Assessing the EE Program Outcome Assessment Process
Case Study: EE401 – Senior Design Capstone Project Course

Christopher M. Korpela
Department of Electrical Engineering and Computer Science
United States Military Academy, West Point, New York 10996
Christopher.Korpela@usma.edu

Abstract — This paper summaries the results and findings of a two year research project to assess the Electrical Engineering Outcome Assessment Process in the Department of Electrical Engineering and Computer Science at the United States Military Academy. In particular, the Senior Design Capstone Project Course, EE401, was evaluated using the revised assessment methods. This analysis is particularly relevant due to the current accreditation the department is undergoing. The results found in this report support previous work published by the author and others in the Summer of 2007. That paper along with this one are part of a classroom research project for the Master Teacher program at West Point.

1. Introduction

Documenting, assessing and evaluating program outcome achievement can be a tedious and data intensive process. These definitions are consistent with those used by ABET (the Accreditation Board for Engineering Technology [1]. At the United States Military Academy at West Point, New York, we recently reviewed our program assessment process to determine a more efficient way of assessing and evaluating outcome achievement without sacrificing the quality of the evaluation. We were able to reduce overhead and increase efficiency in two areas: outcomes and embedded indicators. By carefully examining how we chose embedded indicators, we reduced the number of embedded indicators used to assess each outcome, reduced the number of outcomes that observe any given course, and standardized the rubrics used to examine each embedded indicator [2] [3]. This new framework was then applied to the Electrical Engineering Senior Design Capstone Project Course, EE401. This course spans two semesters (EE401 for the first semester and EE402 for the second semester). When referenced, EE401 represents both EE401 and EE402.

2. Senior Design Capstone Project

The intent of Senior Design Capstone Project course in the Electrical Engineering Program is to provide cadets with a challenging engineering problem that requires them to integrate key concepts from several previous EE courses. Multidisciplinary projects add to that challenge because the students who participate in cross-disciplinary projects have to also learn the capabilities and limitations of other disciplines. While more challenging, a multidisciplinary project provides the students with a better perspective of real-world engineering projects. Many peculiarities associated with these multidisciplinary projects must be addressed such as the formation, monitoring, and evaluation of cross-disciplinary teams. Common problems that are normally encountered are scheduling, grading, resource allocation, and control of the group. Group dynamics and the unique results of what a cross-disciplinary team can produce are also key areas. The group's faculty advisor must play a key leadership role to ensure that the group stays on track, interacts well within the group and amongst the other departments, and ensures steady progress is made towards project completion. A series of design reviews throughout the year gives the group waypoints to measure progress as well as practice presenting in front of an audience. Some unique features not normally found in a senior design course such as peer evaluations, guest lecturers, and project's day have been implemented [4].

3. Objectives and Outcomes

One of our program objectives (long term goals) is to have our graduates apply disciplinary knowledge and skills to develop and implement solutions to applied problems individually and in diverse teams. This objective is linked to three outcomes (things students should be able to do at graduation): being able to draw progressively from more complex design-test-build experiences, engaging in design efforts in a team setting, and being able to apply math-science-engineering knowledge relevant to specific problems.

Our multidisciplinary projects are the culminating result of a cadet's educational program. In order to measure effectiveness, assessment is done at a variety of levels. Each course has an end of course survey linked into the academy-wide course administration software. Results are complied at the course, program, department, and academy level. Graduating seniors and graduates after three years are surveyed about the program's effectiveness. Faculty also participate in assessment by preparing course assessment reports, serving on goal teams, and monitoring outcomes. Each of the seven engineering programs maintains an advisory board to provide feedback on program effectiveness and objective accomplishment.

Our graduates have provided useful feedback in improving our program. Over 85% of our graduates respond with a very positive outlook from their undergraduate experience. Graduate input has helped link the math program closer to the engineering programs, helped create a more realistic design environment, and become an integral part in updating our program objectives. The USMA EE program is rated #6 in the latest US News and World Report survey of undergraduate EE programs [4].

a. Previous Assessment Model

In the previous assessment model, in order to assess an outcome, monitors determined which set of embedded indicators to use. Since we did not have a holistic approach, some courses bore a much heavier assessment burden than others. For example, nearly every graded event in the capstone design course was assessed and the design reviews were assessed by six different outcome monitors. Additionally, any time a course director wanted to change a course he or she would need to consult with several outcome monitors to ensure that the changes did not have a detrimental affect on the outcome assessment process, or at least ensure that the outcome monitor took the changes into consideration. This unduly constrained the course director's ability to revise and improve his or her own courses in response to changes in technology, textbooks, or student performance or feedback [3].

b. New Assessment Model

The new EE Program assessment model reduced the embedded indicators at early stages of student development, chose indicators that all students complete, and tried to keep embedded indicators for a single outcome within the same class year. To minimize course director burden, we restricted outcome assessment to one outcome indicator per event and shared the embedded indicator assessment across the faculty where practicable [3].

4. EE401 Assessment

From a faculty advisor perspective, the assessment process did not involve much additional work and was not too cumbersome. Being one who helped to revise the embedded indicators and rubrics, it was a fairly easy process.

Program Outcomes	1st Semester	2nd Semester
Math, Science, Engineering skills		
Identify, formulate and solve problems	Preliminary Design Review	
Computer and information technology	MS Project Mini-Lab	
Design and conduct experiments		Sub-Systems Demo & Lab Notebook
Communication		Project's Day (Oral) & Final Rpt (written)
Work on Teams	Peer Evals	Advisor Assessment of performance
Professional and ethical considerations		
Incorporate societal, global, contemporary issues and realistic constraints into engineering solutions		Critical Design Review & Final Report
Life-long learning		Final Design Review

Table 1. Embedded Indicators

Table 1 illustrates the embedded indicators over the entire year for EE401. Those highlighted in yellow represent indicators that must be filled out by the faculty advisor. Examples of three of these indicators are shown as attachments (Final Design Review, Critical Design Review and Sub-system Demo). The rubrics used for the indicators are also attached.

For the students, the new assessment process is completely transparent. The only change they see is that some of their work is kept and copies are given back to them. The students complete peer evaluations and the other group members and several examples of those are also included.

5. Results

In the capstone senior design course, virtually every assignment was being reviewed by each of our outcome monitors. The senior design project course director was collecting outcome achievement data on nearly every event for nearly every outcome. We eliminated duplicate outcome measures on the same event unless measurement could be deferred until the end of the semester as with design project reports or lab notebook reviews. To minimize workload, we assigned embedded indicator assessment across the faculty where feasible. An example of this is in our Outcome 6, "Work effectively on a diverse team." In the attached embedded indicators, I show examples of my evaluations on my senior design team (advisor assessment of performance"). In this course, each student team is assigned a faculty advisor. We fence our entire faculty's time during the two-hour block that the course meets, enabling close interaction with the project advisor. The faculty advisor serves in the same role as a senior engineer or distinguished member of the technical staff in industry. Part of the advisor's role is to assess each individual's ability to function on the team. Throughout the first and second semester, the advisor provides grades and feedback to the student on their performance and ability to function on the team. During the second semester, the advisor completes a standardized rubric-based grading sheet assessing the student's ability to serve as a team member. Also shown is an example rubric which is essentially a grading sheet during the preliminary and critical design reviews for the advisors to assess the students' achievement of Outcome 8, relating to societal, global, contemporary issues and designing within realistic constraints.

6. Conclusions

We have found that by streamlining the outcome process and using a rubric approach applied across multiple outcomes, we can greatly reduce the number of performance indicators yet preserve our ability to accurately assess our program.

This new assessment process was applied to the EE Senior Design Capstone Project Course. The embedded indicators do not burden one particular course or director. The rubrics are easy to use and provide a standardized format across all of the indicators. The system is transparent to the students who are the ones being evaluated.

The views expressed are those of the authors and do not reflect the official policy or position of the U.S. Military Academy, the U.S. Department of the Army, the U.S. Department of Defense or the United States Government.

7. References

[1] ABET, Inc. Accreditation Policy and Procedure Manual, October 29, 2005. Available online: www.abet.org

[2] Lisa A. Shay, Bryan S. Goda, Peter Hanlon, and John D. Hill. "Outcome Assessment at the United States Military Academy." In Proceedings of the 32nd ASEE/IEEE Frontiers in Education Conference.

[3] Robert Sadowski, Lisa A. Shay, Christopher Korpela, and Erik Fretheim. "Assessing the EE Program Outcome Assessment Process." presented at the American Society for Engineering Education Conference in Honolulu, Hawaii, 24-27 June 2007.

[4] Peter Hanlon, Bryan S. Goda, Lisa A. Shay. " Experience with Multidisciplinary Design Projects at the US Military Academy." In Proceedings of the 2004 ASEE Annual Conference and Exposition.

CHRISTOPHER M. KORPELA is an Instructor in the Department of Electrical Engineering and Computer Science at the United States Military Academy at West Point. He received an M.S. in Electrical Engineering from the University of Colorado in 2006 and is a Senior Member of the Institute of Electrical and Electronic Engineers.

OUTCOME: 5 COURSE: EE402 – Electronic System Design II

DEFINITION: Communicate solutions clearly, both orally and in writing

EVENT: Project's Day (Technical Oral Presentation in booth format)

RUBRIC: 1(Weak) to 5 (Strong)

1. Inadequate communication. Major content is missing. Style and organization does not conform to professional standards. Even with repeated reading and/or explanation, ideas are unable to be conveyed.
2. Poor communication. Some content is missing. Style and organization hinders the conveyance of ideas. Requires repeated reading and/or explanation to clarify what is being communicated.
3. Moderately clear communication. May be missing minor content but the central ideas are conveyed. The organization presents ideas in a logical progression. Style may be awkward but does not mask the communication of ideas.
4. Clear communication with minor errors. No content deficiencies and a logical presentation of ideas. Style and organization may contain minor errors but does not hamper the communication of ideas.
5. Clear communication with no errors. No content deficiencies. Ideas are presented in a logical order. Style and organization meet professional standards and enhance the communication of ideas.

EXAMPLE: 1(Weak) to 5 (Strong)

1. Minimal explanation of the project objectives, methods and techniques used. Significant inaccuracies in the technical details. Does not give examples or applications of project. Ignores prototype and poster board in presenting the project. Unable to recognize the technical level/ interest level of the audience. Limited responsiveness to the audience. Presentation shows few, if any, signs of prior preparation and planning. Appears apprehensive or displays significantly less than ideal behavior.

2. Expected to explain the project objectives, some methods and techniques used to create the project, some what accurate in the technical details, may give examples or applications of project, limited use of the prototype and poster board in presenting the project. Limited ability to recognize the technical level/ interest level of the audience. Limited interaction with the audience. Presentation shows few signs of prior preparation and planning. May appear apprehensive or display less than ideal behavior.

3. Expected to explain the project objectives, most methods and techniques used to create the project, mostly accurate in the technical details, give examples or applications of project, makes use of the prototype and poster board in presenting the project. Some ability to recognize and react to the technical level/ interest level of the audience. Interact and field questions from the audience. Presentation should show signs of prior preparation and planning. Displays confidence and professional demeanor.

4. Expected to explain the project objectives, all methods and techniques used to create the project, minor inaccuracy in the technical details, give examples or applications of project and tie technical specifications to demonstrated results, make use of prototype and poster board in presenting the project. Able to recognize and react to the technical level/ interest level of the audience. Interact and field questions from the audience. Presentation shows sign of prior preparation and planning. Displays confidence and professional demeanor.

5. Clear and accurate articulation of all aspects of project. (technical details, applications, demonstrated results, conclusion, future efforts, etc.). Seamless use of audio, visual, and kinesthetic aids. Highly confident and professional demeanor. Presentation highly tuned to audience.

Please circle appropriate level for each project:

Project	**1 Weak**	**2**	**3**	**4**	**5 Strong**

Example Rubric for Assessing Oral Communication

Project: WEB BOT

EE402 Final Design Review Grading Rubric

Content (80 pts):

- 20 points based on assessment using Outcome 8 rubric (independent learning)
- Compute average of instructor and advisors assessments for each student
- Apply the following scale:
  - 5→A+ = 97%　　2→C = 73%
  - 4→A- = 90%　　1→F = 60%
  - 3→B = 83%
- Use linear interpolation for non-integer values (4.5 = 93.5%, 3.5 = 86.5%, etc)
- 60 points based on integration testing: procedure, level of detail, quality of results, analysis of results

Format (10 pts):

- ☑ Paper copy of your presentation at the beginning of your briefing
- ☑ Followed guidance for slide content and order

☑ Title and group members/advisor ☑ Problem statement ☑ Requirements Summary ▪ Specifications ▪ Constraints ☑ Revised block diagram	☑ Responsibility matrix ☑ New subsystem test results (if not briefed at CDR or sub-system demo) ☑ Integration Test Plan ☑ Integration Test Results	☑ Revised Budget ☐ ~~Summary of the schedule~~ ☑ Social, Political, Economic Implications ☑ "Bridging the Gap" ☑ Conclusions/Questions

- ☒ Presentation appearance
  - Correct grammar and spelling　IEE INSTEAD OF IEEE 802.11
  - Consistent font
  - Consistent background
  - Legible text

Presentation style (10 pts):

- ☑ Used appropriate language
- ☑ Did not display distracting mannerisms from either the presenter or the other team members not currently presenting
- ☑ Used a pointer properly – did not point across body, didn't hit the screen, didn't wave, swing, or play with pointer when not pointing to the screen
- ☑ Adhered to time limitation
- ☑ Had a person record instructor feedback and questions at end of briefing
- ☑ Appeared rehearsed – transitions were smooth

Cadet	Integration testing (60)	Independent learning (20)	Format (10)	Style (10)	Total (100)
BRYAN	52	18	9	10	89
KRICK	52	18	9	10	89

Project: Web Bot

Integration testing

	1	2	3	4	5
Procedure	No procedure given.	The procedure does not measure appropriate specifications or interconnected sub-systems.	The procedure measures appropriate specifications on interconnected sub-systems.	The procedure sets out a logical sequence for appropriately integrating sub-systems.	Procedure logically integrates sub-systems in a hierarchical manner.
Equipment	No equipment listed.	Equipment is inappropriate for listed measurements.	Equipment is appropriate for listed measurements.	Chose the best available equipment for listed measurements.	Using equipment to maximum capability for listed measurements (eg. Automatic data collection)
Data	Collected data on most sub-systems separately without any integration.	Collected data on all sub-systems separately without any integration.	Collected data on some pairs of connected sub-systems.	Collected data on most pairs of connected sub-systems.	Integrated all sub-systems.
Analysis	No analysis.	Some analysis, but didn't compare data to specifications.	Compared data to specifications and met most specifications.	Compared data to specifications and met most specs. Has a clear plan for redesign to meet specs.	Compared data to specifications and met all specifications.

Overall Average: 3.5

Evaluation Worksheet

OUTCOME: 9 INDICATOR: 1 COURSE: EE402 – Electronic System Design II

DEFINITION: Demonstrate the ability to conduct independent inquiry and learning as well as recognition of the need to continue doing so over a career in the military and beyond. [ABET Criterion 3 Outcome (i)]

EVENT: Final Design Review (Technical Oral Presentation)

RUBRIC: 1(Weak) to 5 (Strong)

Evaluator: Korpela

Project: WebBot

Please indicate the appropriate level for each EE cadet on your design project team:

Cadet	1 Weak	2	3	4	5 Strong	Comments
Bryan			X			Constraints ~~Specifica~~ Specifications still need work
Krick			X			PING sensor - description of scanning

Address social, economic, political standards

802.11 standard - hand off of 1 AP to another

Project: WEB BOT

EE402 Critical Design Review Grading Rubric

Content (75 pts):

- 50 points based on assessment using Outcome 8 rubric
- Compute average of instructor and advisors assessments for each student
- Apply the following scale:
  - 5→A+ = 97%
  - 4→A- = 90%
  - 3→B = 83%
  - 2→C = 73%
  - 1→F = 60%
- Use linear interpolation for non-integer values (4.5 = 93.5%, 3.5 = 86.5%, etc)
- 25 points based on testing: procedure, level of detail, quality of results, analysis of results

DID SOME TESTING, RAN INTO INTERFACE PROBLEM w/ MATILDA
PING SENSOR NOT WORKING, OR CAN'T COMMUNICATE w/ IT
ARE ABLE TO CONTROL MATILDA w/ LAPTOP AND MICROCONTROLLER
≈B

Format (10 pts):

- ☑ Paper copy of your presentation at the beginning of your briefing
- ☑ Followed guidance for slide content and order

☑ Title and group members/advisor ☑ Problem statement ☑ Requirements Summary ▪ Specifications ▪ Constraints- Discuss how they affected design	☑ Revised block diagram ☑ Responsibility matrix ☑ Test results for each subsystem	☑ Revised Budget ☐ ~~Summary of the schedule~~ ☑ Social, Political, Economic Implications ☑ Conclusions/Questions

- ☑ Presentation appearance
  - Correct grammar and spelling
  - Consistent font
  - Consistent background
  - Legible text

Presentation style (15 pts):

- ☑ Used appropriate language CONFUSING PROTOCOLS (RS-232) WITH CONNECTOR TYPE (DB-9, RJ-11)
- ☑ Did not display distracting mannerisms from either the presenter or the other team members not currently presenting
- ☑ Used a pointer properly – did not point across body, didn't hit the screen, didn't wave, swing, or play with pointer when not pointing to the screen
- ☑ Adhered to time limitation 1037 - 1055
- ☐ Had a person record instructor feedback and questions at end of briefing
- ☑ Appeared rehearsed – transitions were smooth.

Cadet	Constraints (50)	Testing (25)	Format (10)	Style (15)	Total (100)
KRICK	~~38~~ 40	21	10	14	~~83~~ 85
BRYAN	~~38~~ 40	21	10	14	~~83~~ 85

Evaluation Worksheet

OUTCOME: 8 INDICATOR: 1 COURSE: EE402 – Electronic System Design II

DEFINITION: Incorporate understanding and knowledge of societal, global and other contemporary issues in the development of engineering solutions that meet realistic constraints.

EVENT: Critical Design Review (Technical Oral Presentation)
FOCUS: "Development of engineering solutions that meet realistic constraints." Assessment of societal, global and other contemporary issues will be conducted by a review of the project final written reports.

RUBRIC: 1(Weak) to 5 (Strong)

Evaluator: Korpela

Project: WebBot

Please indicate the appropriate level for each EE cadet on your design project team:

Cadet	1 Weak	2	3	4	5 Strong	Comments
Bryan			X			Test plan and results not very detailed. Lacking specifications
Krick			X			in briefing. Lacking analysis, moderate consideration of constraints.

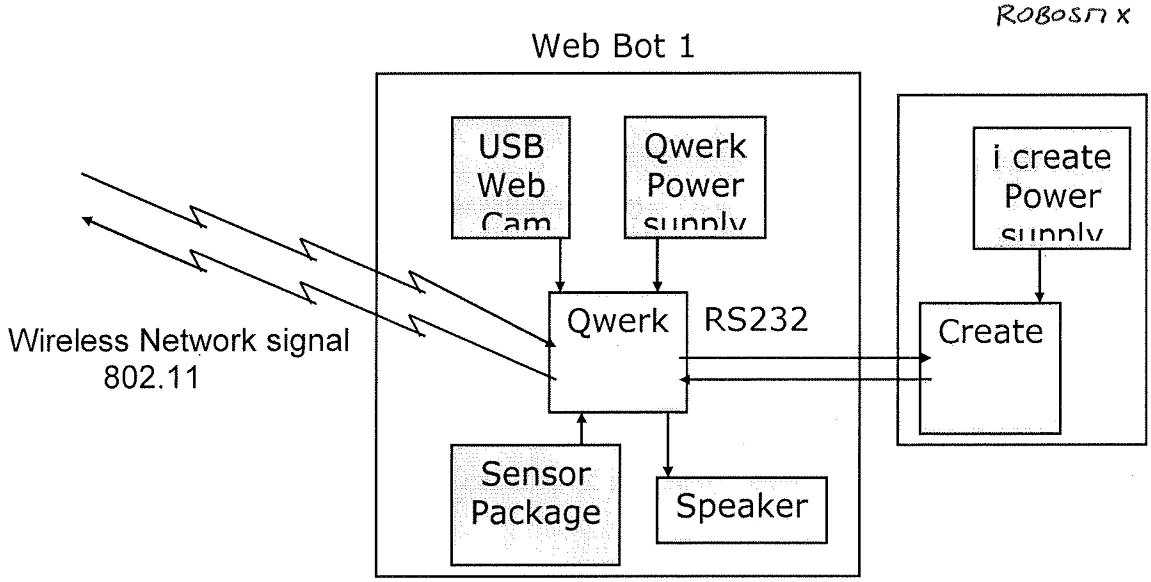
Web Bot Project

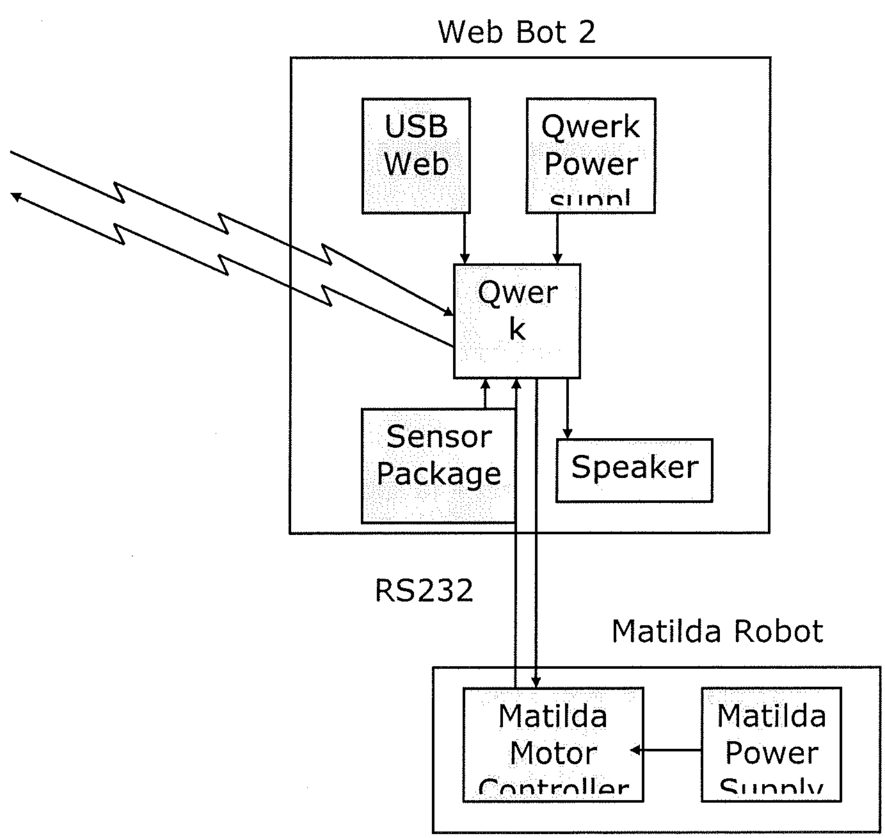
CDT Joseph Krick CDT Patrick Bryan

Subsystem Design Demo

NEEDS TO BE REVISED

PLATFORM NOW HAS A ROBOSTIX ALSO





EE402 Subsystem Demonstration

OUTCOME: 4

COURSE: EE402 – Electronic System Design II

DEFINITION: Design and conduct experiments to collect, analyze, and interpret data with modern engineering tools and techniques.

EVENT: Sub-System Demo

RUBRIC: 1(Weak) to 5 (Strong)

Evaluator: Korpela

Project: Webbot

Please indicate the appropriate level for each EE cadet on your design project team:

Cadet	**1 Weak**	**2**	**3**	**4**	**5 Strong**	**Comments (Subsystem Demonstrated)**
Bryan			X			Little comparision between specifications and
Krick			X			measurements

Subsystems in Project — Demonstrated?

1. Pan-tilt video — Y
2. Create movement — N
3. Movement Matilda — Y
4. PING Sensor — Y
5. IR Sensor — Y

EE 402 – Electronic System Design I

Peer and Self Assessment

NAME Bryan, Patrick　　　　Project: WebBot

Instructions:

Step 1: Multiply the number of team members by ten: 10 x 4 = 40

Step 2: Allocate the total number of points computed above among team members, including yourself, based on [illegible] contributions to the [illegible] during the rating period. All aspects of the project should be considered ([illegible], planning, administration, writing, leadership, attitude, initiative, etc.)

YOU	I need to develop my communication with CS team to better understand the workings of the GUI and Server integration	10
Krick, Joseph	CDT Krick needs to develop his understanding of microcontrollers.	10
Lobdell, Scott	CDT Lobdell needs to improve communication and work on integration.	10
Smith, Ben	CDT Smith need to improve Communication.	10

TOTAL 40

EE 402 – Electronic System Design II

Peer and Self Assessment

NAME Krick, Joseph   Project: Webbot

Instructions:

Step 1: Multiply the number of team members by ten: 10 x 4 = 40

Step 2: Allocate the total number of points computed above among team members, including yourself, based on effort and contributions to the project during the rating period. All aspects of the project should be considered (technical work, planning, administration, writing, leadership, attitude, initiative, etc.)

ALLOCATE POINTS TO ALL TEAM MEMBERS, BEGIN WITH YOURSELF.

Team Member	Observations	Points Allocated
YOU	Designed matilda sensor platform, tested power supply setup	~~10~~ 11
Bryan, Patrick	– Set up sensor tests waiting on him to integrate sensors with Robo stick	~~8~~ 9
Lobdel, Scott	Working on setting up the server	10
Smith, Ben	Works with scott on setting up the server need to improve communication between [illegible]	10

TOTAL 38

Assessing the EE Program Outcome Assessment Process

Abstract

Program outcome assessment is an integral part of systematic curriculum review and improvement. Accrediting commissions expect each student to achieve program outcomes by the time of graduation. Programs undergoing accreditation must have an assessment process that demonstrates program outcome achievement. Documenting and assessing just how graduates are meeting program outcomes can become a tedious and data intensive process. We report on our "assessment" of our assessment process that resulted in more streamlined procedures by targeting performance indicators. Our methodology included the development of a learn, practice and demonstrate model for each outcome that focuses performance indicators at the appropriate point in development. We target actual outcome achievement during the "demonstrate" phase with rubrics to detail the level of mastery on a modified Likert scale.

We originally used seventy-eight embedded performance indicators spread throughout the curriculum. We reduced to thirty indicators using a mixture of internal and external measures such as individual classroom events and fundamentals of engineering exam topical area results. We also emplaced guidelines targeting a single outcome measurement per indicator. For example, in our capstone senior design course, virtually every assignment was being reviewed by one of our outcome monitors. By targeting performance indicators at specific sub-events and looking at those which had to be assessed during the course versus indicators assessed by advisors or senior faculty, we were able to reduce the embedded performance indicators by a factor of three. We applied similar techniques to reduce individual course director workload. We have found that by streamlining the outcome process and using a rubric approach applied across multiple outcomes, we can greatly reduce the number of performance indicators yet preserve our ability to accurately assess our program. Reduced workload assessing the program has enabled us to place more effort into improving the program.

I. Introduction

Documenting, assessing and evaluating program outcome achievement can be a tedious and data intensive process. (Note that we use the term "assess" to mean the identification and collection of data and "evaluate" to mean interpretation of data. These definitions are consistent with those used by ABET[1]). At the United States Military Academy in West Point, NY, we recently reviewed our program assessment process to determine a more efficient way of assessing and evaluating outcome achievement without sacrificing the quality of the evaluation. Our program created outcomes and an outcome assessment process in 2000, just as the ABET EC2000 criteria were published. We were one of the early programs to be accredited under the new standards. After several years assessing under the new system, we were concerned about the time and effort our faculty spent in the outcome assessment and evaluation process. We convened a panel of senior faculty to review our assessment process and were able to reduce overhead and increase efficiency in two areas: outcomes and embedded indicators. We revised our nine program outcomes to more directly map to ABET Criterion 3: a-k while still meeting Criterion 5 and supporting our program objectives. By carefully examining how we chose embedded indicators, we reduced the number of embedded indicators used to assess each outcome, reduced the number of outcomes that observe any given course, and standardized the rubrics used to examine each embedded indicator. We reduced the faculty time assessing thereby increasing faculty buy-in, without sacrificing the quality of the assement or evaluation.

Sophomore Fall Semester	Sophomore Spr. Semester	Junior Fall Semester	Junior Spr. Semester	Senior Fall Semester	Senior Spr. Semester
MA205 Calculus 2	EE 360 Dig. Logic	EE 302 Intro. to EE	EE 362 Intro. Elec.	EE 462 Elec. Dsgn	EE400 EE Seminar
SS201 Econ	MA 364 Engr. Math	EE 381 Sig & Sys	EE 383 EMAG	EE 401 EE Sys Dsgn. I	EE 402 EE Sys Dsgn II
PH201 Physics	PH202 Physics 2	EE375 Comp Arch	EE Depth	EE Depth	EE Depth
LX203 Lang	LX204 Lang 2	ME 311 Therm-Fluid	CE 302 Stat & Dyn	EE 377 Power	Elective
PY201 Philosophy	EV203 Terr Anal	MA206 Prob & Stat	PL300 Leadership	HI301 Mil. Art	HI302 Mil. Art
	SS202 Amer. Pol.	EN302 Adv.Comp.	SS307 Intn'l Rel		LW403 Law

Core	EE Core	Elective	Engineering Breadth

Six Depth Options

Robotics

- EE 487 Micro Proc
- XE 472 Controls
- XE 475 Mechatron

Communications

- EE 477 Comm Sys
- EE 478 Dig Comm.
- EE 482 Wireless **or** EE 483 Photonics

Information Assurance

- CS 301 Fund
- EE 478 Dig Comm.
- IT 382 Net Sys
- CS 482 Info. Ass.

Computer Architecture

- CS 301 Fund CS
- EE 487 Micro Proc
- EE 484 Adv Arch

Electronics

- EE 486 Solid State
- EE 483 Photonics
- EE 482 Wireless

Figure 1: Electrical Engineering Curriculum

The remainder of this paper is organized into four sections: Section II provides an overview of the Electrical Engineering program at our university. This provides context for understanding the former and current assessment processes. Section III describes the former outcome assessment process and highlights opportunities we found for increasing efficiency. Section IV describes our current assessment process summarizing the systematic review, what aspects were changed, and why they were changed. Section V presents our conclusions as we finish our first year using the new process.

II. Overview of the Electrical Engineering Program

West Point is a medium-sized academic institution with 4000 undergraduate students. Every student takes a core curriculum of 26 courses in a four year bachelor's degree program. All Electrical Engineering (EE) majors study a common core of EE subjects to include digital logic, circuit analysis, computer architecture, signals and systems, electronics and electromagnetics as illustrated in Figure 1. There are twelve core EE courses including a year-long senior design project. EE majors also select an engineering depth sequence (three or four courses) in the area of robotics, communications, computer architecture, information assurance, or electronics. For interdisciplinary exposure, EE majors take two courses covering thermodynamics, statics, dynamics and fluids. Finally, they have one elective drawn from a selection of courses within the department.

III. The Former EE Program Assessment Process

Our program uses a multi-tiered assessment process that operates on two different time cycles, as shown in Figure 2. Every semester, the course director for each course assesses student performance and whether or not the course met its objectives. The course director prepares a course summary which he or she reviews with his or her thread director and program director. The thread director is a senior faculty member who oversees a collection of related courses that typically share a pre-requisite structure. The thread director provides continuity among the courses and analyzes proposed changes in terms of impacts on other courses in the thread. Once any changes proposed in the course summary have been reviewed, the program director approves the course summary and it becomes a historical record of the conduct of the course. When the course is taught next, the incoming course director reviews the previous course summary and prepares a course proposal that incorporates approved changes to the course and may propose new changes. The course proposal is reviewed and approved by the thread and program directors and completing the per-semester course review process.

The second process is outcome assessment which occurs annually. Our program uses nine outcomes, shown in Table 1, that are tailored to the needs of our constituents and support our program objectives and ABET Criterion 3: a-k. Each outcome has a faculty member assigned to monitor our graduates’ achievement of that outcome. The "outcome monitors" are responsible for the annual outcome assessment. The monitor analyzes the courses in the curriculum and determines which courses and events best support the program outcome. The faculty member then gathers, collates and analyzes data from the relevant courses. At the end of the academic year, the entire faculty convenes at an offsite conference where each outcome monitor presents the evaluation of his or her assessment. The faculty discusses the evaluations;

determine areas of concern or areas needing improvement, and with the consent of Electrical Engineering program director, set priorities and strategies for improvement. In addition to our faculty review, the program director briefs the Dean of the Academic Board annually on the state of the program.

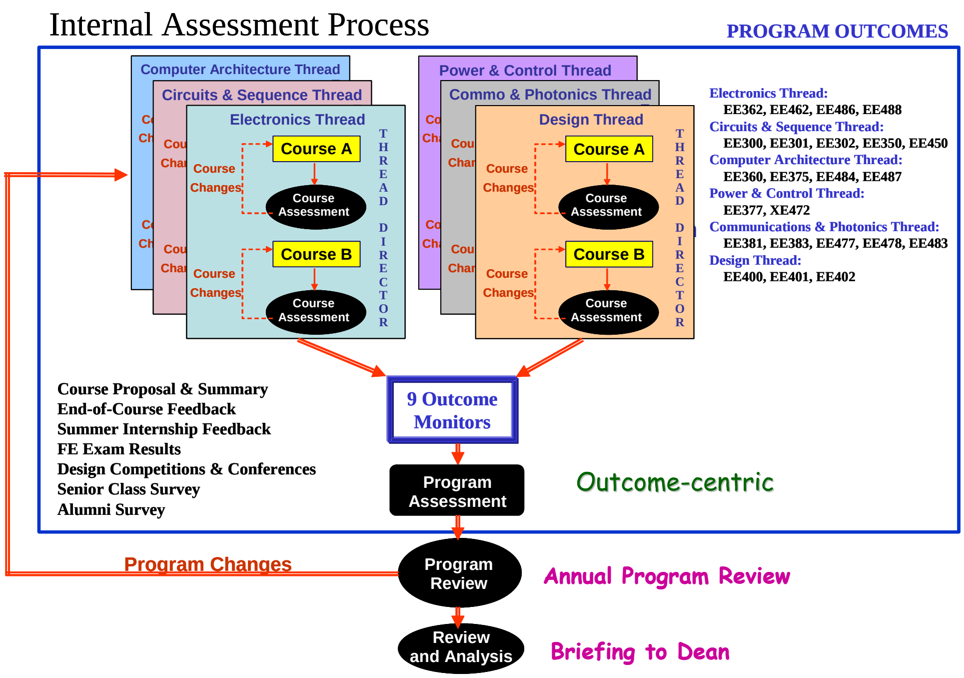


Figure 2: Overview of EE Program Assessment Process

Since our program outcomes are different from ABET Criterion 3: a-k, we devised a mapping or crosswalk between our outcomes and the supported ABET Criterion 3: a-k as shown in Table 1. When the outcomes were revised in 2000, our intent was to formulate outcomes that supported our objectives while also covering all aspects of ABET Criterion 3: a-k. We did not have an annual outcome assessment program formalized and ease of assessment was not a consideration when formulating the outcomes.[2] The resultant many-to-many mapping among our program outcomes and ABET Criterion 3: a-k increased the complexity of our outcome assessment process.

In order to assess an outcome, monitors determined which set of embedded indicators to use. Table 2 shows the set of embedded indicators assessed by the various outcome monitors. Since we did not have a holistic approach, some courses bore a much heavier assessment burden than others. For example, nearly every graded event in our capstone design courses, Electronic Design I & II, was assessed and the design reviews were assessed by six different outcome monitors! Additionally, any time a course director wanted to change a course he or she would need to consult with several outcome monitors to ensure that the changes did not have a detrimental affect on the outcome assessment process, or at least ensure that the outcome monitor took the changes into consideration. This unduly constrained the course director's ability to revise and improve his or her own courses in response to changes in technology, textbooks, or student performance or feedback.

		ABET Outcomes 3a-k										
Program Outcome to ABET A-K crosswalk Strong Support = 3 Moderate Support = 2 Weak Support=1 Former Electrical Engineering Program Outcomes		(a) an ability to apply knowledge of mathematics, science, and engineering	(b) an ability to design and conduct experiments, as well as to analyze and interpret data	(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	(d) an ability to function on multi-disciplinary teams	(e) an ability to identify, formulate, and solve engineering problems	(f) an understanding of professional and ethical responsibility	(g) an ability to communicate effectively	(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	(i) a recognition of the need for, and an ability to engage in life-long learning	(j) a knowledge of contemporary issues	(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
1	Apply knowledge of mathematics, probability and statistics, and the physical, computing and engineering sciences to the solution of theoretical, practical and applied problems.	3	1	1	1	3	1	1	1	1	1	1
2	Recognize problems that can be solved with electrical engineering techniques and those that either cannot be solved or require the skills and techniques of other disciplines.	2	1	1	1	3	1	1	1	1	1	1
3	Apply creativity, and information and computer technology, in addition to disciplinary knowledge, in solving engineering problems.	3	1	1	1	3	1	1	1	1	1	3
4	Design and conduct experiments and simulations; collect, analyze and interpret data; determine and predict the performance of devices, circuits and systems.	1	3	1	1	1	1	1	1	1	1	3
5	Communicate solutions to problems clearly, both orally and in writing.	1	1	1	1	1	1	3	1	1	1	1
6	Work as individuals and as members of diverse teams to design a device, circuit, component or system that meets desired needs or specifications.	2	1	3	3	1	1	1	1	1	1	1
7	Apply professional and ethical considerations to the development of engineering solutions.	1	1	1	1	1	3	1	1	1	1	1
8	Incorporate understanding of societal and global issues and knowledge of contemporary issues in the development of engineering solutions.	1	1	2	1	1	1	1	3	1	3	1
9	Demonstrate the ability to conduct independent inquiry and learning as well as recognition of the need to continue doing so over a career in the military and beyond.	2	1	1	1	1	1	1	1	3	1	1

Table 1: EE Program Outcome to ABET Criterion 3: a-k Crosswalk

	Embedded Indicators								
	Simplified Program Outcomes								
	1	2	3	4	5	6	7	8	9
Courses	Math, science, engineering skills	Identify, formulate and solve problems	Computer and information technology	Design and conduct experiments	Oral and written communicati on	Work in teams to solve problems	Professional and ethical considerations	Societal, global, contemporary issues in developing solutions	Life-long learning
Digital Logic	Examinations Labs, Design Project		Design Project, VHDL labs	Design Project, VHDL	Design Project	Final Project		Lab 3	
Circuits I (Intro to EE)	Examinations Quizzes, Labs, Final Exam								
Signals & Systems	Examinations Design Proj, Final Exam		MATLAB project						
Computer Architecture			VHDL labs and project	VHDL labs and project					
Circuits II (Intro. Elec.)	Examinations Labs, Design Project		Design Proj, IC-CAP, MATLAB, PSpice	Design Project, IC-CAP, PSpice	Final Project	Final Project			
E&M Fields	Examinations Design Project, Final Exam								
Electronic Design	Quizzes 1-4, Labs, Design Project		Design Project, PSpice	Mini-Labs	Final Project	Final Project			
EE Sys Design I		Design Project	Design Proj, MS Project, MATLAB, PSpice	Design Project	Design Review	Final Project, Prelim. Design Review	Ethics Quizzes	Ethics Quizzes	Design Project
EE Sys Design II		Design Project	Design Project	Design Project, CDR, Lab Notebooks	Design Review, Poster Reports	Final Report, Critical and Final Design Reviews			Design Project
EE Seminar							Ethics Quizzes	Ethics Quizzes, Paper	
Solid State Electronics	Examinations Final Exam		MAGIC						

Table 2: Initial Course-Outcome Matrix

		ABET Outcomes 3a-k										
Program Outcome to ABET A-K crosswalk Strong Support = X Revised Electrical Engineering Program Outcomes		(a) an ability to apply knowledge of mathematics, science, and engineering	(b) an ability to design and conduct experiments, as well as to analyze and interpret data	(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	(d) an ability to function on multi-disciplinary teams	(e) an ability to identify, formulate, and solve engineering problems	(f) an understanding of professional and ethical responsibility	(g) an ability to communicate effectively	(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	(i) a recognition of the need for, and an ability to engage in life-long learning	(j) a knowledge of contemporary issues	(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
1	Apply knowledge of mathematics, probability, statistics, physical science, engineering, and computer science to the solution of problems	X										
2	Identify, formulate, and solve electrical engineering problems					X						
3	Apply techniques, simulations, information and computing technology, and disciplinary knowledge in solving engineering problems											X
4	Design and conduct experiments to collect, analyze, and interpret data with modern engineering tools and techniques		X									X
5	Communicate solutions clearly, both orally and in writing							X				
6	Work individually or in diverse teams				X							
7	Apply professional and ethical considerations to engineering problems.						X					
8	Incorporate understanding and knowledge of societal, global and other contemporary issues in the development of engineering solutions that meet realistic constraints			X					X		X	
9	Demonstrate the ability to learn on their own									X		

Table 3: Revised EE Program Outcome to ABET Criterion 3: a-k Crosswalk

Simplified Program Outcomes		Embedded Indicators: Courses								External Indicators		
		Computer Architecture	Signals & Systems	EM Fields	Intro to Electronics	Elec. Design	EE. Sys Design I	EE Sys Design II	EE Seminar	FE	Alumni Survey	Other Metrics
1	Math, Science, Engineering skills		Final Exam	Final Exam						Math, Chemistry		
2	Identify, formulate and solve problems				Design Project		Preliminary Design Review			Circuits		
3	Computer and information technology	VHDL Design				Design Project	MS Project Mini-Lab			Computers		
4	Design and conduct experiments					Oscillator Lab		Sub-Systems Demo & Lab Notebook		Instrument-ation		
5	Communication							Project's Day (Oral) & Final Rpt (written)				NCUR Papers/ Synopsis
6	Work on Teams						Peer Evals	Advisor Assessment of performance				
7	Professional and ethical considerations								Ethics Quizzes and Final Paper	Ethics		
8	Incorporate societal, global, contemporary issues and realistic constraints into engineering solutions							Critical Design Review & Final Report		Economic Analysis		
9	Life-long learning							Final Design Review			Continual Learning Questions	Summer Internship Briefing

Table 4: Revised Outcome-Indicator Matrix

Finally, each outcome monitor designed his or her own rubrics to assess outcome achievement. There was no standardization among rubrics, even between outcomes that were assessing similar aspects of ABET Criterion 3: a-k. A course director whose graded events were assessed by several outcomes was burdened with several sets of rubrics in different formats. As faculty came and left, each outcome monitor had to learn who had which course and provide him or her with a new set of rubrics. Conversely, each new course director needed to know which outcome monitors to give which documents at the end of the semester or academic year. As outcome monitors changed, the new monitor might revise the rubric or institute a new rubric, which must then be promulgated and embraced by the supporting course directors. This system, while successful, required a large investment of time by senior faculty members to ensure the necessary communication was taking place.

IV. The Current EE Program Assessment Process

After a few years of assessing our program under the original model, we realized that it was too cumbersome. We observed that our program outcomes overlapped with multiple ABET Criterion 3: a-k resulting in duplication of assessment. We had embedded indicators at all points along a student's development path rather than assessing achievement only when students demonstrate mastery of the concepts. Some courses were assessed by several outcome monitors, putting a high burden on those course directors to provide assessment data to all the outcome monitors. We didn't have a consistent approach to using embedded indicators and needed a set of rubrics understandable by all faculty with general guidelines to minimize impact on any single faculty member or course. These results were entirely consistent with nine individual faculty members developing their own outcome measurement strategy and we realized that we needed to simplify our procedures. In spring 2006, we formed a small panel of senior faculty to review our assessment process. A summary of the guidelines we developed to structure the review process are listed in Table 5 with discussion in the following section. The goal of the new assessment model was to keep the best features of the old program, reduce faculty workload, reduce overlap and reach a greater level of consistency. From the original assessment model, we kept the assessment of individual outcomes by faculty members, annual outcome briefings and review by the entire faculty and annual guidance set by the program director.

A. Outcomes:
   (1) Match to ABET Criterion 3: a-k, Criterion 5: the professional component, and program objectives.
   (2) Keep lines to ABET Criterion 3: a-k well delineated and not duplicated.

B. Embedded Indicators
   (1) Develop rubrics assigning a level of mastery.
   (2) Use a modified Likert scale (1-5) with 3 as the minimum successful achievement level.
   (3) For numeric results (grades), define an average score for minimum successful achievement level.
   (4) Reduce embedded indicators at early stages of student development.
   (5) Only assess one outcome per embedded indicator event.
   (6) As much as possible, choose indicators that all students complete.
   (7) Keep embedded indicators for a single outcome within the same class year.
   (8) Share the embedded indicator assessment across the faculty where practicable.
   (9) Carefully use external indicators (e.g. FE results) by crafting reasonable achievement levels.

Table 5: Summary of General Assessment Guidelines

Our original program outcomes in Table 1 were not created with ABET assessment strictly in mind. They evolved from the ABET Criterion 3: a-k, the ABET Criterion 5: the professional component, and our program objectives derived from department, university, and constituent goals. Five outcomes moderately or strongly supported ABET Criterion 3a alone, as shown in Table 1. As a result, five outcome monitors were evaluating the same ABET Criterion 3: a-k as part of their assessment. There were also redundancies in Criteria 3c, 3e and 3k. Taken across the program as a whole, the duplicative effort offered little advantage. Our first action was to modify our outcomes and streamline their alignment with the ABET Criterion 3:a-k while still supporting our program objectives. Our revised outcomes are depicted in Table 3 and were validated by our advisory board. Our next step was to specify which outcome strongly supported a particular ABET Criterion 3: a-k and eliminate any weak or moderate support to provide guidance to the faculty. The results are shown in Table 3 which eliminates the previous ambiguity amongst program outcomes and ABET Criterion 3: a-k, thereby alleviating outcome monitors from duplicating effort. The only remaining overlap was on Criterion 3k: modern engineering tools. In this instance, we divided the assessment between computer and information technology used for simulation (Outcome 3) versus laboratory software used for data collection (Outcome 4). Our former approach was perfectly valid; however, it made our own assessment and the task of the external ABET evaluator more difficult. Many programs have adopted the ABET Criterion 3: a-k verbatim as their program outcomes eliminating the problem entirely.

After revising our outcomes, the panel examined how we chose embedded indicators to assess those outcomes. Our original process contained embedded indicators at every point throughout the curriculum as shown in Table 2. The original intent was to check an outcome early enough to enable corrective action in subsequent courses. The difficulty arises in how to collate data that spans multiple graduating classes and weight it appropriately to make a collective assessment. If one purpose of assessment is to show student outcome achievement upon graduation, then assessment early in their development may not be a meaningful measure. Multi-year data presents a two-fold problem: either mixing separate academic years in a single outcome assessment or storing the data for later assessment by graduating class year. Most programs use the former approach. We chose to keep indicators within the same academic year if possible to alleviate the cross class challenge.

We adopted a “learn, practice, demonstrate” model with outcome assessment occurring during the demonstrate phase. Our revised set of embedded indicators is shown in Table 4. For example, Outcome 4 involves the design and conduct of experiments to collect, analyze, and interpret data with modern engineering tools and techniques. Students “learn” how to conduct experiments beginning with chemistry and physics courses. Students have their first EE lab experiences with highly scripted labs in Digital Logic and Circuits I. As students progress through the program and enter the practice phase, lab experiences are progressively less scripted. The experimental experience culminates during the senior design project where students must design their own experiments and document the results. This is the logical place to assess student outcome achievement. For Outcome 4, the indicators used during senior year are an Oscillator laboratory exercise in the Electronics Design course, the sub-system demonstration and laboratory notebook review in the capstone design course (EE Systems Design II) and FE results from the instrumentation portion. This does not preclude or diminish benchmarking of student achievement as they progress through the curriculum. At the program director level, our course proposal and thread director methodology provides the necessary oversight. It is included as part of our annual outcome assessment briefing where we discuss strengths and weaknesses of students by class year as they pertain to each outcome with actionable items as the result.

The faculty panel then examined the embedded indicators themselves. In general, direct measures of outcome achievement provide the preferred solution as ABET considers course grades and survey data insufficient by themselves. Our first challenge was to provide a basis for comparison across different events. For example, how do you compare achievement in a critical design review to the final exam in another course? We adopted a rubric approach for each embedded indicator on a modified Likert scale from 1 to 5 with 3 as the minimum level of successful achievement. An example rubric is shown in Table 6 for assessing the oral component of Outcome 5, "Communicate effectively, both orally and in writing." At the end of the semester, every senior design project team assembles a project board, display, and demo in a tradeshow format held in a large auditorium. An outside panel of judges conducts a design competition while the entire event is open to the public with other students, secondary schools, and the community attending. Unbeknownst to the students, we use two junior faculty to visit each booth, hear the briefing, and assess the students performance using the rubric in Table 6. For graded events, we looked at average course QPAs, student achievement levels, and generally used a “B” as the minimum achievement level which translates to “3” on the modified Likert scale. The result is a simple method to average Likert scores among embedded indicators with a numeric result that is consistent across all outcomes. An additional benefit is easier correlation of measured outcomes values to other instruments such as student and alumni surveys which also use a 5-element modified Likert scale at our university.

Next, the faculty panel emplaced guidelines allowing only a single outcome to be measured per embedded indicator to keep the overhead on any particular course director minimal. In our capstone senior design course, virtually every assignment was being reviewed by each of our outcome monitors. The senior design project course director was collecting outcome achievement data on nearly every event for nearly every outcome. We eliminated duplicate outcome measures on the same event unless measurement could be deferred until the end of the semester as with design project reports or lab notebook reviews. To minimize workload, we assigned embedded indicator assessment across the faculty where feasible. An example of this is in our Outcome 6, "Work effectively on a diverse team." In Table 4, we show that in the EE Design II course (the second semester of our year-long senior project course), we have "advisor assessment of performance". In this course, each student team is assigned a faculty advisor. We fence our entire faculty’s time during the two-hour block that the course meets, enabling close interaction with the project advisor. The faculty advisor serves in the same role as a senior engineer or distinguished member of the technical staff in industry. Part of the advisor’s role is to assess each individual’s ability to function on the team. Throughout the first and second semester, the advisor provides grades and feedback to the student on their performance and ability to function on the team. During the second semester, the advisor completes a standardized rubric-based grading sheet assessing the student’s ability to serve as a team member. Also shown in Table 4, we provide similar rubric-based grading sheets during the preliminary and critical design reviews for the advisors to assess the students’ achievement of Outcome 8, relating to societal, global, contemporary issues and designing within realistic constraints.

OUTCOME: 5 COURSE: EE402 – Electronic System Design II

DEFINITION: Communicate solutions clearly, both orally and in writing

EVENT: Project's Day (Technical Oral Presentation in booth format)

RUBRIC: 1(Weak) to 5 (Strong)

1. Inadequate communication. Major content is missing. Style and organization does not conform to professional standards. Even with repeated reading and/or explanation, ideas are unable to be conveyed.
2. Poor communication. Some content is missing. Style and organization hinders the conveyance of ideas. Requires repeated reading and/or explanation to clarify what is being communicated.
3. Moderately clear communication. May be missing minor content but the central ideas are conveyed. The organization presents ideas in a logical progression. Style may be awkward but does not mask the communication of ideas.
4. Clear communication with minor errors. No content deficiencies and a logical presentation of ideas. Style and organization may contain minor errors but does not hamper the communication of ideas.
5. Clear communication with no errors. No content deficiencies. Ideas are presented in a logical order. Style and organization meet professional standards and enhance the communication of ideas.

EXAMPLE: 1(Weak) to 5 (Strong)

1. Minimal explanation of the project objectives, methods and techniques used. Significant inaccuracies in the technical details. Does not give examples or applications of project. Ignores prototype and poster board in presenting the project. Unable to recognize the technical level/ interest level of the audience. Limited responsiveness to the audience. Presentation shows few, if any, signs of prior preparation and planning. Appears apprehensive or displays significantly less than ideal behavior.

2. Expected to explain the project objectives, some methods and techniques used to create the project, some what accurate in the technical details, may give examples or applications of project, limited use of the prototype and poster board in presenting the project. Limited ability to recognize the technical level/ interest level of the audience. Limited interaction with the audience. Presentation shows few signs of prior preparation and planning. May appear apprehensive or display less than ideal behavior.

3. Expected to explain the project objectives, most methods and techniques used to create the project, mostly accurate in the technical details, give examples or applications of project, makes use of the prototype and poster board in presenting the project. Some ability to recognize and react to the technical level/ interest level of the audience. Interact and field questions from the audience. Presentation should show signs of prior preparation and planning. Displays confidence and professional demeanor.

4. Expected to explain the project objectives, all methods and techniques used to create the project, minor inaccuracy in the technical details, give examples or applications of project and tie technical specifications to demonstrated results, make use of prototype and poster board in presenting the project. Able to recognize and react to the technical level/ interest level of the audience. Interact and field questions from the audience. Presentation shows sign of prior preparation and planning. Displays confidence and professional demeanor.

5. Clear and accurate articulation of all aspects of project. (technical details, applications, demonstrated results, conclusion, future efforts, etc.). Seamless use of audio, visual, and kinesthetic aids. Highly confident and professional demeanor. Presentation highly tuned to audience.

Please circle appropriate level for each project:

Project	**1 Weak**	**2**	**3**	**4**	**5 Strong**

Table 6: Example Rubric for Assessing Oral Communication

Finally, the faculty panel reviewed how we incorporated external indicators into our assessment process. External indicators, such as Fundamentals of Engineering (FE) exam, are another useful source of feedback. All our majors are required to take the FE exam during their senior year and the program directs the students to take the EE specific afternoon portion. The testing fee is funded through the Dean's office for all ABET majors. The following fall we get program specific feedback in terms of the overall pass rate and percentage correct rate for various subject areas: ethics, computers, math, chemistry, circuits, etc. Faculty are still required to assess the results. The FE results present unique challenges since fewer than two percent of all undergrads take the exam (often the above average students) and the population includes both undergrad and graduate students, whereas all our students take the FE exam during the Spring semester of their senior year. Our assessment began in defining reasonable rubrics. For example, our students are embedded in a moral ethical environment and are required to take courses in philosophy, leadership, and psychology. As a result they receive more professional and ethical training than the average EE undergrad. We expect that our students should meet or exceed the national average in the ethics portion of the FE and set our minimum level at that point. For the other areas of the curriculum, we set our minimum success level to within one standard deviation of the national average. Although we would like a one hundred percent pass rate for the FE exam that is not a realistic criterion for successful achievement of any outcome.

After several months of study, the senior faculty panel completed the review process and briefed the program director, who approved the changes they recommended. These changes were then presented to the entire faculty, with additional instructions for the outcome monitors. The changes to both the outcomes and the assessment process has resulted in reduced overhead, less time spent assessing and evaluating the program, and increased faculty buy-in, without reducing the quality of the assessment or evaluation.

V. Conclusions

Continuous assessment and curriculum development is the sign of a healthy, mature program. However, assessment can take on a life of its own if not managed. Our initial forays using a free-market approach led to duplication of faculty effort and a cumbersome process. A critical review of our outcome assessment model revealed several inefficiencies. Taking a holistic view of the assessment process, we were able to craft a series of recommendations to effectively reduce faculty time and synchronize efforts across the program. Part of our initial challenge lie in the program outcomes and their relationship to ABET Criterion 3: a-k and Criterion 5: the professional component. By slightly revising our outcomes and providing clear guidance on which Criterion they supported, faculty could target effort on appropriate embedded indicators.

Our methodology included the development of a learn, practice and demonstrate model for each outcome that focused performance indicators at the demonstrate phase of development. We developed rubrics assigning a level of mastery for each indicator with examples based on a modified Likert scale with 3 as the minimum successful achievement level. A secondary output was a set of guidelines for using embedded indicators. We reduced embedded indicators at early stages of student development, chose indicators that all students complete, and tried to keep embedded indicators for a single outcome within the same class year. To minimize course director burden, we restricted outcome assessment to one outcome indicator per event and shared the embedded indicator assessment across the faculty where practicable. Finally, we used external indicators such as the FE exam after careful consideration of reasonable achievement levels. We have found that by streamlining the outcome process and using a rubric approach applied across multiple outcomes, we can greatly reduce the number of performance indicators yet preserve our ability to accurately assess our program.

The views expressed are those of the authors and do not reflect the official policy or position of the U.S. Military Academy, the U.S. Department of the Army, the U.S. Department of Defense or the United States Government.

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ROBERT W. SADOWSKI is an Associate Professor and the Electrical Engineering Program Director in the Department of Electrical Engineering and Computer Science at the US Military Academy at West Point. He received the Ph.D. in Electrical Engineering from Stanford University in 1995 as a John and Fannie Hertz Foundation Fellow and is a Senior Member of the Institute of Electrical and Electronic Engineers.

LISA A. SHAY is an Assistant Professor in the Department of Electrical Engineering and Computer Science at the US Military Academy at West Point. She received the M.Sc. in Engineering from Cambridge University in 1996 as a Marshall Scholar, the Ph.D. in Electrical Engineering from Rensselaer Polytechnic Institute in 2002 and is a Senior Member of the Institute of Electrical and Electronic Engineers.

CHRISTOPHER M. KORPELA is an Instructor in the Department of Electrical Engineering and Computer Science at the US Military Academy at West Point. He received his M.S. in Electrical Engineering from the University of Colorado in 2006 and is a member of the Institute of Electrical and Electronic Engineers.