9. NAVAL ARCHITECTURE AND MARINE ENGINEERING

Program Outcomes and Assessment

The College and each program are currently engaged in implementing the recommendations of Michigan Curriculum 2000. This section of the Self-Study reports on the progress of implementation, the specific objectives and outcomes of the individual courses forming the new curriculum, and describes our assessment plans that have been adopted to gage the success of the new curriculum and to guide improvements to it.

9.1 NAME Program Outcomes

As mentioned previously, by January 1997, each NAME course had been assigned a lead faculty member and a coordinating Academic Affairs Committee member who were responsible for developing preliminary course outlines. The Academic Affairs Committee member's primary responsibility was to ensure that a course was developed to contribute appropriately to the program as a whole. The lead faculty member's primary responsibility was to ensure that the course covers the essential materials relevant to the course's engineering topics. Specific course objectives thereby evolved and by February 1998 both objectives and outcomes were being identified for each course. In May 1998 the set of course objectives and outcomes for all undergraduate NAME courses were reviewed by the faculty.

One of the major requirements of the courses as a whole was to provide, through their synthesis, a means of achieving the following program outcomes which are based on our program objectives (the outcome's relation to ABET Criterion 3 and to Program Criterion 1 follow in the brackets):

1. an ability to apply knowledge of mathematics, science, and engineering within naval architecture and marine engineering [ABET: 3a];
2. an ability to formulate engineering problems and develop practical solutions [ABET: 3e and 3k];
3. an ability to design products and processes applicable to naval architecture and marine engineering [ABET: 3c];
4. an ability to design, conduct, analyze, and interpret the results of engineering experiments [ABET: 3b];
5. an ability to work effectively in diverse teams and provide leadership to teams and organizations [ABET: 3d];
6. an ability for effective oral, graphic, and written communication [ABET: 3g];
7. a broad education necessary to understand the impact of engineering decisions in a global/societal/economic/environmental context [ABET: 3h];
8. an understanding of professional and ethical responsibility [ABET: 3f];
9. a recognition of the need for and an ability to engage in life-long learning [ABET: 3i];

10. a broad education necessary to contribute effectively beyond their professional careers [ABET: 3j];
11. a sense of responsibility to make a contribution to society [ABET: 3f];
12. an ability to apply probability and statistical methods to naval architecture and marine engineering problems [Program: 1a];
13. an ability to apply basic knowledge in fluid mechanics, dynamics, structural mechanics, material properties, hydrostatics, and energy/propulsion systems in the context of marine vehicles [ABET: 3a; Program: 1b];
14. a familiarity and experience with instrumentation appropriate to naval architecture and marine engineering including experiment design, data collection, data analysis, and formal laboratory report writing [ABET: 3b; Program: 1c];
15. an understanding of the organization, methods and techniques of marine system manufacture and the use of concurrent marine design [ABET: 3k];
16. an understanding of and experience in marine system conceptual and preliminary design using industrial capability design software, including a team design experience with formal written and oral presentation [ABET: 3c and 3g].

Our students, having developed such abilities and understanding can then be prepared for professional practices as described in our educational objectives:

- Prepare engineers for professional practice in the design and manufacture of vehicles to operate in the marine environment. Primary emphasis is on the scientific, engineering, and design aspects of ships, small boats, and craft, and also submersibles, platforms, and other marine systems. The program also emphasizes the ability to work effectively in teams and culminates with a major team design experience.

- Prepare students for professional practice in the marine industries, for further graduate study, and for life-long learning.

The relationship between our program outcomes and those of ABET Criterion 3 is very important but quite straightforward. Criterion 3 states that engineering programs must demonstrate that their graduates have:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

There is nearly one-to-one correspondence between our outcomes 1, 2, 4, 5, 7, 8, 9, 10 and 15 with ABET Criterion 3 a, e , b, d, h, f, i, j, and k respectively. Our outcomes 5, 7 and 10 are somewhat broader in description than the corresponding ABET criteria d, h and j respectively. We consider our outcome 11 a more specific component of ABET criterion 3f. Our outcomes 2 and 15 are much the same as ABET outcomes e and k although the combination of 2 and 15 compare even closer with the combination of e and k. In a similar fashion, our outcomes 3 and 6 can be interpreted as essentially the same as ABET criteria 3c and 3g respectively although we also require their incorporation (effective design and communication) in our outcome 16. Our general approach therefore is that achieving or satisfying ABET outcomes must be judged in light of also achieving the corresponding NAME program outcomes. This approach also is used throughout our outcomes assessment processes as described later in this section.

The objectives of the program courses are established based on providing the students a means of achieving our program outcomes. In the development of our new curriculum, designed within the framework of Curriculum 2000 as discussed in the previous section of this self-study, the objectives and educational outcomes were established in what we refer to as our Step I efforts. Our Step II efforts involve development of objectives, outcomes and assessment tools for each course within the department. The course objectives are developed based on our program outcomes, and the course outcomes are developed based on the course's objectives. The course outcomes are linked directly to the course objectives. Also listed are the assessment tools for the course and the specific outcomes for which they are used. Step II templates for all of the NAME program's undergraduate courses have been developed and are updated on a continual basis.

To assist us in ensuring that our graduates, through successful completion of our curriculum, achieve the program outcomes, we have established a cross reference of outcomes with each NAME undergraduate course. We have linked each outcome with the courses bearing a strong or modest relationship to the outcome. The relationship is further defined by linkage with specific course outcomes (which appear in the course Step II template). Each course outcome has associated with it a set of assessment tools used to appraise the student's level of achievement of the outcomes. The following tools are used for course outcomes assessment:

- course projects
- course evaluations
- case studies
- exams and quizzes
- final examinations
- homework
- laboratory exercises
- laboratory reports
- mid-term examinations

- oral presentations
- student portfolios
- team project reports

Our senior design course NA475 also includes student development of design notebooks, contract design packages, individual team member assessment of other team members, and final oral presentations to a faculty jury.

In 1998 we revamped our approach to student course evaluation as an assessment tool to more effectively assess our program outcome achievement in addition to the more traditional approach of targeting primarily the individual course and instructor. This approach was based on the linkage of the course with the program outcomes. We required specific questions to be asked on the evaluation forms for any program outcomes related to the course. These results can then be used in assessment of the achievements of our students regarding the individual course and collectively regarding program outcomes achievement.

To further assist us in obtaining feedback information for improving the program at the course level, we now require that each instructor of the individual courses evaluate the success of the course and the course content, and communicate this information to the Academic Affairs Committee and the faculty at large. This end-of-term course assessment summary tool was introduced in the Fall of 1998 as a means of efficiently providing this information and has already met with considerable success.

9.2 Assessment Processes

In overview, the processes used to ensure that graduates have achieved our program and course outcomes have the generic form shown in Figure 9.1. The program or the individual courses are designed and implemented to achieve particular outcomes based on the objectives of the program or course. Following implementation, assessment is performed based on these documented outcomes. A more detailed example schematic presentation is shown in Figure 9.2 for the course level. The figure does not necessarily show the complete detail, nor do we attempt to fit our processes to conform to such a template; Figures 9.1 and 9.2 (and Figure 9.3 to follow) are nonetheless representative and help in the description of our assessment processes.

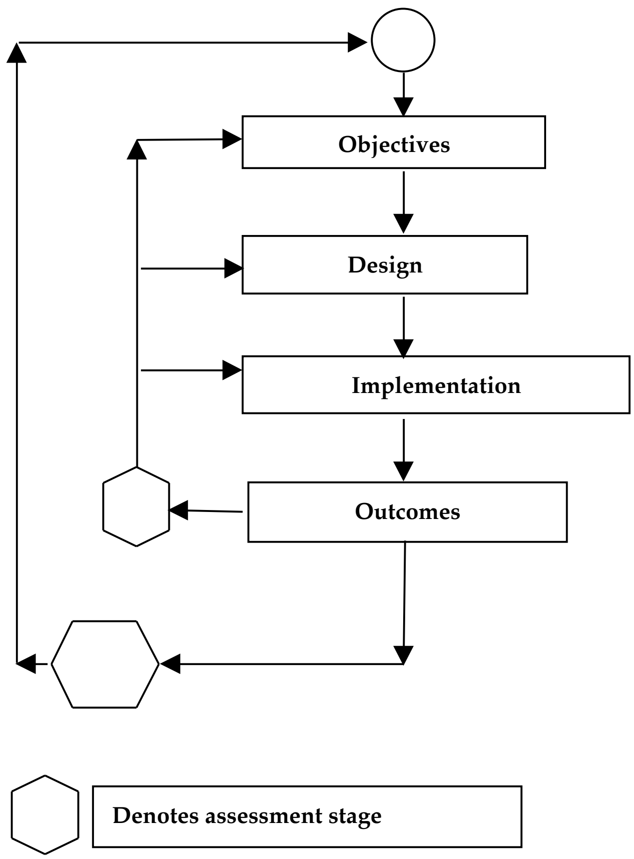

Figure 9.1. NAME Generic Assessment

Many aspects of instruction are at the discretion of the individual faculty members to make immediate improvements in the design and implementation of their particular courses. Exams, quizzes, term projects and reports remain an essential feature of assessing the student's achievement of outcomes and technical competence. This level of assessment therefore remains within the local level of course-student-instructor (Figure 9.2), and communicated to the program level primarily through course grading and the pass/fail system. An important aspect of good teaching is of course being able to respond individually to students on this local scale and to ensure that day-to-day and class-to-class activities flow properly and that classroom achievement is at an appropriate level. The processes of course evaluation and assessment by the faculty (both NAME and the College Curriculum Committee) as discussed previously are shown in the outer loop of Figure 9.2.

The assessment tools used for individual courses are listed in the Step II templates. Examinations, homework assignments, and project reports are common tools used by the instructors to evaluate the students' competencies in various outcomes for the courses. We have collected samples of these data. For some individual students within a course, we developed a portfolio of their work which includes all of the quizzes, examinations, reports, etc. for that course. These portfolios were assembled for program courses during the academic year 1998-1999 and are available for review.

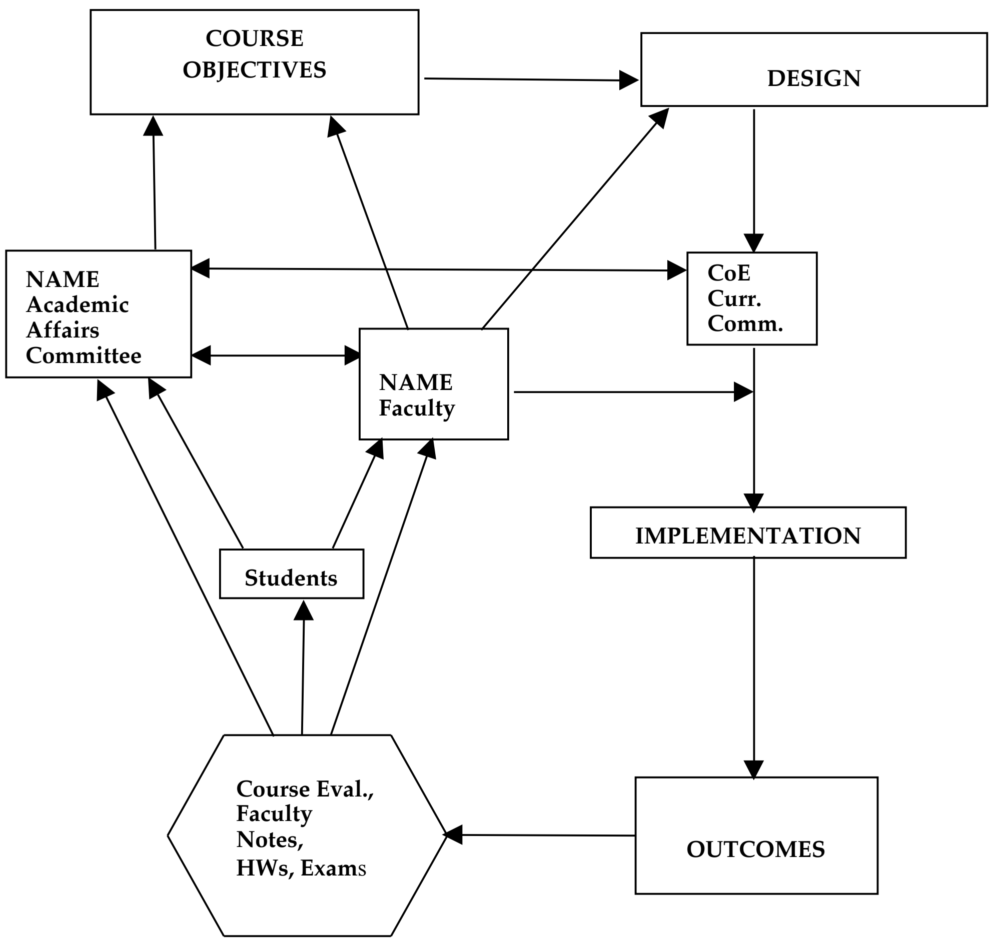

Figure 9.2. NAME Course Level Assessment Processes

Much of the additional detail of the operations associated with our program curriculum design, implementation, and assessment can be seen to be summarized within Figure 9.3. Within the inner-most loop, the program objectives are developed and may be modified based on the assessment of the evolving needs perceived by the faculty and students of the department. Some program changes such as degree requirements, number of credits for courses, prerequisites, or substantial changes in course content must also be assessed at the College level through the Curriculum Committee; these changes are communicated via our department Academic Affairs Committee. At another level, our program is reviewed and assessed by the Dean and Executive Committee of the College, for example through our five-year review process, hiring of faculty, etc. At still another level our other constituents are involved through national advisory board meetings, professional society involvement, conference attendance and other activities on and off the campus.

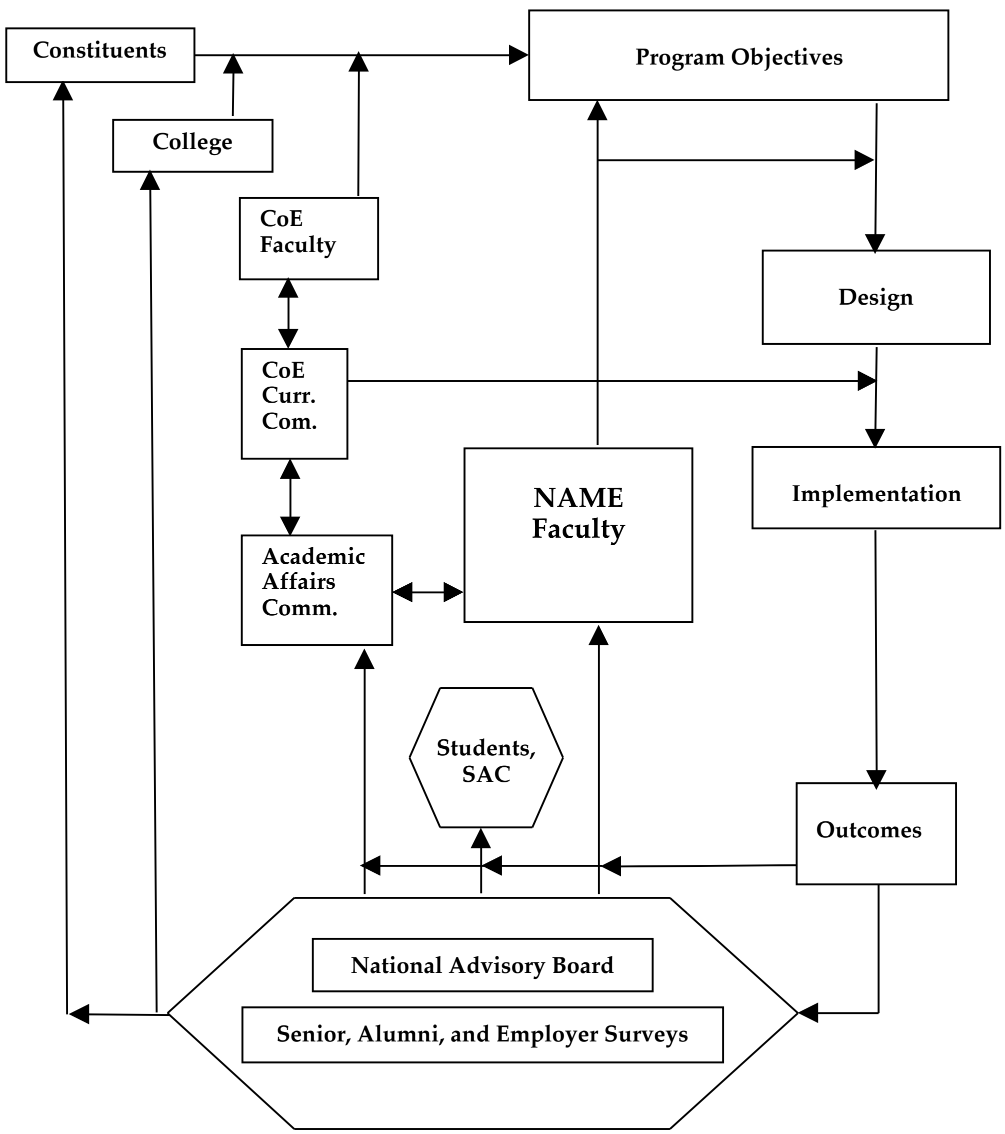

Figure 9.3. NAME Program Level Assessment Processes

In a recent development to improve our assessment processes, a college wide effort was undertaken to design and administer new senior surveys. We have administered three thus far, Winter 1998, Fall 1999, and Winter 1999. Open-ended data entry and reporting is done through the Office of the Associate Dean for Undergraduate Education. Closed-ended data entry is outsourced through Information Transfer Systems (ITS). Summaries of results of closed-ended data for Winter and Fall semesters 1998 have been completed.

The students responding to our senior survey for the most part did not take courses which were revised for our Curriculum 2000 efforts. Their responses therefore offer a base-line data set to which we can compare future responses from students graduating under our new curriculum. Judging from the responses received in Winter and Fall 1998, a majority of our students felt that we were placing the right amount of emphasis on engineering science within the curriculum. It is interesting to note that some felt there was too much emphasis and that none felt there was too little emphasis on engineering science. A majority of our 1998 students felt that there was too little emphasis on engineering applications. Also a majority felt the emphasis on design was about right; but some felt there there was too little and none felt there was too much emphasis on design. There is some evidence that students had become more satisfied with the emphasis on design based on a comparison of the Winter semester to Fall semester although the data is too limited to make any conclusion as yet. This is definitely a trend to watch however as Curriculum 2000 comes into place and the curriculum matures.

Our students also appear to agree with our assessment that the curriculum needed strengthening in our Curriculum 2000 ethics and environmental threads. There is evidence that our students felt a bit more emphasis on written and oral presentation of technical materials was in order. The data also suggests that the emphasis placed on teamwork and the use of computers in our curriculum is well balanced. There is also evidently a high level of student satisfaction regarding the educational environment within our department and the College. Faculty accessibility, advising, contact, guidance, and instruction received very positive assessment from the seniors. The strongest showing came in the area of student contact with staff; this combined with a sense of community among students and an overall positive experience with their educational program.

In another college wide effort, an alumni survey was developed by the College ABET subgroup in consultation with the School of Education. A substantial focus was on the measurement of achievement of our educational outcomes. It was administered in 1998 to alumni graduating in 1996, 1993 and 1988. More than 2000 surveys were mailed, sorted by department and included a cover letter from the department chair. A report has been generated for each cohort and the combined cohorts by each program. Our current plan is to administer the survey each year to 2, 5 and 10 year alumni.

Our alumni indicated that they had indeed been well prepared by their undergraduate program in the areas of math, science and engineering skills, engineering problem solving skills, communication skills and in their abilities to use modern engineering techniques, skills, and tools. Our graduates also indicated they had acquired abilities to design and conduct experiments, to design a system, component or process, and to function on a team. In general, they also believed they had achieved an appropriate level of appreciation for ethical values and knowledge of contemporary issues. To a degree similar to that found in our senior survey, our alumni indicate that some improvement can be sought in the preparation they receive regarding the social, economic and environmental impact of their engineering work and in generating further interest in continuing education. Again, these former students graduated before the implementation of Curriculum 2000 and we of course would like to see improvement in these categories (without detriment to the strong showing in our traditional strengths in mathematics, science and engineering skills).

Another tool we have developed for our program assessment is an employer survey administered through the College. The employer survey was implemented in the Fall of 1998 and an initial set of data has been summarized. The data are compiled for the College as a whole although there is evidently a proportionate response for naval architecture and marine engineering. We again see a high level satisfaction among our employer constituents. Our graduates' math, science and engineering skills, engineering problem solving skills, communication skills, and their abilities to use modern engineering tools are all highly ranked by the employers. Also highly rated are our students' abilities to design experiments and systems and to work in teams. Our employers also felt our graduates had good appreciation of ethical values. The employers also rated as very good (though not rated as highly as some other outcomes) our graduates' understanding of social, economic and environmental impact, interest in continuing education, and knowledge of contemporary issues. It is striking to note the importance our employers place on the ability to work on teams, an import aspect of our curriculum threads. Furthermore, there is a high level of importance placed on all of our educational outcomes given by the prospective employers of our students.

Two additional tools have been developed for our program assessment: a second, more detailed alumni survey and an employment questionnaire for graduating students. Our NAME alumni survey was mailed in April 1999 to serve us during our strategic planning this summer and for providing more detailed program assessment. At the writing of this report, we have received nearly 400 surveys and are in the process of compiling data. Also this summer, we will be compiling the results of our employment questionnaires. The results of these surveys will be available in late summer and we plan to include the data in our Strategic Plan 2000-2004 report.

In summary, the materials available for review include:

- Senior Survey Reports
- Alumni Survey Reports (College)
- NAME Alumni Survey Results
- Employer Survey Reports
- Student portfolios for each course
- NAME Annual Reports

- NA470 and NA475 Senior Design Reports
- Final Design Project Presentation (Video)
- Strategic Plan 2000-2004 report

10. NUCLEAR ENGINEERING AND RADIOLOGICAL SCIENCE

10.1 Assessment Process

The NERS undergraduate curriculum is continuously assessed by Faculty, Students, and the Departmental Advisory board in order to respond to these needs of these constituents and in order to improve its effectiveness for the students.

Assessment occurs at two levels: the overall program level, and the curricular and individual course level. There are objectives and measurable outcomes at each level, designed so that achievement of the outcomes ensures the objectives are being met.

Program Objectives and Outcomes

*Established in consultation between faculty and advisory board, consistent with the mission of the department, with input sought from students, employers and alumni.
*Available on web.
(http://www.engin.umich.edu/dept/nuclear/academics/courses/abetmission/abetmission.html)
*Are systematically reviewed based on based on
- senior and alumni surveys
- chair's exit interviews
- program advisor interviews
- post-graduation status data.

*Constituents with input to objectives & outcomes
- Faculty (e.g. at faculty retreat)
- Advisory Board
- Students

*Evidence of Review and Improvement
- Creation in Radiological Sciences Undergrad Track (Based on discussions with employers/alumni and review of employment trends; creation of NERS 211 as anchor course for both NE and RS tracks, increased flexibility in math/technical electives, re-creation of NERS 425 as RS sr. lab, re-creation of NERS 554 as RS design course)
- Engineering Curriculum 2000 (Based on discussions with employers, CoE advisory board, review of engineering education literature. Key features: communications instruction more tightly integrated into technical courses, greater emphasis on teamwork experience, probability, ongoing improvements in math instruction)

Course Objectives and Outcomes

*Objectives for each course established with reference to overall program outcomes.
*Available on web. (http://www.engin.umich.edu/dept/nuclear/academics/courses/courses.html)
*Individual courses are responsible for ensuring students learn the material (achieve the outcomes) assigned to that course.
*Courses continuously reviewed to ensure they meet their objectives.
*Course review is based on data including:

* Student performance
* Student assessment (course specific evaluations)
* Student comment during advising interviews and chair's exit interview
* Faculty course review (included with yearly activity report in May)

*Material is reviewed by Curriculum Committee at least once a year to assess the degree to which outcomes are being achieved, anticipate and prevent problems, and improve achievement of outcomes.
*Faculty also anticipate potential problems and address them at course level or through proposed curricular changes.
*Major curricular changes needed to improve outcomes originate with either faculty or Curriculum Committee, and, as necessary, pass through full faculty and CoE Curriculum Committee for approval.

This entire process is, of course, itself subject to continuous improvement, as we learn what is and is not useful.

10.2 Closing the Loop: Recent Examples of Curricular Improvements in NERS

10.2.1 Communications

Communications skills are important to our graduates, both for those going into engineering practice and for those going onto graduate school. (NERS Program Outcome #7).

Background

Several years ago NERS ran a pilot program in which students in the junior level NERS 315 laboratory course would simultaneously enroll in their senior level Tech Comm 498. The Tech Comm course would then support the students in writing their lab reports. The result was a general improvement in the quality of the reports, but NERS/Tech Comm faculty cooperation was critical. This program ran for several terms, but was ended, largely due to lack of resources. (More recently several larger departments (e.g. MEAM) have begun to develop similar programs to more tightly integrate communications with design and lab courses)

Discussions with employers, and feedback from the NERS Advisory Board echoes the general importance of communications skills for our graduates. Recent senior and alumni survey results suggests that the level of student accomplishment in communications may be insufficient relative to its importance in the world.

Actions

Along with all programs in the College of Engineering, NERS is implementing Communications Across the Curriculum (CAC). The College as a whole now supports this program, so resources are expected to be diverted from other efforts into this new program. The anchor course will be Eng 100, Introduction to Engineering, which includes a significant technical communications component, and replaces English 125. Within NERS Communications Across the Curriculum continues with NERS 211, NERS

315 and the design courses NERS 442 and NERS 554. Communications Across the Curriculum is being integrated into these courses on the following schedule:

NERS Course	Term of CAC Implementation
NERS 211	Winter 2000
NERS 315	Winter 2000
NERS 442	Winter 2001
NERS 554	Winter 2001

The NERS Curriculum Committee, and individual course instructors, are working closely with Tech Comm instructors in designing this new element of the curriculum.

10.2.2.Radiological Science Design

The senior design courses, along with the senior lab courses are intended to provide students an opportunity to integrate all of their newly acquired skills in significant open-ended projects. With the introduction of the Radiological Sciences path into the undergraduate program it was decided that a design experience tuned to this path was needed. (This requirement addresses NERS Program Outcomes 1, 2, 3, 4, 6, 7, 9, 12)

Background

The long existing Radiation Shielding course, NERS 554, which has long been a favorite senior technical elective, was selected as the basis for a radiological science design course. The course was shifted to a design course in Winter 1999. The instructor's post-course evaluation, reviewed by the Curriculum Committee in May 1999, indicated that, as a design course, it was unsatisfactory. Insufficient open-ended problem solving was provided, little opportunity was provided for teamwork, and no formal reports were required.

Actions

The course will be taught again in Winter 2000, with significantly more design content. Students will be divided into teams each of which will be expected to design and assess a realistic radiation shield system, hopefully within the U of M environment to that student will be able to assess the problem at first hand. Possible projects under development include neutron shielding for the Michigan Ion Beam Lab, medical accelerator shielding in the U of M radiation oncology clinic, photon/x-ray shielding between the Glow Discharge Lab and the Radiological Health Engineering Lab, and beam port shielding for the Ford Nuclear Reactor. Other potential projects include shipping cask radiation shield design and general population exposure due to high level waste shipments. Large scale production transport codes such as MCNP, TART and EGS4 will be used, and several formal reports (preliminary assessment document, progress report, final report) will be required.

10.2.3 Humanities & Social Science and Economics & Ethics

A broad education is critical for all members of society. Engineering students need to understand the societal context of their work. (NERS Program Outcome 8 & 9)

Background

Currently 12.5% of every student's course work is in Humanities & Social Sciences. However, for several years student advising interviews have suggested that students consider these courses largely irrelevant. Open questions on the Fall 1998 senior survey echoed this, with 63% of the students identifying these courses as among the least valuable (with no other course category so singled out). On the same survey 66% of the students recommended evaluating "non-NERS required courses," which includes the Humanities & Social Science category.

The report of the October 1998 NERS Advisory Board suggest that economics should be a required topic for our students, and we note that over the years 1995 -- 1998 an average of only 3 students per year took an economics course (and only one student over this period took more than one).

Professional ethics has been identified as part of the College of Engineering Curriculum task force as important for our students. Course evaluation and senior survey data are somewhat ambiguous on students' perception of their development of ethical reasoning skills.

Actions

A course in economics is now formally recommended for all students; and students are also advised to use economics to form one of their Humanities and Social Science sequences. A list of recommended philosophy courses in logic and ethics has also been developed. NERS 211 has been implemented to include an introduction to ethical reasoning within the NERS context.

In addition, the College of Engineering is supporting the development of a portable ethics module, with discipline specific submodules, that can be used in existing technical classes. Part of the focus of this module is professional organizations, standards and regulations. NERS has not yet made a decision regarding the use of this module.