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Program Assessment: A Structured, Systematic, Sustainable Example for Civil Engineers*

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As the outcomes-based accreditation process has continued to evolve since its implementation six years ago, the standards for program assessment and continuous improvement are progressively being raised and many schools struggle with what is required. This paper offers an example of a structured, systematic, sustainable assessment program implemented by the civil engineering program at the United States Military Academy. The process is compatible with the university assessment process and has eight years of documented results. The assessment includes fast loop and slow loop cycles that accomplish very different things. Other features include standardized course assessments, embedded indicators, performance measures for all outcomes and objectives, advisory boards, feedback from all constituencies, faculty involvement, and closing of the feedback loop.

Keywords: course assessments; embedded indicators; performance measures; outcomes; objectives; advisory boards; constituencies; feedback loop

INTRODUCTION

ASSESSMENT AND CONTINUOUS IMPROVEMENT have become a major part of the accreditation process for engineering programs in the United States. ABET Inc., the accrediting agency for engineering programs, has established some guidelines and requirements for this assessment. The truly successful programs have embraced the philosophy that improvement comes only from introspection, examination, consultation with constituents, and then reasoned action based on the analysis and synthesis of the data received. A tremendous amount of work has been done over the last decade with respect to creating program outcomes and developing a credible assessment system that provides convincing evidence of outcome attainment without creating excessive administrative burden. The specific ABET guidance has changed over the years as more programs have received evaluations and individual programs have shared their good ideas. Some have taken a hierarchical approach where educational activities in the form of lesson and course objectives are linked to program outcomes and objectives [1]. Assessment systems have been built around student portfolios [2, 3] and multi-disciplinary design courses [4, 5]. Some programs have taken a longitudinal approach that tracks the progress of students from admission through graduation [6], while others have suggested incorporating the ABET criteria into the development of curricula [7]. Other studies focused on using multiple assessment measures in combination [8], while some suggest what can be accomplished with a new program where data are not available [9].

Each engineering program is unique and must therefore create an assessment program that incorporates the needs of its university and captures the strengths and areas for improvement of the curriculum, facilities, faculty, resources, and students that comprise the program. A program that cobbles together an assessment program solely for accreditation purposes will gain little from it and will experience significant frustration. Good assessment takes time and effort which are both precious resources, but to be sustainable over time, the process also has to be efficient. Although someone needs to lead the effort, the work can be effectively shared among various faculty members, which also leads to greater buy-in from the faculty at large.

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This paper shares the systematic assessment program that has been used by the civil engineering program at the United States Military Academy over the last eight years. The program is characterized by a process that builds on the university assessment system, a flexible slow loop assessment cycle, a highly structured fast loop cycle, an advisory board that has evolved over time, a course assessment process that collects data, which in turn rolls up into an annual program assessment, and almost a decade of documented results. For each outcome and objective, there are a series of performance measures and desired standards that are based on student performance, survey results, and instructor ratings. Based on the results, a rating is assigned each year and recommendations are made for the future. The follow-up reporting on those recommendations closes the feedback loop and starts a new cycle of assessment.

THE ASSESSMENT MODEL

The United States Military Academy has described its assessment process for the curriculum and instruction in its widely circulated publication, 'Educating Army Leaders for the 21st Century' [10]. The academic program goals are developed from the needs of the Army. Those goals are attained through articulating a learning model that includes the structure, process, and content of the desired learning experience; designing an appropriate curriculum; designing the individual courses that comprise the curriculum; and implementing the instruction. The university assessment system consists of four phases that are linked to the curriculum and instruction steps as shown in Fig. 1. The USMA Civil Engineering program has adopted the university model using the same four phases of assessing the learning model, program design, implementation, and outcomes for its program assessment. Because there is a requirement to develop program outcomes and objectives that meet the needs of program constituents, a phase 0 element was added to accommodate this.

The USMA CE program has adopted a two-loop cycle suggested by the ABET literature as shown in Fig 2. While ABET no longer uses the two-loop cycle, it remains a valuable means to separate the major program changes from the routine changes made on a year-to-year basis. The slow loop is completed every three years—immediately after an accreditation visit and at the mid-point between visits. This allows any major changes to be implemented and assessed prior to an accreditation visit. The slow loop encompasses phases 0, I, and part of II of the assessment model where changes to the objectives, outcomes, and learning model are made. Major revisions of the curriculum occur in the slow loop. The conduct of the slow loop assessment is totally flexible and the format is based on the issues that arise over a three year period.

The 2003 slow loop assessment [11] involved a zero-based, bottom up look at the CE curriculum caused by some changes in the institutional priorities. The process involved six teams, working independently and returning to a larger group, to iteratively devise a new curriculum. The result was the development of seven new courses in the civil and mechanical engineering programs and the largest curriculum change in two decades. Because this new curriculum was still being assessed as the new courses were developed and experiencing initial offerings, the 2006 slow loop assessment involved no major curriculum changes. The relevant issues were collected and addressed using GroupSystems [12] software to assemble input in an efficient manner. Decisions and program changes were made in subsequent faculty meetings and provided to the advisory board for input. The program outcomes and objectives were revised. Three new program outcomes were added in response to the American Society of Civil Engineers Policy 465, which has established a body of knowledge [13] for civil engineers and makes the

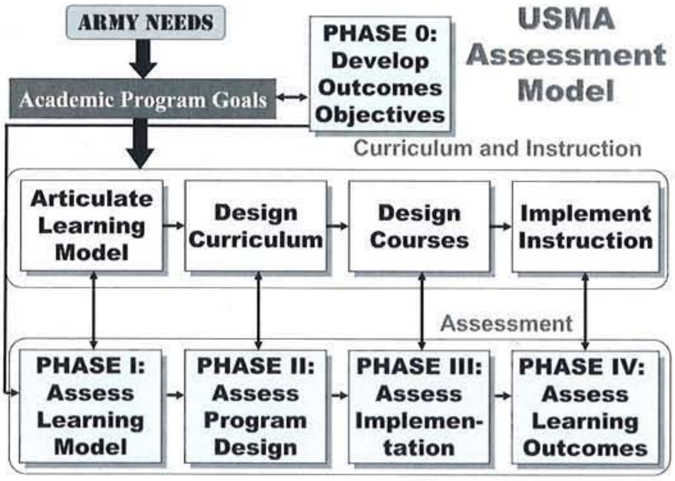


Fig. 1. The USMA assessment process [1] on which the USMA CE program assessment process is based.

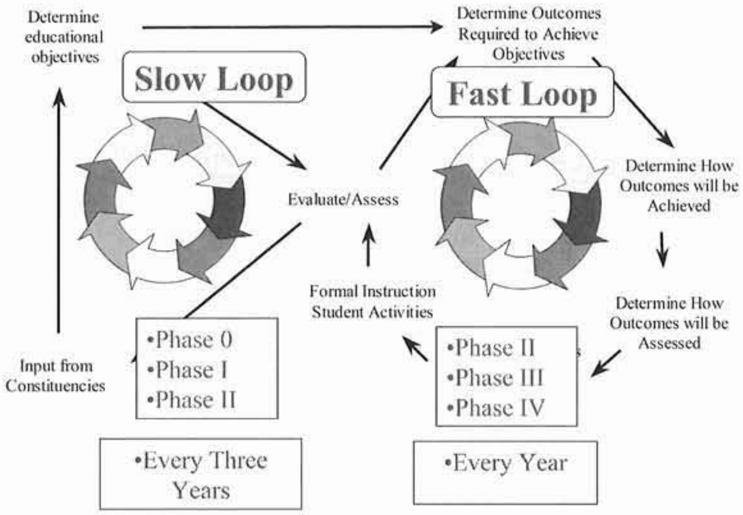


Fig. 2. The USMA CE program assessment process adopts the two loop process that appeared in early ABET literature.

master's degree or equivalent a requirement for professional licensure.

In contrast, the fast-loop assessment is conducted annually and follows a rigid, systematic format. The process, shown in Fig. 3, is sustainable because the data are collected in the same manner every year and minor changes are made based on the input from constituents. Annual input is collected at the program level in the form of student surveys, graduate surveys, fundamentals of engineering exam results, and advisory board minutes. The CE program conducts annual course assessments for every course in the curriculum. Because there is a consistent systematic format for the course assessment, data regarding student performance, course objectives, and instructor ratings can be collected and assembled. The fast loop assessment culminates in a formal program assessment briefing to the department head. The briefing covers minor changes to the curriculum resulting from the latest round of course assessments (Phase II from Fig. 1); implementation in terms of faculty performance, student performance and resources (Phase III); and the assessment of program objectives and outcomes (Phase IV). The most substantial portion of the briefing is the implementation. Student performance assessment includes the capstone project, independent study projects and competitions, summer intern experience, student chapter activities and student awards. The faculty is assessed based on qualifications, teaching ratings, professional society participation, service activities, scholarship, and support to the Army over the previous year. Recruitment of student and faculty statistics are analyzed in terms of enrollments, diversity, and quality. Resources are assessed based on facilities, budget, laboratories, computers, support staff, and external support. The briefing begins with the recommendations made at the previous program assessment along with a status report on their implementation. The briefing ends with the new recommendations based on the annual assessment. Progress on these new recommendations will become part of the next program assessment, which is how the feedback loop is closed. The program briefing is the record of the annual assessment and is the first document in the

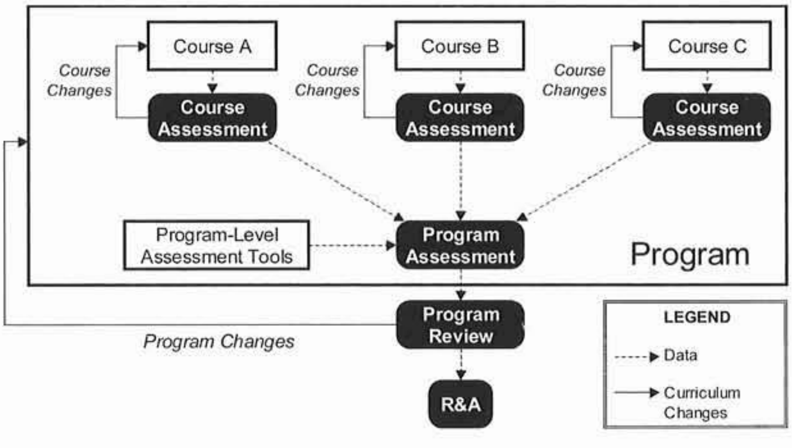


Fig. 3. The USMA CE fast loop process is a systematic annual assessment that is highly structured and relies heavily on input from program constituents and from the assessment of individual courses in the curriculum.

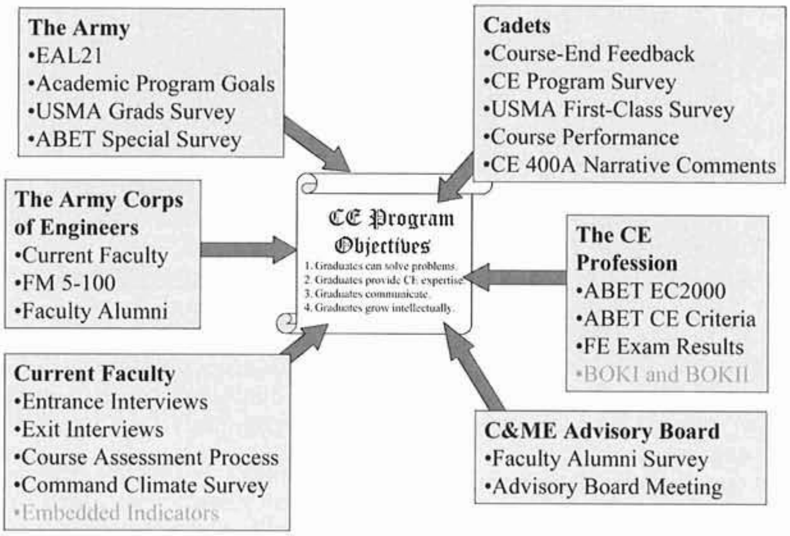


Fig. 4. The USMA CE program has identified its constituencies and solicits input from each using a variety of tools.

annual assessment notebook that contains all of the raw data used in the assessment. A summarized version of the results is provided to the Dean in the annual Review and Analysis briefing.

PROGRAM CONSTITUENCIES AND THEIR INPUT

The program constituents are the customers, the clients—those who the program is designed to serve. The USMA CE program has identified its constituents as the Army, the Corps of Engineers, the current faculty, the students, the graduates/alumni, and the civil engineering profession. The USMA CE program is one of the few programs that lists a specific branch of the Army (i.e., Corps of Engineers) as a constituent. The constituencies were involved in the development of program outcomes and objectives and continue to provide survey and advisory board input as to whether they need to be revised. Figure 4 shows these constituencies and the formal input that they provide. The CE program is able to take advantage of many institutional level surveys to collect data.

Because the Army is the industry into which each of the USMA graduates will enter upon graduation, the institution puts extensive thought into the needs of the Army. The Army needs leaders of character who possess ethics, leadership and team skills, versatility, communication skills, and dedication to lifelong learning and who understand technology, information systems, history, people and organizations and cultures [10]. The USMA academic program goals are directly based on these needs. Because the institution is so focused on this area, there is very little the CE program needs to do to discover the needs of the Army. USMA seeks input from Army leaders on the quality of its graduates through surveys sent to graduates and commanders of graduates for year groups several years after graduation. A special tri-annual institutional survey is sent to graduates directly in support of accreditation preparation. The programs provide input on what questions to ask. Data on graduates from the civil engineering program can be separated from the graduates at large. The data are the most useful tools available for assessing program objectives.

The program is more directly engaged in determining the needs of the Corps of Engineers, the branch of the Army that most graduates will choose. The doctrinal field manual *FM 5-100 Engineer Combat Operations* [14] is a major source of what graduates are expected to do, with particular emphasis on sustainment engineering. Because most faculty members are also Corps of Engineer officers, they provide feedback on behalf of both the faculty and the Corps of Engineers. Most faculty return to the field Army after teaching and their survey input is collected.

The current faculty provides input through a variety of means to include entrance surveys, exit interviews, an institution-wide command climate survey and input at various faculty meetings. Faculty members prepare the course assessments through which so much of the program data are collected. Student feedback is obtained in every course through web-based end of course surveys that evaluate the effectiveness of the course and their individual instructor. Some questions are common throughout the institution, which allows a comparison of performance across departments. The questions asked at the CE program level are directly correlated to a model that defines excellent teaching [15–17]. These data can be compared across courses and over time to assess the quality of teaching in the CE program. Students also complete exit surveys at both the program and institutional levels at the time of graduation. In addition, the students address the appropriateness of the program outcomes and objectives in a journal entry and survey administered in CE400, the civil engineering professional practice course.

The needs of the civil engineering profession are obtained through accreditation criteria. While the EAC provides the general criteria [18], the American Society of Civil Engineers (ASCE) write the program criteria [18, 19] that are specific to civil engineering programs. Most recently, additional input has been provided through the body of knowledge (BOK I and BOK II) efforts supported by ASCE committees [13]. Active faculty participation on professional society educational and technical committees provides input as well.

Finally, input is received through annual meetings of the CE advisory board which comprises members of various program constituencies. The advisory board has evolved significantly over the last six years. The initial advisory board consisted of department alumni who returned to West Point for a designated weekend, received an overview of the program and completed a survey form. The next iteration was a board of designated individuals that represented specific constituencies (faculty, students, and outside members that represented alumni, the Army, other institutions and the profession). The CE program director chaired the one day meeting, asked the board for input on specific issues, and recorded the comments in formalized minutes. Today the board consists of twelve very prominent outside representatives from industry, academia, and the Army. The board leader is a one of these members. After some preparatory work, the board meets annually for a day at West Point. They receive update briefings from the CE program director, interview students, interview faculty, meet in executive session and present their thoughts to the CE program leadership. A written report follows and the CE program director responds with written feedback to the report. As the board evolves, the quality of the input and the influence the board has with the rest of the institution has grown as well.

PROGRAM OBJECTIVES

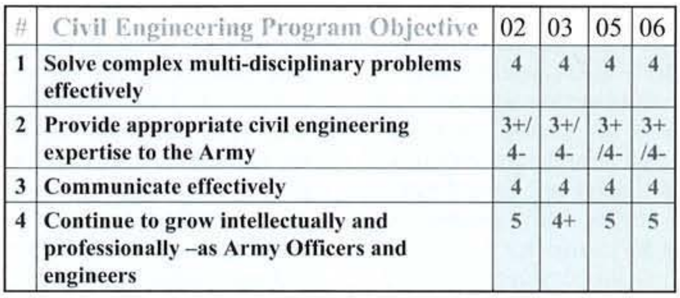
As defined by the accreditation criteria [18], program objectives are defined as 'broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve.' With considerable input from program constituents, the USMA CE program developed the following objectives:

1. As Army leaders, graduates solve complex, multi-disciplinary problems effectively, to include:
    - recognizing and fully defining the physical, technological, social, political, and economic aspects of a complex problem;
    - using a methodical process to solve the problem;
    - demonstrating creativity in the formulation of alternative solutions;
    - using appropriate techniques and tools to enhance the problem-solving process;
    - working effectively on teams; and
    - developing high-quality solutions that consider the technological, social, political, economic, and ethical dimensions of the problem.
2. Graduates provide appropriate civil engineering expertise to the Army, when called upon to do so.
3. Graduates communicate effectively.
4. Graduates continue to grow intellectually and professionally—as Army officers and as engineers.

The slow loop assessments are used to update and revise these objectives. Constituent surveys and advisory board meetings provide much of the input data. Changes to objectives must be made slowly as there is significant lag time between implementation and ability to assess the effect. The objectives were not changed in the 2003 slow loop and were modified slightly in 2006.

The process of ongoing evaluation of the extent to which these program objectives are being attained is accomplished through survey data assembled in the fast loop process. Direct measures of performance are much more difficult to obtain than for outcomes because the attainment occurs several years after graduation. Institutional surveys have been the best tool and have provided some excellent data on professional society participation, professional licensure and attainment of master's degrees on the parts of graduates. Since the institutional survey polls commanders as well as graduates, data are attained on graduate performance from their current employers. Based on the survey results, the program director provides an annual rating for each program objective on an annual basis with the results shown in Fig. 5.

A rating of 4 typically denotes successful accomplishment of the objective. Figure 5 shows that the performance for Objective 2 'Provide appropriate civil engineering expertise to the Army' has consistently rated a 3+/4- over a four year period. The program analyzed whether action needed to be taken to improve the rating. The faculty concluded that the CE graduates are Army officers first and civil engineers second. They will never work in a structural design shop and a third of them will not even choose the Corps of Engineers as a branch. Because the student's core curriculum is so broad-based, USMA students need to overload three out of their eight semesters to meet the minimum technical content for accreditation. This is a necessary trade-off and the USMA CE graduates may not reach a much higher level. To make changes that would increase their civil engineering expertise would cause a corresponding detriment in other areas.



#	Civil Engineering Program Objective	02	03	05	06
1	**Solve complex multi-disciplinary problems effectively**	4	4	4	4
2	**Provide appropriate civil engineering expertise to the Army**	3+/4-	3+/4-	3+/4-	3+/4-
3	**Communicate effectively**	4	4	4	4
4	**Continue to grow intellectually and professionally –as Army Officers and engineers**	5	4+	5	5

Fig. 5. Based on the survey results from graduates and their employers, an annual rating from 1 to 5 is given that evaluates the degree to which the CE program objectives are being attained.

PROGRAM OUTCOMES

Program outcomes are defined as 'statements that describe what students are expected to know and be able to do by the time of graduation.' [18] Each program is different and is expected to create outcomes that meet the needs of that specific program and enable the graduates to ultimately attain the program objectives. To ensure that certain standards are met within any program, the accreditation criteria 3(a–k) specify some minimum attainments that must be included within every program's outcomes. The current USMA CE program outcomes are:

1. Graduates design civil engineering components and systems.
2. Graduates demonstrate creativity, in the context of engineering problem-solving.
3. Graduates solve problems in the structural, construction management, hydraulic, and geotechnical discipline areas of civil engineering.
4. Graduates solve problems in mathematics through differential equations, calculus-based physics, and general chemistry.
5. Graduates design and conduct experiments, and analyze and interpret data.
6. Graduates function effectively on multidisciplinary teams.
7. Graduates describe the roles and responsibilities of civil engineers and analyze the issues they face in professional practice.
8. Graduates use modern engineering tools to solve problems.
9. Graduates write effectively.
10. Graduates speak effectively.
11. Graduates incorporate knowledge of contemporary issues into the solution of engineering problems.
12. Graduates draw upon a broad education necessary to anticipate the impact of engineering solutions in a global and societal context.
13. Graduates are prepared and motivated to pursue continued intellectual and professional growth—as Army officers and engineers.
14. Graduates explain the basic concepts of management.
15. Graduates explain the basic concepts of business and public policy.
16. Graduates are leaders of character.

The outcomes assessment process consisted of developing program outcomes, documenting input from constituencies, identifying where in the curriculum each outcome was addressed, creating performance measures and desired standards for each outcome, evaluating the student performance against these measures on an annual basis, and then making program decisions/changes based on these results. Because the program has control of its students through graduation, it is much easier to obtain good data on which to assess student attainment of outcomes than it is for objectives.

As with objectives, the slow loop process is used for revision of outcomes based on input from constituents. No changes to outcomes were made in 2003, but the 2006 slow loop resulted in some substantial changes. The ASCE Policy 465 and the creation of a body of knowledge for civil engineers created new requirements for the USMA CE program. These requirements currently appear in new civil engineering program criteria that have been approved by the Engineering Accreditation Commission and should take effect for programs evaluated in 2008 [20]. The addition of outcomes 14, 15, and 16 are directly attributable to this policy. Outcomes 14 and 15 are taken directly from the new program criteria and outcome 16 was modified to reflect the unique emphasis on leadership at the Military Academy. The latest supplement to the Body of Knowledge [21] used the cognitive levels associated with Bloom's taxonomy [22] to classify the desired attainment level in various outcomes. The USMA CE program outcomes were reworded to choose action verbs that more clearly define the cognitive level being sought. Several USMA CE faculty members are serving on ASCE Committee on Academic Prerequisites for Professional Practice sub-committees that are implementing this policy. The Curriculum sub-committee has formally assessed the current USMA CE curriculum with regard to compliance with the new body of knowledge [23, 24].

The course assessment process helps identify the contributions of various courses to the overall program outcomes. Figure 6 shows the results where course directors have submitted a rating of 1 (no contribution) to 5 (very large contribution) for each outcome. Those courses that provide a rating of 4 or 5 for a particular outcome become a good source for a direct measure of student performance. Similarly, the course notebooks in which samples of student work are assembled should include examples that support the outcome. If no course attains a rating of at least 3 for a particular outcome, a curriculum change to include the outcome may be in order.

The USMA CE program has developed performance measures for each outcome using the data that are collected on an annual basis in the fast loop process. The sources of data in order of priority from most to least credible are F. E. exam scores, outside agency evaluations, student performance on course requirements, survey data, instructor course assessment ratings and satisfactory course completion. The best data are results from the Fundamentals of Engineering Examination. The exam is administered nationally, is unbiased by faculty members, and almost every USMA CE major takes the exam. Performance data are provided in each of the subject areas covered on the exam and can be used to assess attainment of some program outcomes.

Outside visitors provide credible data because they do not hold the same bias as faculty. Experts from industry and professional practice are typically invited to the Academy on Projects Day to evaluate student capstone and independent study projects. The evaluators complete grade sheets that are tailored to correlate to program outcomes. The degree to which students communicate orally and in writing is certainly evaluated. It is an opportunity to attain direct measurement data on some of the more difficult to quantify outcomes such as creativity and understanding contemporary issues.

Many programs grapple with how to attain direct measures of student performance. Much of the accreditation literature [25–28] has indicated that survey data and course grades are useful but not sufficient to demonstrate attainment of outcomes. The next section of this paper specifically addresses how the USMA CE program uses embedded indicators to provide direct measures of performance. Surveys still provide useful data that can contribute to the overall assessment of a program outcome. USMA surveys all of the graduating seniors and the CE program conducts a more targeted survey. The questions typically require a Likert scale response that provides a numerical score that can be compared against other questions and to the same question from previous year groups. Often questions and their responses can be directly applicable to a specific outcome.

In the course assessment process, the faculty member is making judgments about the degree to which students attained the course objectives. When these course objectives can be tied directly to a program outcome, the instructor rating becomes another data point to consider in making an overall assessment. This is particularly useful in laboratory courses where some course objectives relate directly to outcome 5: design and conduct experiments. While course grades are considered a weak indicator, the data can be useful. Course grades as an assessment tool is much enhanced by the institutional policy prescribing the use of criterion-referenced grading. With norm-referenced grading, grades are a poor assessment measure, because there is no clear connection between the level of performance and the grade. With criterion-referenced grading, the connection is explicit. When a particular required course such as international relations, economic policy, or physics clearly correlates to a particular outcome, successful completion of that course is a

	Course											
Program Outcome	**CE300**	**CE364**	**CE371**	**CE380**	**CE400**	**CE404**	**CE460**	**CE471**	**CE483**	**CE491**	**CE492**	**Max Value**
Apply the engineering thought process to design CE components and systems	5	5	5	3	3	5	3	5	4	4	5	5
Creativity	3	2	4	2	4	4	5	4	4	2	5	5
Proficiency in structural engineering	4	4	3	1	2	5	3	4.5	5	5	5	5
Proficiency in environmental engineering	1	1	2	3	1	1	3	1	1	1	3	3
Proficiency in hydrology & hydraulic engineering	1	1	2	5	2	1	1	1	1	1	4	5
Proficiency in geotechnical engineering.	1	3	4	1	1	1	2	1	2	2	4	4
Proficiency in mathematics	4	5	3	4	1	3	3	3	4	4	4	5
Proficiency in calculus-based physics	4	3	2	2	1	2	1	3	3	3	1	4
Proficiency in general chemistry	1	1	2	1	1	1	1	1	2	1	1	2
Design and conduct experiments, analyze and interpret data in civil engineering discipline areas	4	4	4	1	1	3	2	2	5	1	2	5
Function on multidisciplinary teams	1	1	3	4	4	2	4	3.5	1	1	5	5
Roles and responsibilities of civil engineers and the issues / professional practice	2	2	4	3	5	4	5	3	3	2	5	5
Use the modern engineering tools necessary for engineering practice	3	4	4	5	1	5	3	3	4	5	5	5
Write effectively	3	5	3	3	4	4	3	3	5	3	5	5
Speak effectively	3	2	2	2	2	2	4	2	3	2	5	5
Knowledge of contemporary issues	2	2	3	4	3	3	3	3	3	2	3	4
Broad education to understand the impact of engineering solutions in a global/societal context	2	3	4	3	3	3	3	2	3	2	3	4
The preparation for and willingness to pursue continued intellectual and professional growth	3	3	3	3	5	2	4	3	3	3	4	5

1=No Contribution 2=Small Contribution 3=Average Contribution 4=Large Contribution 5=Very Large Contribution

Fig. 6. Ratings are provided through the course assessment process that rate the contributions of each course toward attainment of the CE program outcomes.

data point that should at least be considered. Desirable standards are created for these data points and performance measures are created for each program outcome.

Figure 7 shows an example of the performance measures for program outcome 1: graduates design civil engineering components and systems. There are five questions on the Civil Engineering First Class Survey (CE1CS) and the USMA First Class Survey (1CS) that relate to this outcome. The students rated their abilities on a Likert scale of 1 (strongly disagree) to 5 (strongly agree). The desired average response is between 4 (agree) and 5 (strongly agree). Figure 7 shows that the standard was met on four out of the five questions for the most recent survey. The benchmark is the average response to the same question from civil engineering students over the past five years. On the USMA survey, the response of the civil engineers can be compared with the rest of the student body. The embedded indicators are direct measures of student work. The performance on the capstone project as determined by the embedded indicator was slightly lower than the standard, but the reports from the judges who helped grade the capstone and independent study presentations were highly favorable. Based on this performance by the CE majors in the class of 2006, the CE program director assessed the attainment of this outcome as 4 on a rating scale of 1 to 5 (Fig. 8). The same process was conducted for the all of the 13 outcomes in existence at the time and the results are shown in Fig. 8, along with the ratings over the past five years. It might appear that performance has declined slightly, but in reality, the system has evolved and the standards for attaining a rating of 5 have increased.

EMBEDDED INDICATORS

Programs are encouraged to develop assessment systems that are sustainable over time and avoid creating data collection systems solely for the purpose of accreditation. Embedded indicators are direct measures of student performance based on assignments already in the curriculum. They can be questions from an exam, a specific essay, a design problem, a group project, or even an entire final exam. The objective is to identify areas that are already being assessed that correlate directly to a specific program outcome. The score on that assignment becomes a direct measure data point for assessment. The embedded indicator should not be taken as proof that an outcome is being attained. There may be many other opportunities

Survey Data:

Tool	#	Item	Std.	Bench mark	Avg. Resp.	Remarks
CE1CS	15	I can formulate a sound methodology for solving an engineering problem.	4/5	4.36	4.32	0 of 38 cadets disagreed.
CE1CS	16	I can design a CE component or system to meet a need	4/5	4.43	4.37	1 of 38 cadets disagreed.
1CS	83	The ability to think of creative solutions to real world problems	4/5	4.29	4.00	Lower than the average response for all cadets (4.20).
1CS	63	I can solve basic real-world technical problems.	4/5	4.66	4.26	Higher than average response of all cadets (4.18)
1CS	80	I can confront ambiguous situations.	4/5	4.30	3.83	Slightly lower than average response of all cadets (4.20). Lower than the benchmark

CE492 Embedded Indicators:

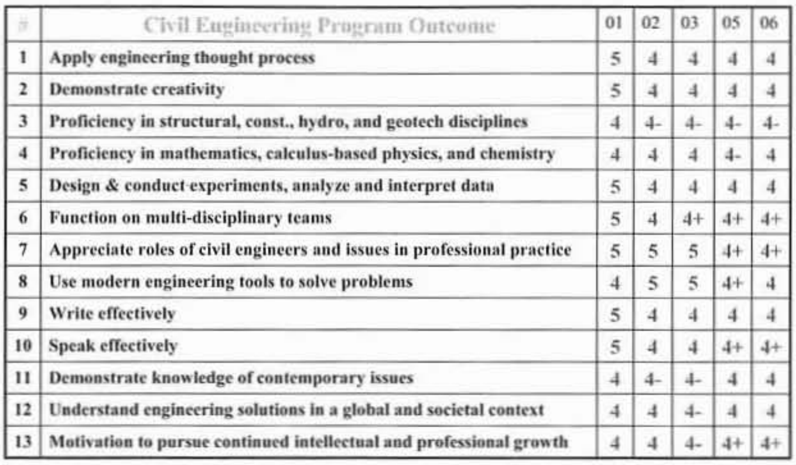
Correlation Rating	Performance Score	Performance Standard	Comments
11.8	3.4	3.5	**Minimally satisfactory performance, Strong correlation**

Correlation between CE492 tasks and program objective is sufficient if correlation rating is > 1.0
Performance scores range from 1 to 5 where 1-2 is unsatisfactory, 2-2.5 is minimally unsatisfactory, 2.5-3.5 minimally satisfactory, 3.5-4.5 good, 4.5-5.0 outstanding

Other Course Embedded Indicators:

Course	Embedded Indicator	Performance Score	Performance Standard	Comments
CE300	**PS #9 (Beam Design)**	**94.7%**	**80%**	**Strong performance**
CE364	**EDP**	**N/A**	**80%**	**Will be collected during 2006-2007 cycle**

Fig. 7. Each CE program outcome has a series of performance measures based on surveys, direct performance measures, course assessments, and instructor ratings that are used to assess the degree to which an outcome is being attained.



#	Civil Engineering Program Outcome	01	02	03	05	06
1	**Apply engineering thought process**	5	4	4	4	4
2	**Demonstrate creativity**	5	4	4	4	4
3	**Proficiency in structural, const., hydro, and geotech disciplines**	4	4-	4-	4-	4-
4	**Proficiency in mathematics, calculus-based physics, and chemistry**	4	4	4	4-	4
5	**Design & conduct experiments, analyze and interpret data**	5	4	4	4	4
6	**Function on multi-disciplinary teams**	5	4	4+	4+	4+
7	**Appreciate roles of civil engineers and issues in professional practice**	5	5	5	4+	4+
8	**Use modern engineering tools to solve problems**	4	5	5	4+	4
9	**Write effectively**	5	4	4	4	4
10	**Speak effectively**	5	4	4	4+	4+
11	**Demonstrate knowledge of contemporary issues**	4	4-	4-	4	4
12	**Understand engineering solutions in a global and societal context**	4	4	4-	4	4
13	**Motivation to pursue continued intellectual and professional growth**	4	4	4-	4+	4+

Fig. 8. The CE program director assigns a rating to each program outcome on an annual basis that evaluates the degree to which each outcome is being attained.

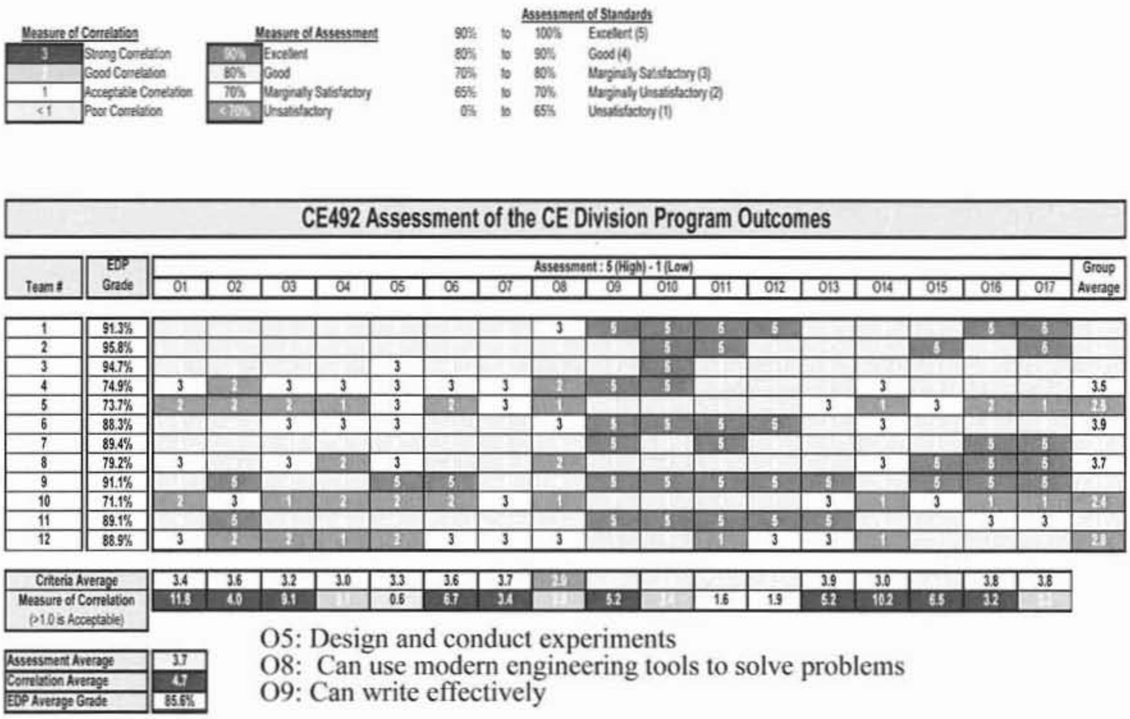
in the curriculum to attain the outcome. Rather it is a snapshot in time and is useful only as a single indicator.

The most recent addition to the USMA CE program has been the identification of embedded indicators for every outcome. For outcome 3 that requires graduates to solve problems in the geotechnical sub discipline of civil engineering, the final examination score in CE371, Soil Mechanics and Foundation Design is a relevant embedded indicator. In CE400, Professional Practice of Civil Engineering, the students are required to write ten journal entries. One of the journal entry topics specifically addresses the roles and responsibilities of the civil engineer professional. The score on that essay becomes a direct measure for attainment of outcome 7. Students are required to use a variety of software packages. The AUTOCAD problem set in CE390, the Site Civil course, is an embedded indicator for outcome 8, using modern engineering tools to solve engineering problems. Figure 7 shows that the two embedded indicators for outcome 1 were problem set #9 from the CE300 (Engineering Mechanics and Design), which involved the design of a simple beam and the engineering design problem from CE364 (Mechanics of Materials), which required the design of a series of roof t-beams that require a load analysis and design based on shear, moment and deflection. Data for these indicators will be collected through course assessment process.

The capstone course CE492, Design of Structural Systems, is unique because it is a culminating design experience and incorporates many of the CE program outcomes. A special tool was designed to capture the student performance and how it relates to the various program outcomes. As described in [29–31], the capstone design is graded where a fixed number of points are allocated to over 50 different areas that include site plan, assumptions, load calculations, social implications, floor plans, architectural layout, cost estimates, construction schedule, quality of presentation, etc. A correlation matrix is created that quantifies the relative contribution of each graded part to the program outcomes. After the tool is developed, the instructor simply enters the scores on each item for each design group and the results are shown in Fig. 9. Based on the average of each group's performance, two scores emerge for each program outcome. The first score (criteria average) reflects student performance on those tasks in the capstone design that relate to a specific outcome and the second score (measure of correlation) records the extent to which the outcome is covered in the culminating design experience. For those outcomes where the correlation score is low, the outcome should be attained through other courses in the curriculum. Figs 7 and 9 show that for outcome 1 (design civil engineering components and systems), the correlation between the capstone design and this outcome is the highest (11.8) of any program outcome but the student performance (3.4) is satisfactory but slightly below the desired standard of 3.5. These embedded indicator tools for individual courses and the capstone design provide relevant direct measure data points for outcome assessment.

COURSE ASSESSMENTS

As shown in Fig. 3, a major component of the fast loop assessment is the course assessment process [32–33] where every course in the CE program is examined once a year. The formal assessment takes place in a one hour meeting attended by the CE program director, group directors, course directors and interested faculty members. Prior to the meeting, the course director prepares an assessment report in a prescribed format that is distributed to the attendees in advance of the meeting. The assessment consists of three parts. The first is *course description* which consists of the verbatim course description from the university course catalogue, current and projected enrollment numbers, course objectives,



Measure of Correlation	
3	Strong Correlation
2	Good Correlation
1	Acceptable Correlation
< 1	Poor Correlation

Measure of Assessment	
90%	Excellent
80%	Good
70%	Marginally Satisfactory
< 70%	Unsatisfactory

Assessment of Standards			
90%	to	100%	Excellent (5)
80%	to	90%	Good (4)
70%	to	80%	Marginally Satisfactory (3)
65%	to	70%	Marginally Unsatisfactory (2)
0%	to	65%	Unsatisfactory (1)

CE492 Assessment of the CE Division Program Outcomes

Team #	EDP Grade	Assessment : 5 (High) - 1 (Low)																	Group Average
		O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	O15	O16	O17	
1	91.3%								3	5	5	5	5				5	5	
2	95.8%										5	5				5		5	
3	94.7%					3					5								
4	74.9%	3	2	3	3	3	3	3	2	5	5				3				3.5
5	73.7%	2	2	2	1	3	2	3	1					3	1	3	2	1	2.5
6	88.3%			3	3	3			3	5	5	5	5		3				3.9
7	89.4%									5		5					5	5	
8	79.2%	3		3	2	3			2						3	5	5	5	3.7
9	91.1%		5			5	5			5	5	5	5	5		5	5	5	
10	71.1%	2	3	1	2	2	2	3	1					3	1	3	1	1	2.4
11	89.1%		5							5	5	5	5	5			3	3	
12	88.9%	3	2	2	1	2	3	3	3			1	3	3	1				2.8

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	O15	O16	O17
Criteria Average	3.4	3.6	3.2	3.0	3.3	3.6	3.7	2.9					3.9	3.0		3.8	3.8
Measure of Correlation (>1.0 is Acceptable)	11.8	4.0	9.1	[illegible]	0.6	6.7	3.4	[illegible]	5.2	[illegible]	1.6	1.9	5.2	10.2	6.5	3.2	[illegible]

Assessment Average	3.7
Correlation Average	4.7
EDP Average Grade	85.6%

O5: Design and conduct experiments
O8: Can use modern engineering tools to solve problems
O9: Can write effectively

Fig. 9. The CE program has developed an embedded indicator tool that provides a direct measure of student performance with respect to each CE program outcome on the annual capstone design project.

current textbook, outline of course lessons with their respective contribution to course objectives, outline of laboratory experiences, summary of graded requirements, grading policy, and a reporting of group work, computer usage, active learning, curriculum integration, facilities assessment, and embedded indicators for that course. The second part is *course assessment*. Both the course director and the students (using the end of course web-based survey) rate the degree to which the course objectives were achieved on a 1 (unsatisfactory) to 5 (excellent) scale. The student ratings on the quality of instruction are included in graphical form, along with a summary of the narrative comments from students. The data are compared with previous years for the same course. Student performance is recorded and compared with the past in terms of incoming grade point average of students, grades in the course, and results on the final examination. Results of time surveys that record the amount of time students are spending on the course are included. Finally, the course director rates the contribution of the course to the program outcomes. Figure 6 was based on a roll-up of this assessment from the individual courses.

The final part of the course assessment is recommended changes. The course assessment process is the official venue for making changes to courses. This allows faculty members who teach prerequisite and follow-on courses to provide input into course changes that might affect them. The course director addresses whether the previous year's changes were effective and then makes recommendations for new changes based on the findings in part 2. Decisions are made at the course assessment meeting and are recorded on a memo cover sheet. The entire course assessment document is then placed in the course notebook.

The course assessment process takes considerable time and effort, especially the first time through. Because the reporting is done in the same systematic way each year, it becomes much less onerous to update a previous report. The standardized format makes it easy to consolidate data for the fast loop program assessment. When several courses are interrelated, their respective course assessment meetings are often conducted together to facilitate cross talk and coordination.

ONGOING EFFORTS

While the assessment system within the CE program has evolved and improved, there are a number of courses taught outside the department that contribute to program outcomes, but are not being effectively examined. Because all accredited engineering programs at the Academy are in the same situation, the USMA level ABET committee is addressing this challenge. The USMA curriculum is broad based where every student, regardless of major, is required to take calculus, physics, chemistry, psychology, English, foreign language, history, international relations, geography, information technology, philosophy, law, leadership, and economics. The ABET committee is attempting to meet with outside departments to specifically quantify the contributions that these courses make toward attainment of the ABET 3(a–k) outcomes. Every accredited engineering program can then use that data in its own program assessment.

STAYING CURRENT AND COMMUNICATING

As EC2000, the outcomes-based continuous improvement approach to accreditation continues to evolve, the standards for assessment keep getting higher and the requirements change somewhat from year to year. Every program needs to stay involved in order to keep up with the latest developments. The USMA CE program faculty attempt to stay current by attending and making presentations at such forums as the ABET national meeting [34], the ASEE annual convention [35–38], the ASCE national conference [31, 39—40] and the Rose Hulman Best Practices Workshop [11, 31]. Currently, three out of the twenty faculty members in the USMA CE program are ABET evaluators and one member conducts ABET evaluator training for other institutions. There is no better way to stay current and see what other programs are doing than to serve as an evaluator of other programs. While one or two leaders will orchestrate and lead the assessment effort within the CE program, every attempt is made to involve all faculty members in the process. This divides the work load, educates the faculty members on the process, and helps facilitate support and buy-in from the entire faculty.

CONCLUSIONS

The United States Military Academy CE program has developed and successfully sustained a program assessment process that effectively encompasses slow loop and fast loop evaluations that are each designed to perform very different functions. The system is based on the university assessment system and has eight years of documented data and analysis. The annual assessment culminates in a formal briefing that addresses previous recommendations, reports on the results of data collected over the year, and recommends changes to the program based on that analysis. The foundation of the process is annual course assessments in every course that allow data to be consolidated in a standardized format. Outcomes and objectives are assessed based on a comparison of student performance to prescribed performance measures and an annual rating is given for each individual outcome and objective. Additional input is provided by an external advisory board whose composition and role have evolved over the past six years. The CE program has remained current on changes in assessment requirements through participation on professional society committees, presenting papers at workshops and conferences, and serving as accreditation evaluators for other programs. There are still improvements and adjustments to be made. The 2006 CE program assessment listed 25 specific recommended changes that range from major to extremely minor. The USMA CE assessment program will continue to evolve as a process of continuous improvement is sustained.

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