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# Keeping the Flame Alive: What Happens AFTER the ABET visit

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## I. Introduction

In the United States, engineering programs are accredited by ABET, the Accreditation Board for Engineering and Technology. The Board is made of representatives from each of the various professional societies such as the American Institute of Chemical Engineers, the American Society of Mechanical Engineers, etc. Over the past ten years, ABET has developed a new and comprehensive program to accredit undergraduate engineering programs. The Clark School of Engineering elected to go through their most recent accreditation visit under the new ABET criteria in 1998….the first year the new criteria was in place. One critical difference between the old and the new accreditation process is the focus on outcomes. Prior ABET attention had been directed towards input: what instructors provided students in the classroom, etc. The new focus is on what students have learned as a result of the instructors' input…or learning outcomes. Specifically, ABET identified eleven learning outcomes (see below) as well as mandating that "on-going" evidence be required that engineering students were achieving these outcomes.

Variously described as "a-k", learning outcomes, criteria 3, to name a few, the actual eleven outcomes are striking in their appropriateness and relevance to what engineering education should produce in the well qualified engineering professional. Of these, most engineering faculty would assume that the completion of the usual undergraduate curriculum would accomplish: "the ability to apply knowledge of mathematics, science and engineering; the ability to design and conduct experiments analyze and interpret data; design a system, component or process to meet desired needs" as well as the "ability to use the techniques, skills and modern engineering tools necessary for engineering practice." The more radical advance of ABET is the inclusion of the following as important outcomes of an **engineering** education:

"the ability to function on a multidisciplinary team"
"the ability to communicate effectively"
"an understanding of professional and ethical responsibility"
"the broad education necessary to understand the impact of engineering solutions in a global and societal
contest"
"a recognition of the need for an ability to engage in life-long learning"
"knowledge of contemporary issues"

The purpose of the present paper is to describe the process that was put into place to ensure the initial and on-going measurement of data to provide evidence that a-k outcomes were being achieved in each of the ten accredited program in the Clark School. Now more than two years since the initial visit, we will also describe our efforts to **keep** programs involved in the assessment process, highlighting the Mechanical Engineering department's work.

## II. The Assessment Process at Maryland

The A. James Clark School of Engineering of UMCP is a leader in undergraduate education. Highly ranked in the *US NEWS and WORLD REPORT*, the Clark School prides itself on innovation in the classroom, beginning with the first course. ENES 100 is a first-year engineering design course that allows students to work in small teams and develop engineering solutions to practical problems. Students have specified budgets and have other "real life" constraints such as deadlines. Basic engineering principles are taught as students design and construct a project such as a wind powered water pump, or a solar cooker. Ingenuity, creativity and teamwork are the basic ingredients of a successful project. Field trials and a friendly design competition are celebrations of hard work and sound engineering. Other required courses are increasingly including team based projects as a part of their execution (such as Strength of Materials and Statics).

Students have the opportunity to participate in research activities throughout their undergraduate degree program. In addition, some elect to participate in the student Co-Op, spending a semester each year working fulltime in an professional engineering capacity. Finally, there is a strong culture of student organizations and competitions which encourage undergraduates to apply classroom learning to various real-world problems or design constraints. Thus there are many opportunities, both within the context of the traditional classroom as well as outside, for students to master the skills demanded of the modern day engineer and as required by ABET.

Documenting learning outcomes has been a joint effort on the part of the School and the individually accredited programs (N=10). Early on in the process, a committee was established of representatives of the Dean's staff and each program. This committee determined that while there were unique programmatic aspects that required unique assessment, there were other outcomes that "cut across" programmatic specialties. So to that end, the Director of Student Research was charged with creating and coordinating assessment for the college (as described below). Individual departments also assessed their majors as they wished. The work of one ABET accredited program (Mechanical Engineering) will be described in Section III.

Assessment surveys were designed for entering freshmen, graduating seniors, and School alumni (one year and five years after graduation). The freshman and senior surveys were designed with input from a campus assessment expert, the School's Teaching and Learning Committee, as well as input from the Center for the Study of Higher Education at the Penn State University. Freshman data are updated annually in ENES 100 and provide a baseline of what incoming student see as their levels of confidence in engineering and disciplines such as mathematics, physics and chemistry. Graduating seniors are again surveyed as they complete their senior audit.

The same items are repeated as the Freshman Survey in order to obtain measures of gain on various important learning outcomes. In addition, School alumni are surveyed on an every two year cycle. The data from all of these iterations are maintained in a permanent database from which program reports are generated. Since this process was established, feedback has been provided annually to each accredited program for use in their feedback loops for instructional improvement.

Also at the collegiate level, a survey process of recruiters and other employers of our undergraduates was established. A one-page survey was designed to be consistent with our freshmen, senior and alumni surveys. Potential employers were asked what skills, habits and knowledge areas they were looking for in qualified applicants. They are also asked to rate the candidates they have interviewed as a group in terms of how well the group matched the criteria they were looking for. Further, employers are asked which types of engineering majors they are recruiting and if they have found significant differences in preparation of the applicants by major. Surveys are collected through the Co-Op office and the university's Career Center. In addition, chairs were supplied with copies of the survey for use in their own career related events. Finally, at the "half way point" in the six year accreditation visit cycle, the Director of Student Research will both initiate an additional comprehensive survey of engineering employers which will be mailed and made available on the web for ease of completion.

The college administered surveys are given to engineering students at key intervals in their educational experience in the School. The purpose is to establish from the point of view of the students themselves, how they assess their own competence and mastery of specified learning outcomes. These are "big picture" assessments which occur as the result of many learning experiences: both in and out of the classroom. Also of interest to the ABET committee (as well as faculty members) were the learning outcomes achieved as the result of participation in individual courses. Therefore, the School's standard course evaluation form was revised to take into account student learning outcomes as well as traditional questions related to teacher effort and classroom logistics.

While the course evaluation form may be used in a variety of ways depending on the intentions of the instructor and the program with which s/he is associated, most instructors identify specific learning outcomes that **should** occur as a result of that particular course. No one course is expected to produced gains in all eleven a-k learning outcomes. Students rate their degree of learning along specified outcomes, marking "not applicable" on items not addressed in the course. Instructors are given a semesterly report where they receive the averages of their class on these outcomes as well as more traditional measures of classroom effectiveness. At the end of the semester when student feedback has been analyzed, faculty are asked to review their initial intentions and discuss the degree of congruence with student ratings. Some departments have instigated systems where courses that fall below certain pre-determined cut-offs on specified outcomes are identified for review by the program chair and possible remedial action. Since all courses fit into each program's overall learning objectives, some departments annually review targeted outcomes to ensure that they are being met.

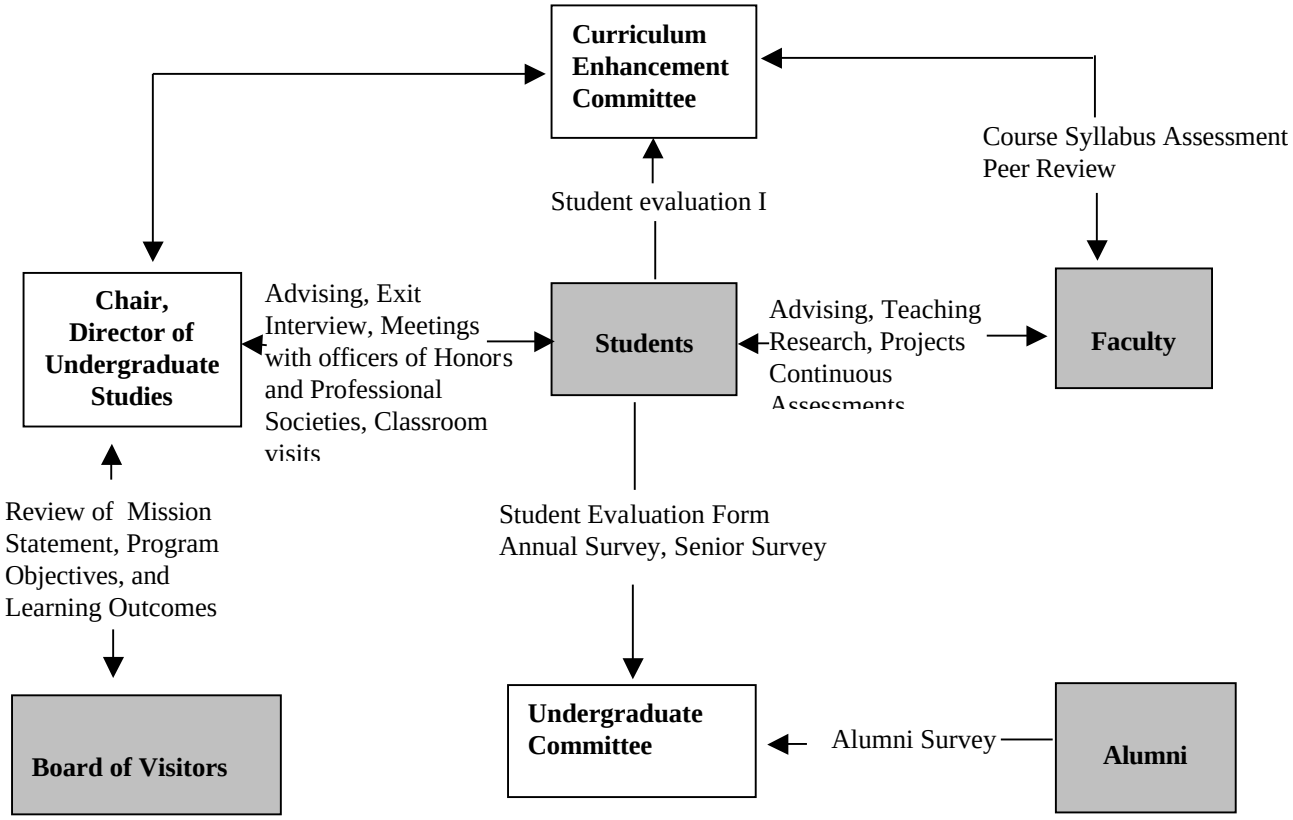
In sum, the Clark School has an on-going cycle of assessments administered at the college level which includes a baseline freshman survey, an exiting senior survey, alumni follow up, as well as input from recruiters and employers who hire our students. In addition, the School requires that instructors determine the learning outcomes for each course and obtain feedback on how well students think the course is assisting them in achieving these outcomes. The more global assessments and specific course feedback from course evaluations are annually given to each department ABET coordinator for use in departmental committees related to on-going instructional improvement. In addition, the Associate Dean for Education chairs an annual meeting where program activities are reviewed and "best practices" shared among representatives of the college. ABET accredited programs are required to write a two page update of their on-going activities in preparation for this regular meeting.

## III. Keeping the Flame Alive in Mechanical Engineering

The Mechanical Engineering program review and assessment process consists of different activities, see figure 1. These activities include continuous assessment by two faculty committees of the teaching/learning process in the Department, continuous assessment by individual faculty as well as faculty groups in specific areas, continuous assessment by the Department Chair and the Director of Undergraduate Studies, and assessment based upon input from the outside including employers and Board of Advisors.

Prior to the Abet "visit" the Department reconstituted two existing committees to oversee the evolution of the undergraduate education process. The Undergraduate Committee was charged with the responsibility of the overall program evolution; the Curriculum Enhancement Committee was charged with the improvement of the teaching/learning process at the course level. The responsibilities and activities of each committee will be described below.

Figure 1: Mechanical Engineering
Process for Program Review




III. 1. The Undergraduate Committee

The Undergraduate Committee includes the Director of the Undergraduate Program, the faculty Advisors for the ASME, ASHRAE and Pi Tau Sigma, and the ABET Coordinator. The mission of the committee, by approval of the faculty, is to oversee and direct continuous improvement of the Mechanical Engineering curriculum consistent with the departmental Mission Statement and the Program Objectives. The committee's first activities were to review the Department mission statement and program objectives. Using the ABET 2000 Criterion 3 and the Department Program Educational Objectives as a guide, the committee devised the Student Learning Outcomes . These outcomes were then correlated with the questions in the College's student course evaluation form (described above) and with the ABET 2000 Criterion 3. In addition, the Committee regularly conducts the following reviews:

Reviewing the semester course evaluations from the program point of view, to insure that the program is being delivered as stated and identify areas for improvement.

Reviewing the results of the College administered Senior Survey

Reviewing the results of the College administered Alumni Surveys, and use the results to help direct the improvement of the Mechanical Engineering program.

III.2. Using the Course Evaluations to Improve Practice

Unlike most typical course evaluations that focus on characteristics of the classroom and student satisfaction with the instructor, the Clark School course evaluation section includes a section devoted to the assessment of student learning outcomes. Students rate the degree to which the class adequately addressed a-k type outcomes. In Mechanical Engineering, these outcome data are presented as histograms representing the responses of the sophomores, juniors and seniors. What is recorded is the percentage of students whose ratings were greater than or equal to three on a scale of 0-4. Examples of these plots are shown in figures 3 and 4. The replies to " the ability to design and conduct experiment has improved", Figure 2, range from .20 for sophomores to .44 for juniors to 0.49 for seniors. It is reasonable that the biggest jump in this question would be in the junior year where the majority of the basic courses and encountered. Similarly, the improvement in the both "My ability to write and speak effectively", Figure 3, both increase sharply for each year. This is expected from the team project courses and the opportunities to present in each year of the program, increasing into the senior year. Thus, the data provide empirical support for the department learning outcomes. Note, the data for each outcome by class level is determined every semester (and added to charts such as Figure 2) so that by the time of the department's next ABET visit, we will have a solid record tracking where and how well in the curriculum various student learning outcomes occur.

Figure 2: My ability to DESIGN and CONDUCT EXPERIMENTS has improved

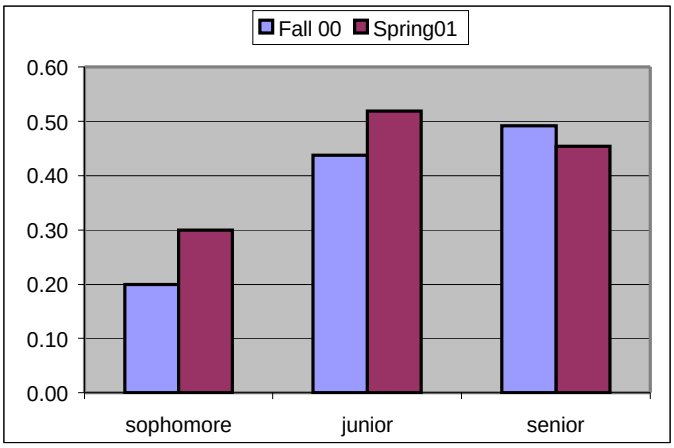



Figure 3: My ability to SPEAK EFFECTIVELY has improved

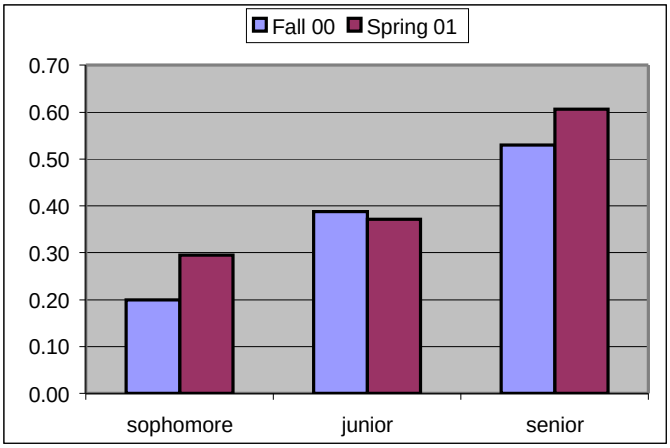
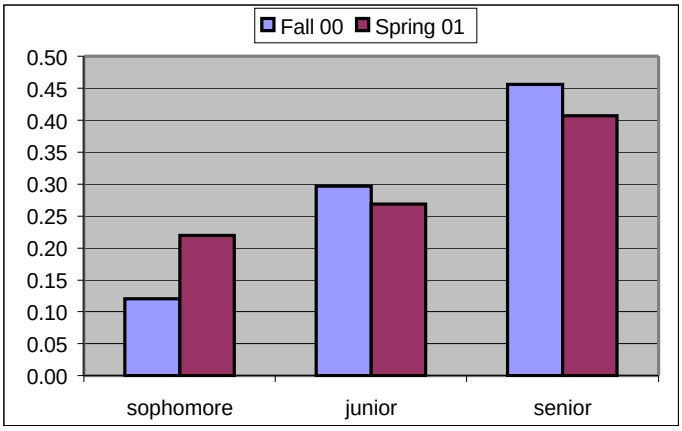



Figure 4: My ability to SPEAK EFFECTIVELY has improved




III. 3. Using the Alumni Survey in Mechanical Engineering

The first alumni surveys were distributed to two groups of alumni. These groups are the graduates from 1990/91 and from 1995/96. The alumni were asked to rate their *competency* in twenty-two areas (outcomes) dealing with knowledge, abilities, skills, experiences, and habits. They were then asked to rate the *importance* of these areas to their professional success.

These survey results have been reviewed by the Committee. It was felt that a comparison of the alumni's perceived level of importance of each area with their perceived level of competence in that area would be of considerable value. In order to plot this, letters were assigned to each area (outcome). These outcomes were then plotted as a scatter map with the perceived level of importance as the ordinate and the perceived level of competence as the abscissa. The ideal result would occur when all letters fell upon a diagonal line. This would indicate a match between importance and competence. This type of information is quite useful to our department as the committee evaluates our curriculum through the eyes of recent graduates.

The outcomes rated "most important" for both groups of alumni were:

N Interpersonal Communications

S Professionalism
J Problem Solving
O Teamwork
K Creative Thinking

This is also quite pleasing since the Mechanical Engineering curriculum stresses these outcomes. Several courses are organized around open-ended problems requiring the students to develop their skills in the above listed outcomes. Examples are ENME 371, Product Engineering and Manufacturing and ENME 472, Integrated Product and Process Development.

Although there is general agreement between the two alumni groups in most of the areas, there are a few areas where the difference is notable. Among the areas that the 1990/91 alumni perceived to be of more importance than the 1995/96 alumni were:

S Professionalism
T Social Awareness
V Appreciation of Diversity

A possible explanation is that these engineers have been in the workplace for five years and have become more aware of the importance of these outcomes as they move into supervisory positions. Among the areas that the 1995/96 alumni perceived to be of more importance than the 1990/91 alumni were:

D Engineering Skills- Basic
E Engineering - Discipline Specific Skills
J Problem Solving
K Creative Thinking
O Teamwork

These outcomes may be associated with the assignments given to entry level engineers and it seems logical that they rate their importance quite high.

The Committee anticipates that further discussion will occur and that refinements will be made in the survey itself and in our analysis and interpretation of the results.

III. 4. Using the Senior Survey in Mechanical Engineering

The educational outcomes questions on the Senior Survey are the same as the Alumni Survey. The highest rated competencies *senior*s about to graduate were as follows:

J Problem Solving,
D Basic Engineering Skills
S Professionalism
E Engineering –Discipline Specific Skills
O Teamwork

The list shows the emphasis that is being integrated into the ME curriculum. The courses that have major open-ended project and team components contribute to the high ratings in terms of J, K and O. The industrial interaction that is present in the curriculum may be the source of the high rating by the students in terms of professionalism, although their interpretation is not clear to us. The results also show that although the curriculum prepares the students well for the initial years after graduation, some adjustments could be made to prepare the students for the long-term profession needs. This would include an expansion of course material related to management and interpersonal communication. Thus the Alumni and Senior Surveys, used in combination, provide valuable information for the on-going improvement of the undergraduate program.

III. 5. Curriculum Enhancement Committee

This second major departmental committee is chaired by a senior faculty member and includes seven faculty and the Director of the Undergraduate Program. The mission of the committee is to develop institutional practices for the on-going evaluation and improvement of the teaching/learning process in the Mechanical Engineering Department. The Committee's responsibilities include:

> *Peer review*: creating a process where faculty review and assist their peers in the enhancement of teaching undergraduates.
>
> *Teaching evaluation review:* establishing a methodology for using the teaching evaluations to give specific feedback to the faculty and show overall trend of the department as a whole.
>
> *Course syllabi review*: includes reviewing the course syllabi and course notebooks in order to suggest improvements.

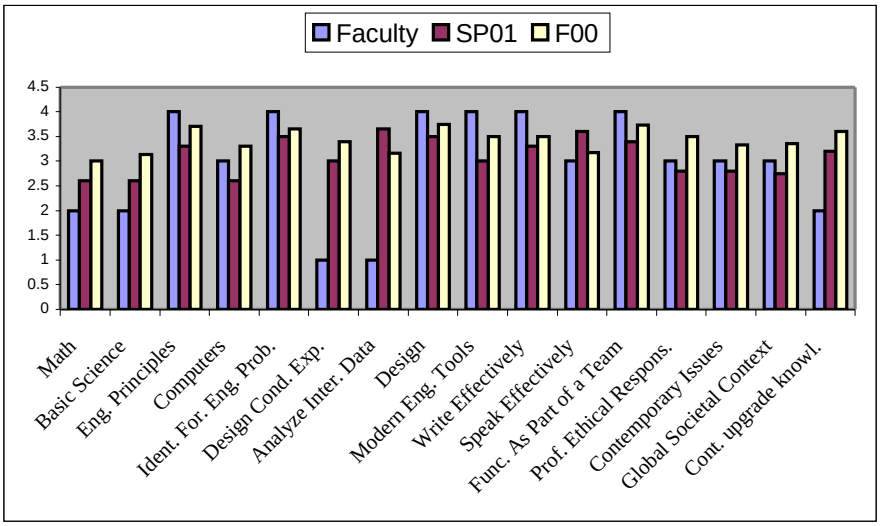
Based upon the committee recommendations, the Department adopted an implementation plan that includes the on-going course, peer and syllabus evaluations described below.

***Courses*** are evaluated according to the following procedure: the Curriculum Enhancement Committee reviews the results of Part I of the course evaluation for each instructor. Part 1 items consist of the student's evaluation pertinent aspects of the course and instructor behaviors. These results are compared to the department average on these items and courses with lower than average performance are then referred to the Syllabus Evaluation Sub-Committee for further review.

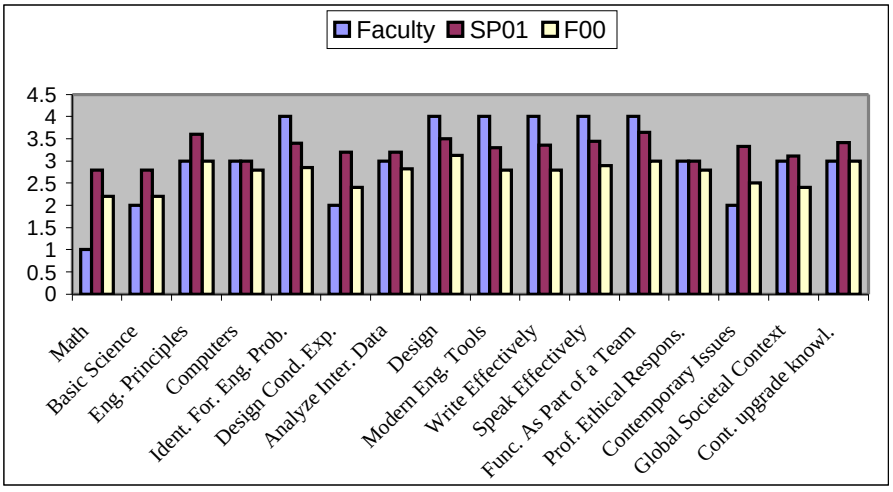
One of the activities that has been instituted to provide continuous improvement to the teaching process is that of faculty pre-scoring their course with respect to the Student Learning Outcomes. That practice clarifies for the faculty where they are focusing their efforts in the course and for the program to determine the coverage of all of the Student Learning Outcomes by the sum of the courses in the curriculum. The student outcome data (from Part II of the course evaluation) is reviewed by the committee as follows. Each faculty member is asked to compare their expected evaluation of the student learning outcomes to the actual students ratings, describe the success of

their course in fulfilling its objectives, address any discrepancies, and make recommendations. Examples of theses are presented in Figures 5 and 6 below:

ENME 472: Integrated Product and Process Development




ENME 371: Product Development




The Committee has also established a department-wide program where every faculty is involved in the ***peer reviewing process***. The faculty was divided into 10 groups of approximately 4 faculty each. Each group performs a sequential peer review of all the members in that group and reports to the Curriculum Enhancement Committee.

The goal of the evaluation process is to provide constructive comments and feedback to the faculty about how they might improve their teaching format, presentation, organization, and interaction with the students. The idea is that by working together in small informal groups, new innovations in presenting material and teaching pedagogy can be rapidly implemented and

improved. The plan aims at fostering collegiality and providing positive feedback and interactions between the members of the teams, in particular, and all of the faculty in general.

The procedure for the evaluation is structured as follows:

*Self-evaluation*. In order to provide the other three members of the group with a basis to provide constructive input, the faculty being evaluated provides a self-evaluation statement which describes his/her objectives for the course, means for assessing the success of the objectives, and an analysis of the strengths and weaknesses of his/her current teaching style. In addition, results of a mid-semester student survey are provided, and a course syllabus.

*Class Visit:* At least once during the semester, the team members visit the course, either as a group or individually, to observe the class dynamics and presentation of the material.

*Discussion*: The group then schedules a time to discuss their observations and provide feedback to the faculty being evaluated.

*Summary Report*: A final report is prepared by the faculty member being reviewed which incorporates the initial self-evaluation, written comments by the reviewers, and written summary by the faculty member describing his/her view of the reviewer comments and how the comments have led to changes in the course.

The ***course syllabus*** represents yet another an important document in the teaching/learning process. The subcommittee instituted the following process for improvement of the syllabus/education process:

The assessment plan focuses on two course syllabi per academic year.

The academic advisor, chair and committee provide the suggestions on the priority to ensure that assessment efforts be effectively used.

The course instructor is included in the review team.

The review team works to identify those parts demonstrating the teaching effectiveness, and those parts that call for further improvement.

The review team prepares a summary report. The report includes two versions of the course syllabus, i.e., before and after, and the evidence of improvement in terms of student learning outcomes. The report is then submitted to Curriculum Enhancement Committee for review and approval.

IV. Summary and Lessons Learned:

This paper describes the on-going efforts of one department (Mechanical Engineering) to "keep the flame alive" or keep the focus on student learning *after* the pressure of an actual accreditation visit. Given the natural competing priorities in any engineering department, a

commitment must be made on the part of both the College and individual departmental programs to not only keep the flow of student data going but also to use that information for the continuous improvement of educational practices. The ME example provided suggests that administrative structures (two key committees) be set up to monitor selected key educational activities: the achievement of expected learning outcomes (at the course and program levels), and the quality of "input" as reflected by syllabi content and instructor pedagogical skills. These committees systematically The Director of the Undergraduate Program has a vital role in maintaining the data analyses and creating the trend lines that will provide the evidence of achievement of student learning outcomes for the next ABET visit. The College provides data to the department for their analysis and use. Furthermore, the College periodically invites program representatives from each department to share their evolving approaches to the assessment of student outcomes. Sharing "best practices" across the College helps keep the programs motivated and open to new approaches as they monitor their own progress and develop materials for the ***next*** ABET visit.

Dr. Sami Anaine, Director, Undergraduate Affairs, Mechanical Engineering, Clark School of Engineering. Dr. Anaine has played a major role in the use of student learning outcome data for policy and program changes in that department. He serves on major ME committees devoted to ABET concerns.

Dr. Gary Pertmer, Associate Dean, Student Affairs, Clark School of Engineering, has extensive experience in ABET related issues at the college level.

Dr. Janet A. Schmidt, Director, Student Research, Clark School of Engineering. An educational psychologist, Dr. Schmidt has been responsible for developing a battery of student learning instruments and an on-going program of data collection for ABET assessment purposes.