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A Systematic and Structured Outcome Assessment Plan for a New Engineering Program*

FARSHAD AMINI and SHIKHA RAHMAN
Department of Civil & Environmental Engineering, P.O. Box 17068, Jackson State University, Jackson, MS 39217-0168, USA. E-mail: famini@jsums.edu

Little is known about the program outcome assessment processes and requirements for new engineering programs. Traditional assessment techniques do not consider the unique situation of newly created engineering programs: the lack of historic assessment data, the need for implementation of improvements in a very short time, the lack of faculty in place at the start of the program, and the administrative issues are some of the factors that influence the assessment plan of a new engineering program. This paper presents a systematic and structured assessment plan for a new civil engineering program that addresses these challenges. Lessons learned and suggestions for implementation of an effective and meaningful assessment plan are presented.

Keywords: assessment; outcomes; engineering; education

INTRODUCTION

TRADITIONAL ASSESSMENT TECHNIQUES in engineering education suffer from long time delays, particularly in the implementation of the areas that need improvements. This effort is often compounded in new engineering programs, where little or no historical data is available [1–2]. In addition, there are relatively small class sizes. In cases like this, the amount of data that can be collected is often limited and its statistical relevance may be less than that for an existing program. As a result, alternate assessment techniques are needed to address this situation.

First, by increasing the number of assessment tools, the amount of data collected can be substantially increased. Second, each assessment tool can address more elements than the usual tools to address a particular outcome. Third, alternative methodologies with quick turn-around times, such as the use of Exit Exam, will prove to be useful. Fourth, particular attention needs to be given to the types of improvements so that they can be implemented in a timely manner. In developing our assessment plan, these four factors were incorporated.

In addition, other unique aspects of a new program impact the assessment process. The lack of faculty in place at the start of the program would require more emphasis on external assessments, although internal direct assessment would remain a primary and vital part of any meaningful assessment process. In this situation, external assessment measures, such as the Department Advisory Board (DAB) evaluation of the capstone design course, the DAB interview of the performance of graduating students, and a formal and direct focus group evaluation will play critical roles.

It is also important to note that the new Department and Program is expected to function like other Departments on campus while, at the same time, trying to establish itself. Some of the main challenges for a new Department include the need for careful time management, and the development of good working relationships with various groups both internally and externally. In addition, the success of the assessment techniques depends, to a large extent, on the successful implementation of improvements that, in turn, must be accomplished in a very short time [2]. The primary objective of this paper is to present a systematic and structured assessment plan for a new civil engineering program. The assessment of the implementation of the improvements and the lessons learned are also discussed.

Situation at Jackson State University

Jackson State University has recently created a new School of Engineering, new engineering programs, and the new Department of Civil & Environmental Engineering. The first class in the Department of Civil & Environmental Engineering students graduated in May 2005 with two students receiving their degrees, and its second class graduated in May 2006 with nine students obtaining their B.S. degrees in Civil Engineering. The Department offers both undergraduate and graduate programs.

Program outcomes

Consistent with ABET Criterion 3 and to support Civil Engineering Program Educational Objectives, the Program Outcomes were developed

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in 2004. The Jackson State University Civil Engineering Program graduates will have:

a. an ability to apply knowledge of math, science, and engineering to solve civil engineering problems;
b. an ability to organize, design and conduct experiments in more than three civil engineering areas, and to analyze and interpret data;
c. an ability to plan and execute an engineering design to meet an identified need including designing a system, component, or process that satisfies constraints and meets desired needs;
d. an ability to function effectively on multi-disciplinary teams using their knowledge of team dynamics, team communication, social norms, and conflict resolution;
e. an ability to define, formulate, and solve engineering problems, and to understand the role of scholarly activities;
f. an understanding of professional and ethical responsibility of civil engineers to practice in their disciplines including understanding of professional practice issues such as procurement of work, bidding vs. quality based selection processes, interaction between design and construction professionals, and importance of professional licensure;
g. an ability to communicate effectively using oral, written, and graphical forms;
h. the broad education necessary though their knowledge of the social science and humanities combined with their own personal experience to understand the impact of engineering solutions in global, economic, moral, political, and societal contexts;
i. recognition of the need for, and an ability to engage in, life-long learning and development and to understand the importance of continuing education;
j. a knowledge of contemporary issues impacting engineering solutions on humankind;
k. an understanding of the need for up to date engineering tools, and the ability to use these tools, as well as new techniques and skills necessary for engineering practice; and
l. proficiency in the following civil engineering areas: environmental engineering, geotechnical engineering, structural engineering, transportation engineering, and water resources engineering.

The Department of Civil and Environmental Engineering decided to use a numbering system, similar to ABET, to avoid confusion when relating our Departmental Outcomes to the ABET Criterion 3 Outcomes. Outcomes (a) through (k) above are somewhat similar to the ABET (a) through (k) outcomes, with some modifications. The Department also felt that some aspects of the ABET Criterion 8 may be included in the Program Outcomes. These aspects are reflected in several outcomes such as Outcomes (b) and (f). For example, the students, at the time of graduation, should understand professional and ethical issues, including understanding of professional practice issues such as procurement of work, bidding vs. quality based selection processes, interaction between design and construction professionals, and importance of professional licensure. In addition, Outcome (l) has been added to incorporate proficiency in several specialized civil engineering areas. As civil engineers, they are required to be proficient in five major civil engineering areas. The faculty discussed at length the merits of each Outcome and its importance to our constituencies before approving the final version. The Program Outcomes are directly related to and support our Program Educational Objectives.

ASSESSMENT PROGRAM

One of the most critical aspects of the ABET Engineering Criteria 2000 (EC-2000) is the existence of an outcome assessment plan for program evaluation and continuous improvement. Outcomes assessment requires the generation of assessment tools or instruments to gather data and document if the program's stated goals are being achieved [3–5].

There are many resources available for the development of an outcome assessment plan. Our assessment plan was developed based on many years of experience with ABET, visits to several Universities, participation at several conferences (such as ABET, ASCE, ASEE, and Best Assessment Symposium), a literature review indicating prior work by peer institutions [6–24], consultations with our constituencies, and the circumstances related to the new Program at Jackson State University. As a result, a systematic assessment plan was developed, and is in place in the Department of Civil and Environmental Engineering. The plan focuses on two primary forms of assessment: (1) assessment of student learning and graduate capability to perform Program Outcomes; and (2) overall student satisfaction with the Program, our facilities, and instruction. The Assessment Plan is structured in such a manner that it is reviewed and adjusted annually through a systematic and timely process by the entire Civil Engineering faculty. The majority of the changes to the assessment plan are minor and typically involve changes in the format/questions of the assessment tools. The Department Advisory Board (DAB), alumni, and students are consulted on the Assessment Plan at least once a year, and play active roles in the assessment process.

Assessment strategy

In order to have comprehensive and valid results, an assessment strategy must be developed. The assessment strategy must, in turn, incorporate meaningful assessment tools. These assessment tools serve as data collection methods that are focused on performance indicators. Our assessment tools have been developed and structured based on the following elements:

- internal assessment;
- external assessment;
- direct and indirect measures for each outcome;
- multiples measures of each outcome;
- qualitative and quantitative components;
- inclusion of quick turn-around data (since the program is new);
- inclusion of many assessment tools (to be able to obtain more data, since the program is new);
- inclusion of several components (to be able to obtain more data, since the program is new); and
- surveys (only as secondary measures).

In using the assessment data, it is important to note that not all assessment measures can be treated equally. For example, the Course Objectives Survey and Alumni Survey tools have less weight that the direct instruments. Similarly, assessment data from external sources may not represent a complete indication of a needed improvement area. As a result, a subjective weighting process is required.

In addition, the assessment plan has been carefully structured such that there is a systematic process to obtain valid results. Some of the main elements of this process are:

- active participations of all program faculty in all assessment processes;
- use of all assessment data in arriving at the improvement areas;
- measurement, evaluation, and assessment of each and every outcome;
- detailed analysis of the results for each assessment tool;
- detailed analysis of the results for each Program Outcome;
- assessment of the assessment plan; and
- assessment of effectiveness of improvement implementation.

Assessment plan

In order to obtain high quality data, and to ensure all students achieve all Program Outcomes, the assessment plan requires the participation of all senior civil engineering students. In fact, participation in the assessment process is part of the grading criteria in "CIV 461 Professional & Ethical Issues in Civil Engineering", typically offered during the last semester of the senior year. In addition, recognizing the importance of faculty involvement, all civil engineering faculty participated in the assessment process. The 100% faculty participation in the assessment processes will ensure that each particular situation is properly addressed, appropriate improvements are identified and implemented, and the effectiveness of the level of implementation is assessed. For the two assessment cycles that have been completed (2004–2005 and 2005–2006 cycles), we have achieved 100% participations by both students and faculty. This level of participation is particularly critical for new programs, where there is limited historic data and small class sizes.

During the initial assessment process, a Department Assessment Committee (DAC), consisting of full-time faculty members, was formed. This committee generally met weekly or bi-weekly to discuss various aspects of the assessment process, and recommend course of action. Our experience indicates that the formation of the DAC, at the start of the Department and for a new Program, has been very effective in implementing a structured and systematic assessment plan.

The Assessment Plan for the Department of Civil & Environmental Engineering uses twelve assessment tools to determine if the Program Outcomes are being achieved. The plan has been carefully designed such that there is a consistent process to measure all Outcomes systematically, and suggest and implement areas of improvements based on the results of assessment. We believe this systematic approach is essential in ensuring that the program goals are met for all Outcomes. Each of the assessment tools used by the Department, along with a brief description and the student performance criteria is listed in Tables 1 and 2. Table 3 is a matrix indicating the use of assessment tools to evaluate the individual Outcomes. These include ten direct measures and three indirect measures. It may also be noted that as the program grows, there is more focus on the course embedded assessment measure.

Definition of level of achievement

The overall Level-of-Achievement Rubric for relevant assessment tools is shown below:

1. Did not complete the work required for this criteria.
2. Demonstrates severe misconceptions about the important concepts; makes many critical errors.
3. Displays an incomplete understanding of the important concepts and has some notable misconceptions; makes some errors when performing important tasks but can complete a rough approximation of them.
4. Applies appropriate strategy or concepts without significant errors.
5. Demonstrates a complete and accurate understanding of concepts

In addition, the Departmental faculty developed specific Level-of-Achievement Rubrics for each individual outcome.

Establishment of program criteria

The rankings are on a scale of 1 to 5, with 5 being the highest level of attainment. The numbers are assigned with faculty consensus in 0.5 increments. The OVERALL ranking is not based on arithmetic mean but rather a subjective weighting

Table 1. Summary of direct assessment measures

Assessment tool	Description of direct assessment tool[2]	Performance criteria
Student Portfolio Evaluation	The faculty directly evaluated each individual student performance based on the student portfolios from class projects, assignments, and laboratory reports in the following areas: (1) ability to conduct individual design; (2) ability to design and conduct experiments; (3) ability to communicate effectively; (4) proficiency in 5 CE area; and (5) understanding the role of scholarly activities using the level of needed achievements (or indicators) described by the faculty and the Level-of-Achievement Rubrics [16].	General satisfaction by the faculty. A minimum of a 3.5 on a 5-point scale.
Performance Appraisals Evaluation (posters)	The faculty directly evaluated individual student performance in the following areas: (1) ability to design and conduct experiments; and (2) ability to communicate effectively using the level of needed achievements (or indicators) described by the faculty and the Level-of-Achievement Rubrics.	Case dependent, but typically, a minimum of a 3.5 on a 5-point scale.
Performance Appraisals (oral evaluation)	The faculty directly evaluated individual student performance during the oral presentation of the Capstone Design Projects using the level of needed achievements (or indicators) described by the faculty and the Level-of-Achievement Rubrics.	Case dependant, but typically a minimum of a 3.5 on a 5-point scale.
Course Embedded Assessment	During this targeted assessment process, the faculty chooses an instrument (homework assignments, project, exam, etc.). Level of achievement required by students is described by the faculty, and is then directly evaluated by the faculty to measure the achievement of the outcome being assessed by the course using the Level-of-Achievement Rubrics for each individual student. At least two courses have been used to evaluate student performance for each outcome. As the program grows, there is more focus on this assessment measure.	A minimum of a 3.5 on a 5-point scale.
Faculty Evaluation of Capstone Design Projects (six credits)	The assessment for achieving outcomes using this assessment tool was performed by the faculty for each individual student based on written proposal, oral proposal presentation, progress reports, final report, final oral presentation and examination, using the level of achievement required (or indicators) described by the faculty and the Level-of-Achievement Rubrics [11, 17].	General satisfaction by the faculty. A minimum of a 3.5 on a 5-point scale.
Professional Evaluation of Capstone Design Projects	Written report and oral examination by external examiner—the DAB directly examined the students' performances based on written proposal, proposal presentation, final written report, final presentation and examination including subsequent answers to questions using the level of needed achievement and the Level-of-Achievement Rubrics.	General satisfaction by the Advisory Council (and/or employers). A minimum of a 3.5 on a 5-point scale.
Focus Group Evaluation	Oral examination by external examiner—a formal and direct assessment tool in which an external evaluator directly examined individual student performance in several outcome areas by asking specific questions using the level of needed achievements (or indicators) and the Level-of-Achievement Rubrics. All students participated during this assessment process.	Generally a minimum of a 3.5 on a 5-point scale, but it may also be case-dependent.
DAB Interviews Evaluation	Oral examination by external examiner—the DAB conducted a group interview of each individual student by asking specific questions to examine students' performances directly, using the level of needed achievements (or indicators) and the Level-of-Achievement Rubrics.	General satisfaction by the DAB that the students meet the published outcomes of the department. A minimum of a 3.5 on a 5-point scale.
Exit Exams	A multiple-choice, closed-book exam, in which the performance of students in 11 specific subjects, taught by the CE faculty, were evaluated by the faculty.	A minimum of 70% on each specific topic, but can also be case-dependent.
FE Exam	The FE Exam is a nationally-normed exam that provides a direct measurement of student abilities on a topic-by-topic basis. This emphasizes strong and weak points within the program.	Perform at or above average for comparative Carnegie 'Doctoral University—High Research Activity' Institutions.

Table 2. Summary of indirect assessment measures

Assessment tool	Description	Performance criteria
Exit Interview	The exit interview evaluation of graduating students is conducted by the Department Chair. The exit interview is designed to obtain the students' perception of the program, and provides a summative view of the program. It also gives an indication of overall student satisfaction. It is structured such that many components regarding students' performance are measured.	Qualitative evaluation of student satisfaction and concerns. Qualitative as well as direct evidence that we are meeting our outcomes. A minimum of a 3.5 on a 5-point scale.
Alumni Survey	A factual-based questionnaire to obtain specific information from our alumni regarding the quality of their education, and determine how well the program prepared them to enter practice.	General satisfaction by alumni and a minimum score of 3.5 on quantitative questions.
Course Objectives Survey	Learning course objectives have been developed for all undergraduate civil engineering courses. Students are surveyed on their ability to perform objectives at the conclusion of the course.	A minimum of a 3.5 on a 5-point scale.

Table 3. Matrix relating assessment tool to measured outcomes

Assessment tool/Outcome	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
1. FE Exam	X				X							
2. Exit Exam	X				X							
3. Exit Interviews	X	X	X	X	X	X	X	X	X	X	X	X
4. Department Advisory Board Interviews						X	X	X	X	X	X	X
5. Advisory Board Capstone Design Evaluation	X		X	X	X	X	X	X	X	X	X	X
6. Faculty Capstone Design Evaluation	X		X	X	X	X	X	X	X	X	X	X
7. Portfolios		X	X		X		X					X
8. Alumni Survey	X	X	X	X	X	X	X	X	X	X	X	X
9. Course Objectives	X	X	X	X	X	X	X	X	X	X	X	
10. Course Embedded Assessments[a]												
11. Performance Appraisals[a]												
12. Focus Groups	X	X	X			X						

Note: [a] The use of these assessment tools for the evaluation of Program Outcome is case-dependent.

based on faculty input. The criteria for achieving goals are listed below.

4 and higher	meets program goals;
3.5	meets program goals, but with some concern;
3 or lower	indicates outcome not achieved for the Academic Cycle; and
I	indicates incomplete for the given item

Assessment of quality of database

The quality of students' response database is assessed using the undeliverable rate:

$$UR = NU/NT,$$

where

$UR =$ undeliverable rate,
$NU =$ number of not participated, and
$NT =$ total number of students received assessments tools.

The students' response rate (RR) is defined as

$$RR = NR/(NT - NU),$$

where

$NR =$ total number of assessment results received from students.

The acceptable values for UR and RR are set. The database is updated regularly to maintain RR above the set average. In our case, the undeliverable rate was 0.0%, and the students' response rate was 100%, for the two assessment cycles (2004–2005 and 2005–2006 cycles).

ASSESSMENT RESULTS

Assessment results and evaluation for the 2005–2006 cycle

During the 2005–2006 academic year, twelve assessment tools were used to determine if the Program Outcomes are achieved. Analysis of the results for each assessment tool and each Outcome were performed systematically using forms created specifically for this purpose. These in-depth analyses were carefully done to provide insights with respect to a particular area of concern or strength. To measure student achievement of

Program Outcomes, the assessment plan also takes into account the overall student satisfaction with respect to their education, the Department, and the faculty.

A majority of the assessment measures used by the Department followed the same format. First, the Chair of Department Assessment Committee (DAC) analyzed the raw data and provided a summary with analysis to the full-time faculty. Next, all full-time faculty discussed the results at a Departmental Meeting and decided if corrective action is needed based on the results. Finally, the faculty met at the end of the academic year to review assessment results as a conglomeration. A majority of the corrective measures resulted from the overall review and not specifically from a single assessment measurement.

Each of the twelve assessment tools addresses multiple Program Outcomes. Similarly, multiple assessment tools are used to measure each Outcome. Therefore, to determine if the Program Outcomes are being met, it is important to consider the entire assessment plan systematically. To accomplish this task, a matrix is generated that indicates the level of student attainment of an Outcome based on that particular tool.

The matrix for the 2004–2005 cycle is shown in Table 4. For a given assessment tool, the scores are on a scale of 1 to 5, with 5 being the highest level of attainment. The criteria for achieving goals were mentioned above. The values for each assessment tool addressing a given Outcome were determined through faculty consensus based on the results of the raw data obtained from the assessment. These values were then used to determine an OVERALL score for each Program Outcome. The OVERALL score is not based on an arithmetic mean, but rather a subjective weighting based on faculty input. In utilization of the assessment data, it is important to note that not all assessment tools can be treated equally. For example, the Course Objectives Survey and Alumni Survey have less weight than the direct instruments. Similarly, assessment data from external sources, may not present a complete indication of a needed improvement area.

As mentioned earlier, the scores in Table 4 take into account the in-depth analysis of each assessment tool and each outcome. These analyses are based on substantial faculty discussions of each case. Overall, the assessment results for the 2005–2006 cycle were very positive with minor exceptions. Exit interviews conducted with the Department Chair, as well as the Focus Group Evaluation indicated that students were very pleased with the Department, their JSU education, and the faculty. Students felt they were adequately prepared to enter into the profession. The assessment results show that all Outcomes have met the program goals satisfactorily. Based on a 1-to-5-point scale, the OVERALL score of all outcomes ranged from 3.5 to 4.5 with an average of 3.9, which is interpreted as meeting the Program goals with satisfaction. Outcomes (b), (g), (i) and (j) have OVERALL scores of 3.5. The ratings for these outcomes were observed to be 3.5 for most of the assessment tools with the lowest (3.0) for Poster Evaluation. The Assessment results revealed four areas of concerns that are related to these Outcomes, as discussed below.

First, although the students were well prepared in conducting experiments and analyzing and interpreting the data, their ability to design their own experiments was somewhat limited. In particular, assessment results from Student Portfolios Evaluation, Poster Presentation, and Focus Group Evaluation indicated that additional exposure to the designing of experiments is needed. The evaluator, conducting Focus Group Evaluation, has specifically indicated that the students' ability in this area is very limited. The students have, however, been 'allowed to fail' and perform their own 'trial and error process'. As a result, they have some ability in designing experiments.

Table 4. Assessment/Outcome Matrix for the 2005–2006 cycle

Assessment Tool/Program Outcome	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
1. Exit Exam	3.5				3.5							
2. Exit Interviews	4.5	3.5	4.0	4.5	4.5	4.5	3.5	4.0	3.5	3.5	4.5	4.5
3. Department Advisory Board Interviews						4.5	3.5	4.5	3.5	3.5	4.0	4.0
4. Advisory Board Capstone Design Evaluation	4.5		4.5	4.5	4.0	4.0	3.5	4.0	3.5	3.5	4.0	4.0
5. Faculty Capstone Design Evaluation	4.5		4.5	4.0	4.5	4.0	3.5	4.0	3.5	3.5	4.0	4.0
6. Portfolios		3.5	4.0		3.5		3.5					4.0
7. Alumni Survey	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
8. Course Objectives Survey	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
9. Performance Appraisals (Oral Eval. of Capstone Design)							4.0					
10. Performance Appraisals (Posters for CIVL 330 & CIVL 340)		3.0					3.0					
11. Focus Groups	4.0	3.5	4.0			4.0						
12. Course Embedded Assessment [CIV 461 & FE Review for (f); CIV 460 & CIVL 421 for (j)]						4.0				3.5		
OVERALL	4.0	3.5	4.0	4.0	4.0	4.5	3.5	4.0	3.5	3.5	4.0	4.0

Note: The scores are on a scale from 1 to 5, with 5 being the highest level of attainment. The numbers are assigned through faculty consensus in 0.5 increments. The OVERALL score is not based on arithmetic mean but rather a subjective weighting based on faculty input. Interpretations: 4+ meets program goals; 3.5 meets program goals, but with some concern; 3 or lower indicates outcome not achieved for the Academic Cycle; and I indicates incomplete for given item.

Second, there were concerns regarding students' ability to communicate effectively in graphical forms. This concern was evident through the results obtained from several assessment tools. Faculty were particularly somewhat dissatisfied with the graphical communication skills of our students as noted in Student Portfolios, Poster Presentation, and Faculty Evaluation of Capstone Design Project. This included insufficient experience with AutoCAD, and other graphical and plotting software. The Department Advisory Board (DAB) also verbally raised concerns about the graphical presentations and the students' graphical skills. In addition, specific comments provided by Employers' Evaluation indicated that the students needed more exposure to graphical communication skills such as more exposure to AutoCAD.

Third, results from four assessment tools including the Exit Interview, DAB Interview, DAB Evaluation of Capstone Design, and Faculty Evaluation of Capstone Design indicated that the students' recognition of the need and an ability to engage in life-long learning and continuing education were limited. The DAB asked specific questions related to the importance of the FE Exam, licensure, and continuing education. The DAB were not totally satisfied by the students' response. Faculty also made several specific comments regarding the students' limited knowledge in this area.

Fourth, there were concerns regarding the knowledge of contemporary issues. This concern was evident through the results obtained from four assessment tools: Exit Interview, DAB Interview, DAB Evaluation of Capstone Design, and Faculty Evaluation of Capstone Design. Faculty were somewhat dissatisfied with the students' knowledge of contemporary issues, and have made specific comments regarding their knowledge in this area.

Major improvement areas based on assessment results for 2005–2006 cycle

One of the assessment's most powerful points of impact is the individual classroom. A change in program activity (e.g., internship or co-op placement) or student service activity (e.g., advising) may take years to produce measurable effect, but enhancement of existing courses can be more readily felt, especially by the students [25]. This is particularly important for a new program, since short-cycle improvements are needed. The overall benefits of course enhancements to a program may be greater than the sum of the enhancements made to individual courses. Enhancement of several courses will, in turn, contribute to the improvements in achieving the goal for a particular Outcome.

Based on the results of the assessment data for the 2005–2006 cycle, there were some concerns about achieving four of the Program Outcomes: (b), (g), (i), and (j). Improvement areas were then identified to address these concerns. The improvements, the outcomes they address, the sources of input, and the percentage of students affected are summarized in Table 5. These improvements have been implemented by the modifications of the existing courses. As a result of these implementations, course syllabi have been modified to include the needed course modules. These course enhancements activities are summarized below.

Table 5. Summary of improvements for the 2005–2006 cycle

Improvement area	Outcome addressed	Primary source(s) of input	Students affected
Improvement No. 1—Enhance designing experiments	(b)	Portfolios; Performance Appraisals; Focus Group Evaluation; Exit Interview.	100%
Improvement No. 2—Improve graphical communication skills	(g)	Portfolios; Performance Appraisals; DAB Evaluation of Capstone Design; Faculty Evaluation of Capstone Design; DAB Interview.	100%
Improvement No. 3 —Promote the importance of life-long learning	(i)	Exit Interview; DAB Interview; DAB Evaluation of Capstone Design; Faculty Evaluation of Capstone Design.	100%
Improvement No. 4—Enhance knowledge of contemporary issues	(j)	Exit Interview; DAB Interview; DAB Evaluation of Capstone Design; Faculty Evaluation of Capstone Design.	100%

Improvement No. 1—Include course modules for designing experiments

Although several of our courses have incorporated the designing of experiments, the assessment results revealed that the students needed additional opportunities in the designing of the laboratory experiments to address a given problem. New modules in designing experiments should be included in all four civil engineering laboratory courses as well as other junior and senior civil engineering courses. The course modules are described below.

CIVL 330 Fluid Mechanics Laboratory—After conducting five experiments, students are assigned one experiment to design Pipe Friction Losses. Students are introduced to the basic principles of experiment design. Given a specific concept, problem or objective, students will choose the instruments or equipment and materials that can be used, write the procedures, decide on the data to be collected, and finally perform the analysis, interpretation and presentation of data to address the problem at hand. Although the instructor put together teams to work on designing the experiments, students are required to submit individual reports. The reports contain objectives, approach in designing experiments, procedures, equipment used, data table, graphs, data analyses and the conclusions or discussions on results.

CIVL 340 Environmental Engineering Laboratory—After conducting three experiments with the help of the instructor, the students are required to design two experiments and implement the design independently: (1) Measurement of Biochemical Oxygen Demand (BOD) and (2) Analysis of Solids in Water Samples. The design is based on the objectives and expected results, including the handling of the samples, the materials needed, the experimental procedures, the major equipment and instruments to be used, and data collection sheets. After the class, the students are expected to be able to design basic experiments to achieve the desired scientific objectives.

CIVL 380 Geotechnical Engineering Laboratory—In this course, students are required to design the compaction test. The purpose of this compaction test design is to find the water content range to reach the maximum dry unit weight of soil after compaction. Students are grouped according to their academic performance. For each group, the instructor assigns a team leader. The team leader works with the team members to finish the design of the a compaction test.

CIV 370 Water Resources Engineering—Students will be required to design two experiments, one using the series and parallel pump theory and the other using the concepts of the hydraulic pump. Although the instructor will put together teams to work on designing the experiments, students will be required to submit individual reports. The reports will contain objectives, approach for designing experiments, procedure, equipments used, data table, graphs, data analyses and the conclusions or discussions on results.

CIV 465 Advanced Water Resources Engineering—Students are required to design two experiments, one using the pipe network theory and the other using well hydraulics or open channel hydraulics concepts. Although the instructor puts together teams to work on designing the experiments, the students are required to submit individual reports. The reports will contain objectives, approach, procedure, equipments used, data table, graphs, data analyses and the conclusions or discussions on results.

CIVL 421 Structure and Materials Laboratory—Basic principles of experimental design are introduced to students. Students are assigned to design experiments to determine the impact of water/cement ratio, mixing time, or vibrating time on the strength of concrete.

Improvement No. 2—Improve students' graphical communication skills

The assessment results revealed that the students' exposure to graphical communication and presentation skills is somewhat limited. Improvement on this issue can be achieved by adding new modules that emphasize the use of AutoCAD and other graphical software in civil engineering courses. These course modules are described below.

EN 201 Engineering Graphics—To further provide an understanding of the general principles of computer-aided design and drafting (CADD) and practices and procedures used to produce working engineering drawings, the following modules have been added to the EN 201 Course.

Specific drawings will be adopted for students to design and draft. Examples are taken from various engineering disciplines and will include working drawings closely related to highways and railroads, airports, bridges, buildings, dams, tunnels, environmental pollution control systems, water purification and/or distribution systems and urban transportation systems.

Students are exposed to working drawing interpretations, as well as the terminology of various systems used in civil and environmental engineering applications.

CIVL 330 Fluid Mechanics Laboratory and CIVL 340 Environmental Engineering Laboratory—Graphical presentations of the experimental results are required in student's lab reports. The students will be required to plot their results using MS Excel and incorporate the graphs into the reports to be written by MS Word. The quality of the graphs is comparable with those in the ASCE professional journals.

CIV 390 Introduction to Transportation Engineering—Using the AutoCAD software, the geometric design of roadways can be exercised. In addition, earthwork volumes (cut and fill) can be estimated using cross-sectional drawings.

CIV 410 & CIV 411 Capstone Design I & II—Students are required to use AutoCAD or Microstation for all the drawings of the Capstone Design Project.

CIV 420 Design of Concrete Structures—Students are required to use AutoCAD for drawings related to projects. In this course, a final project is assigned, where students are required to use AutoCAD to draw beam sections and beam reinforcement schedule.

CIV 430 Foundation Engineering—In this course, students are required to use three graphical software packages for the design projects. These include: (1) gINT; (2) AutoCAD; and (3) KaleidaGraph. gINT is a commercial software for plotting boring logs information. KaleidaGraph is a commercial software for plotting two-dimensional scientific figures. The project design is based on real practical foundation design. Test boring logs data and subsurface information will be provided for the students. Students are required to use gINT software to create the boring logs, to use AutoCAD to finish the foundation design figures, and to use KaleidaGraph to plot the consolidation curve and footing design figure.

IMPROVEMENT NO. 3—PROMOTE THE IMPORTANCE OF LIFE-LONG LEARNING AND CONTINUING EDUCATION

Course modules are added to the existing Civil Engineering courses (CIV 461 and FE Review Course) to enhance the students' understanding of the need and the importance of life-long learning and continuing education.

CIV 461 Professional & Ethical Issues in Civil Engineering—As part of this course, a need for lifelong learning and continuing education, and their importance in being a successful professional are emphasized. An outside speaker is invited to talk to the students about lifelong learning and continuing education and how it helped him/her into a successful career in civil engineering. Students are required to submit a written report on the importance of lifelong learning and continuing education, based on the discussions in the classroom and with the invited speaker.

FE Review Courses—This course prepares students for the National Fundamental Engineering Exam held each April. The review course covers most of the topics in general engineering and civil engineering areas. (See also Appendix I for detailed description of the FE Review course.) The following modifications to this course are made.

- A session related to the steps and strategies for becoming a professional engineer, and the importance of the FE Examination in the development of professional career will be added. The assessment of the students' knowledge in this area will then be conducted by a requirement to prepare a report.
- The course will be offered in early February.
- Attendance on this course will be mandatory.
- Each session will include a short quiz on the topic covered.

IMPROVEMENT NO. 4—ENHANCE STUDENTS' KNOWLEDGE OF CONTEMPORARY ISSUES

New modules are being added to the following courses for improving students' knowledge of contemporary issues that impact engineering solutions.

CIV 430 Foundation Engineering—In this course, the latest review papers on expansive clays are discussed. Expansive clays, in the local area, cause many damages, and economical costs for foundations in residential houses and commercial buildings are significant. Students are assigned the literature review and discuss the expansive clay issue as it relates to foundation design. Students will have an opportunity to find possible solutions to solve the expansive clay problems by searching current technology such as soil stabilization, geosynthetics, and moisture control.

CIVL 421 Structure and Materials Laboratory—A new course module is being added to introduce students to the development and research in nanotechnology for construction. It emphasizes the impact of nanotechnology on construction materials and infrastructure systems.

CIV 441 Water and Wastewater Treatment Processes—The new modules will include arranging field trips to real-world treatment plants and a video show on the state-of-the-art of water and wastewater treatment for the students, to give them a broader understanding of contemporary issues in water treatment and the engineering solutions. The preparation of a written report to address theses issues is also a requirement.

The above improvements have been implemented by modifying the course syllabi to include the needed course modules.

Assessment results and evaluation for the 2004–2005 cycle

During the 2004–2005 academic year, ten assessment tools were used to determine if the Program Outcomes had been achieved. The assessment process was the same as that used during the 2005–2006 academic year, mentioned earlier.

Table 6. Assessment/Outcome Matrix for the 2004–2005 cycle

Assessment Tool/Program outcome	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
1. Exit Exam	3.5				3.5							
2. Exit Interviews	4.5	4.5	4.0	4.5	4.5	4.0	4.0	4.5	4.5	4.0	4.0	4.0
3. Department Advisory Board Interviews						4.0	3.5	4.0	4.0	4.0	3.5	4.0
4. Advisory Board Capstone Design Evaluation	4.5		4.0	3.5	4.0	3.5	4.0	4.0	4.0	4.0	3.5	3.5
5. Faculty Capstone Design Evaluation	4.0		4.0	4.0	4.5	3.5	3.5	3.0	4.0	3.5	4.0	4.5
6. Portfolios		4.5	4.5				3.5					4.5
7. Course Objectives Survey	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
8. Performance Appraisals (Oral Evaluation of Capstone Design)							4.0					
9. Performance Appraisals (Posters for CIVL 330 & CIVL 340)		4.0					3.5					
10. Focus Groups	4.5	4.5	4.0			3.5						
OVERALL	4.0	4.5	4.0	4.0	4.0	3.5	3.5	4.0	4.0	4.0	3.5	4.0

Note: The scores are on a scale of 1 to 5, with 5 being the highest level of attainment. The numbers are assigned through faculty consensus in 0.5 increments. The OVERALL score is not based on arithmetic mean but rather a subjective weighting based on faculty input. Interpretations: 4+ meets program goals; 3.5 meets program goals, but with some concern; 3 or lower indicates outcome not achieved for the Academic Cycle; and I indicates incomplete for given item.

The matrix for the 2004–2005 cycle is shown in Table 6. The assessment results for the 2004–2004 cycle were very positive, with minor exceptions. Exit interviews conducted with the Department Chair, as well as the results from Faculty, DAB evaluations, and Focus Group Evaluations indicated that students were very pleased with the Program. The assessment results show that all Outcomes have met the program goals satisfactorily. Based on a 1-to-5-point scale, the OVERALL rating for all the outcomes ranged from 3.5 to 4.5 with an average of 4.1, which is interpreted as meeting the program goals with satisfaction. The OVERALL ratings for outcomes (f), (g), and (k) were 3.5. In-depth analysis of each assessment tool results, as well as the assessment results for each Outcome revealed some areas of concerns. These concerns are discussed below.

First, Outcome (f) meets the Program goals with some concerns with a ranking of 3.5. Focus Groups, Capstone Design Evaluation by Department Advisory Board and by Faculty all had ratings of 3.5. The Department Advisory Board was concerned about the students' understanding of ethical, moral and professional responsibilities as well as the understanding of engineering practice issues including importance of licensure. Although the students showed some understanding of professional and ethical responsibility of an engineer, there were some concerns about the depth of their knowledge.

Second, Outcome (g) had a ranking of 3.5, meeting the Program goals with some concerns. It appeared that the students' communication skills, particularly written skills, needed improvement. The Department Advisory Board was concerned with the quality of the written report submitted as part of the Capstone Design Project. In addition, faculty were not totally satisfied with the written communication skills of the students indicated in Student Portfolios, Posters, and Capstone Design reports.

Third, Outcome (k) met the Program goals with overall ranking of 3.5. The assessment tools provided scores of 4.0 or higher, except for the Department Advisory Board (DAB) Capstone Design Evaluation, and the DAB Interviews. Although the students had been using a number of important software packages (such as AutoCAD, HEC-1, HEC-RAS, WaterCAD, and MDSolids), the DAB expressed concerns about the students' exposure to new tools, particularly the software packages that are currently used in engineering profession. Recognizing the DAB's knowledge and experience in this area, faculty agreed that additional experience involving computer software applications is needed. This decision was made through faculty consensus, and was based on the DAB's experience.

Major improvement areas for the 2004–2005 cycle

Based on the results of the assessment data for the 2004–2005 cycle, there were some concerns about achieving three of the Program Outcomes: (f), (g), (k). Improvement areas were then identified to address these concerns. The improvements, the outcomes they address, sources of input, and percentages of students affected have been summarized in Table 7. In addition to the improvements based on the assessment results, other areas of improvements were also noted. Both types of improvements and their implementations are discussed below.

As mentioned above, three areas of improvements were identified based on the results of the assessment. These improvement areas are discussed below.

IMPROVEMENT NO. 1—INTRODUCE A NEW COURSE IN PROFESSIONAL AND ETHICAL ISSUES

The assessment results revealed that the students' understanding of the professional and ethical issues in engineering practice was limited. As a result, a one-credit-hour course 'CIV 461 (1) Professional and Ethical Issues in Civil Engineering' has been added to address this area.

IMPROVEMENT NO. 2—IMPROVE STUDENTS' WRITTEN COMMUNICATION SKILLS

The assessment results indicated that the students' communication skills, particularly in technical writing, needed improvements. Improve-

Table 7. Summary of improvements for the 2004–2005 cycle

Improvement area	Outcome (s) addressed	Primary source(s) of input	Students affected
Improvement No. 1—Enhance students' understanding of professional and ethical issues. A new course 'CIV 461 Professional & Ethical Issues in Civil Engineering' has been introduced.	f	DAB Capstone Design Evaluation; Faculty Evaluation of Capstone Design; Focus Group Evaluation.	100%
Improvement No. 2—Improve students' written communication skills. Additional writting reports have been incorporated in several civil engineering courses.	g	Department Advisory Board Interviews; Faculty Evaluation of Capstone Design; Portfolios; Poster Presentations.	100%
Improvement No. 3—Increase use of additional software. Several new software packages have been incorporated.	k	Department Advisory Board Interviews; DAB Capstone Design Evaluation.	100%
Improvement No. 4—Introduce probability and statistics applications in engineering. 'MATH 355' has been replaced by 'MATH 307 Probability & Statistics for Engineers'.	N/A	N/A	100%
Improvement No. 5—Increase the number of faculty. Two new faculty members have been hired in Structural Engineering and Geotechnical Engineering.	N/A	N/A	100%
Improvement No. 6—Implement the FE Review course. An FE Review course is now offered.	N/A	N/A	100%

Note: N/A indicates that the improvements were implemented based on factors other than the assessment results.

ment on this issue has been achieved by incorporating additional writing requirements into the following civil engineering courses.

CIV 340 Introduction to Environmental Engineering—In this course, students are required to submit one written report on recent or emerging issues in environmental engineering.

CIVL 421 Structure and Material Laboratory – Students are assigned to write a research report on one of the methodologies for Non-Destructive Evaluation (NDE) of concrete.

CIV 430 Foundation Engineering – Students are assigned group projects, which would require a written report and power point presentation.

CIV 441 Water and Wastewater Treatment Processes—Written reports are required to address the state-of-the-art technologies for water and wastewater treatment.

CIV 460 Design of Environmental Engineering Facilities—A field trip to real-world treatment plants has been scheduled for the students, and written reports about the trip are required.

Improvement No. 3—Use of additional software

Increasing the use of contemporary engineering software in the existing civil engineering courses can improve the students' abilities and skills that are needed for engineering practice. This improvement addresses the Program Outcome (k), which was one of the concerns among the faculty and the Department Advisory Board (DAB). This improvement has been achieved by incorporating additional software packages into the various courses.

CIV 320 Structural Analysis—Computer software, SAP2000, has been introduced and used for solving structural analysis problems.

CIV 380 Introduction to Geotechnical Engineering – Students are assigned problems that require use of Zstress and Consol software. Zstress is used for effective stress analysis and Consol to determine consolidation for different geotechnical engineering scenarios.

CIV 420 Design of Concrete Structures—The software package PCA-Addose for concrete column and beam design has been introduced and used in this course.

CIV476 Advanced Design of Steel Structure—The software package RamSteel has been introduced and used for the design of steel structure systems.

The assessment results and major improvements for the 2004–2005 cycle were presented to and discussed with the students at the Students' Forum on April 29 2005, and the Department Advisory Board (DAB) on October 14 2005.

In addition to the three above mentioned improvement areas (based on the Program Outcome assessment results),other improvements have been implemented. These improvements were needed for fundamental improvement and evolution of our Program. These improvement areas and implementations are discussed below.

IMPROVEMENT NO. 4—INTRODUCE A NEW COURSE IN PROBABILITIES AND STATISTICS FOR ENGINEERS

A new course 'MATH 307 (1) Probabilities and Statistics for Engineers' was added to the curriculum. The Department of Civil and Environmental Engineering worked closely with the Department of Mathematics to jointly develop this course. This course has replaced the 'MATH 355 (3) Probabilities and Statistics'. MATH 307 has been designed to also address applications of probability and statistics in various engineering disciplines, which was not covered in MATH 355. The faculty agreed that this change could improve the students' ability to apply probability and statistics to solve engineering problems.

IMPROVEMENT NO. 5—INCREASE THE NUMBER OF FACULTY MEMBERS

The Department had three full-time faculty members, one half-time (joint) faculty member, and a Chairman. At least two additional full-time faculty members were needed with expertise in structural and geotechnical engineering. This was to reduce the dependency on adjunct faculty and assure quality education, full time advising, and better interaction for students.

IMPROVEMENT NO. 6—OFFER AN FE REVIEW COURSE

Based on student and faculty recommendations, the FE Review course is offered during the Spring semester to prepare students for the Exit Exam as well as the FE Exam. Dr. Lin Li is the Coordinator of the FE Review course. The FE Review courses will be offered, tentatively at the end of March, over a three-week period. Classes will be offered in the evening, from 5 to 8 p. m. Each class will cover one or two areas in the FE Exam. Various faculties will be assigned review classes based on their expertise. Faculty agreed to offer Review classes in the areas of Mathematics, Chemistry, Statics, Dynamics, Mechanics of Materials, Structural Analysis and Design, Fluid Mechanics, Hydraulics and Hydrologic Systems, Environmental Engineering, Transportation Engineering, Soil Mechanics, Foundation Engineering, Construction Management, Thermodynamics and Materials Science, Ethics, and Engineering Economics.

Assessment of effectiveness of improvements implementation for the 2004–2005 cycle

In order to evaluate the effectiveness of the implementation of improvements, an assessment of the level of improvements has been made. This was primarily accomplished using a factual-based questionnaire which was filled in by all graduating senior students in our Program. The senior students evaluate the effectiveness of the implementation using the scale provided, with 5 being very effective, and 1 being not effective at all. The form also provides space for comments. An average score of 4 or above indicates that the implementation meets the program goals, while a score of 3.5 shows that the implementation meets the program goals, with some concerns. In addition to the five significant areas of improvements, the program also implemented the FE Review course, offered during the period March 27–April 12 (four days a week, three hours a day). The results of the evaluation of the assessment are summarized in Table 8. In addition, the assessment results provided some indication of the effectiveness of the improvements. In particular, the course objective surveys have been used to evaluate Improvements 1, 2, 3, and 4. The assessment

Table 8. Assessment of effectiveness of implementation of improvements

Improvement area	Average score	No. of students responding
Improvement No. 1—Enhance students' professional & ethical issues. A new course 'CIV 461 Professional & Ethical Issues in Civil Engineering' has been introduced.	4.5	100%
Improvement No. 2—Improve students' communication skills. Additional writing reports have been incorporated in several civil engineering courses.	4.5	100%
Improvement No. 3—Increase use of additional software. Several new software packages have been incorporated.	4.5	100%
Improvement No. 4—Introduce probability and statistics applications in engineering. 'MATH 355' has been replaced by 'MATH 307 Probability & Statistics for Engineers' for new students.	4.0	37%
Improvement No. 5—Increase the number of faculty. Two new faculty members, in Structural Engineering and Geotechnical Engineering, have been hired.	5.0	100%
Improvement No. 6—Offer the FE Review course. An FE review course is now offered.	3.5	91%
Summary of comments: The FE review course should be offered earlier.		

Note: The scores are on a scale of 1 to 5, with 5 being very effective. The average score represents the average score for all senior students who responded to a particular question. Interpretation: 4+ meets program goals; 3.5 meets program goals, with some concerns; 3 or lower indicates that the improvement was not achieved.

results for the 2005–2006 cycle have indicated notable improvements in students' performance in the improvement areas 1,2, and 3. For example, the students' understanding of the professional and ethical issues, written communications skills, and students' ability to use various software have been enhanced.

These results indicate that the implementations of the improvements have been highly effective for all improvement areas, except Improvement No. 6. The main concern, as stated by most students, was that the FE Review course should be offered earlier. This concern has been addressed by a commitment to offer the Review course approximately six weeks earlier, beginning in early February. Other changes to the FE Review course were discussed earlier.

CONCLUSIONS

Recently created new engineering programs face unique challenges during the assessment process. The new engineering program will not only need to be mentored to mature itself in a very short time, but must also provide momentum for the program to move forward. To address the educational challenges and to obtain meaningful results, alternate assessment techniques may have to be developed. Some of the elements of the assessment process include:

- more emphasis on external assessment;
- inclusion of quick turn-around data;
- inclusion of a large number of assessment tools;
- inclusion of several components within some assessment tools; and
- implementation of short-cycle improvements.

Owing to the limited historic data and small class sizes, it is critical that the new programs aim for 100% participation by both faculty and students during the assessment process. This will result in additional data for measurement, assessment, and evaluation.

Careful planning during the initial stages of the Program development is the key to a successful assessment. The establishments of a Department Advisory Board and a Department Assessment Committee during the initial stages of the Program have proven to be very effective. The planning must be flexible enough to accommodate Program changes, and should adopt various features of any meaningful assessment plan that are appropriate to that particular program at the institution. The planning must then be followed by systematic implementations.

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Farshad Amini is professor and founding chair of the Department of Civil & Environmental Engineering at Jackson State University. He is the author of more than 100 published articles, and has been principal investigator of more than twenty fine major research grants from such organizations as the U.S. National Science Foundation (NSF), Army Research Office (ARO), Air Force Office of Scientific Research (AFOSR), Navy Department Defense (DOD), U.S. Geological Survey (USGS), and the Mississippi Department of Transportation (MDOT). He has developed new undergraduate and graduate programs in Civil Engineering at Jackson State University. Dr. Amini is active in engineering program assessment, and has developed new assessment schemes.

Shikha Rahman is assistant professor in the Department of Civil & Environmental Engineering at Jackson State University. She received her Ph.D. degree from the Georgia Institute of Technology. Her research areas include open channel hydraulics, sediment transport, turbulence, and environmental hydraulics. She has published her research in such journals as the *Journal of Engineering Mechanics*, *ASCE*, *Experiments in Fluids*, and *Limnology and Oceanography*. Dr. Rahman is active in engineering program assessment.