and four-year transfer institution requirements, to best position students for success as they move forward. These alignments also enable assessment results to become inputs to the Institutional Strategic Planning Process as well as the Institutional Effectiveness Plans used to judge high level effectiveness of academic and operational divisions.

Acknowledgements

The authors wish to acknowledge Rowan College at Burlington County and all those who have helped to create and maintain an institutional culture of assessment. Special thanks are given to RCBC's President, Mr. Paul Drayton, and to the Board of Trustees who wholeheartedly support assessment efforts, for the benefit of all students.

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