Unit Plan for Assessing and Improving Student Learning in Degree Programs

Unit: Materials Science and Engineering
Unit Head approval: **Date: 5/9/08**

SECTION 1: PAST ASSESSMENT RESULTS

Brief description of changes or improvements made in your unit as the result of assessment results since 2000.

Undergraduate program

The entire MSE undergraduate curriculum has undergone major changes since 2000 including the addition of a senior design class in response to the previous ABET accreditation review cycle. At the same time the senior design component was shifted from the senior laboratories to the senior materials design and selection courses. A biomaterials specialization was added to keep the curriculum up to date. There was an increase of total hours required for graduation from 128 to 131 to accommodate needed background in biology and materials for students in biomaterials and to allow the requirement that students in one concentration take at least one core technical course in a different concentration to broaden their background. Many minor changes have also been made. Additional courses have been developed and provided. Beyond five courses in the biomaterials curriculum, these include a course in sustainable materials design and courses in computational materials science, optical properties of materials, and nano-materials.

The performance of students on individual examinations and assignments in upper level courses provides direct feedback on how well the students are learning given material. If students fail to perform well at upper levels, the lower level courses are adjusted to address areas of concern. This has resulted, for example, in the revision of the basic mathematics courses taken by College of Engineering students. Revisions to individual course content have been made based on this type of feedback. Such changes are generally made "on the fly" by instructors in given classes. For example, an instructor may choose to spend more or less time on review of material. Most of these differences are small and can be considered "personal taste." However, in extreme cases it has become apparent that a given instructor is simply not teaching the material satisfactorily. This is dealt with through conversations between the Head and that faculty member. If that does not fix the problem then generally teaching assignments are changed.

The most dramatic example of changes made to an individual course within MSE to address problems was the result of continuing difficulties with the undergraduate laboratories MSE 307 and 308. Changes have mostly involved matching (reducing) the workload required to the credit of the course such that an appropriate level of work is associated with the class. Changes also included reduction in the scale of some of the lab reports, more to a form that would be used in industry, restructuring the format of the reports, improving grading and feedback on the reports, changes in instructor, etc.

Graduate program

The major change to the graduate program in general during this reporting period was the creation of two new joint master of science programs, one combining the BS and MS in MSE and the second combining a BS and a Masters of Business Administration. The five-year BS-MS program in Materials Science and Engineering combines two degrees: a BS in MSE with an MS (with thesis) in MSE. Current MSE students enrolled in the College of Engineering at Illinois who maintain superior academic performance are eligible to apply for this program. Students admitted to the program will receive both degrees once all requirements

for the 5-Year BS-MS degree program have been successfully completed but will be permitted to participate in the Graduation Ceremonies with their BS class if they have completed 131 hours. The degree reduces the required number of hours required for the bachelors to 120. This has been accepted, as in other combined BS/MS degree programs, because they are taking additional advanced courses that make up for some of the technical and free electives and because a thesis project substitutes for the senior design project in the normal BS program. The net result is the completion of both degrees in five years for a student without advanced placement credit. These students will likely continue for a Ph.D in MSE here or at other institutions

In addition we reduced the number of course hours required for the Ph.D. by four hours and compensated with an increase in thesis hours and accepting up to four hours of seminar and colloquium credit for the MS-Ph.D. combined program.

The combined BS/MBA degree program is similar. The Illinois MBA and the Department of Materials Science and Engineering have jointly established a program leading to the degrees of Master of Business Administration and Master of Science in Material Science Engineering or Doctorate of Philosophy in Material Science and Engineering. The two degrees are awarded on the basis of a total of 92 hours of coursework with MS thesis (96 hours without thesis) or 156 hours of coursework for doctorate degree, 60 hours of which are in the MBA program.

The MBA/MSE program is open to students who have completed an accredited bachelor's degree and who meet the admission criteria of the MBA program and Department of Material Science and Engineering. This joint degree program is available to both domestic and international students.

The primary changes specific to the graduate program course list are the addition of courses to introduce new graduate students from outside of the discipline to the key issues in Materials Science and Engineering. These two courses concern Soft Materials, adapted from a pre-existing graduate course in polymers, and a new course in Hard Materials. Various changes have been made to the mixed senior undergraduate/beginning graduate program. These courses are being offered on a trial basis and are intended for students entering without prior background in these subjects. This change reflects a general feeling among both students and faculty coming from other disciplines that their background is weak in materials science. Furthermore hard and soft materials graduate students need additional background in the other area.

The structure of the qualifying examination that tests the student's knowledge of fundamentals of materials science and engineering has been extensively revised since 2000 going from 8-10 exams to a much broader suite of exams, 28 of which have been offered at various times since 2001. The broader spectrum of topics allows for a more in-depth interrogation of the student's knowledge in a subject relevant to their research area.

Several new courses at the senior undergraduate/lower level graduate student level have been added on special topics since 2000 including courses entitled phase transformations, introduction to nanotechnology, materials for sustainability, photovoltaic cells, and optical properties of materials. Most of these have been offered repeatedly on either an annual or biannual basis. These courses are designed to provide in-depth examination of topics at the cutting-edge of materials science and engineering at a high level.

SECTION 2: REVISED ASSESSMENT PLAN

(a) PROCESS: Brief description of the process followed to develop or revise this assessment plan.

Assessment methods have been developed by discussion among the faculty of the Department and with the impetus of the ABET accreditation process and have been described in various documents associated therewith. These have been reviewed during accreditation visits. Further the status of the Department including its educational objectives at both the graduate and undergraduate level were reviewed by the entire faculty of Materials Science and Engineering and further reviewed by the College of Engineering as part of the development of the departmental Strategic Plan initiative.

Assessment tools have been developed to supplement assessment metrics available in the normal course of business (for example the performance of students on standardized tests and their acceptance in follow-on stages of their career) as seemed appropriate to judge the various aspects of the program. Examples of these assessment tools are provided in the following sections. The results of the assessments are analyzed quantitatively and contribute to the development of the MSE educational program.

(b) STUDENT OUTCOMES: List Unit's student learning outcomes (knowledge, skills, and attitudes).

The department of Materials Science and Engineering uses the ABET a-k criteria for their undergraduate program learning outcomes. Outcomes expected at the graduate level are the ability of students to function as independent scientists and engineers and to be leaders in their chosen fields. Knowledge of their field is expected to be commensurate with the skills of an independent scientist and engineer at the relevant graduate level. The expectations of all of our students can be generalized as fitting under the goals of the department:

- To provide our students with an understanding of the underlying principles of synthesis, characterization and processing of materials and of the interrelationships of structure, processing and properties.

- To prepare our students for professional careers in industry, for advanced study in the field, and as independent scientists and engineers, by integrating a strong, broad science base with substantial experience in engineering and teamwork.

- To accomplish the above in a quality learning-environment and with an overall program that enables the students to become life-long leaders and learners in their field.

(c) MEASURES AND METHODS USED TO ASSESS OUTCOMES:

Undergraduate Program

A wide variety of assessment tools are used to qualitatively assess the achievement of the program outcomes. The assessment tools affect the development of the curriculum and individual courses as shown in Figure 1. The primary tool is specific evaluation questions associated with individual courses that test the student's ability to address the program outcomes on examinations and other assignments. The detailed connections of course components and outcomes are described in detail in the course self-assessments prepared by the course instructors based on the material actually taught and the examination questions and responses specifically given.

The non-course-related program assessment tools include student comments and surveys, and alumni surveys. A set of college-wide assessment tools are also available. To monitor the performance of the more junior instructors, a peer-evaluation system is provided in which senior faculty visit courses taught by the assistant professors each semester and at least one lecture per year for the associate

professors. An evaluation of the instructor's performance is provided by the peer-evaluator to the instructor and the Department Head. This input is also considered by the Faculty Development Committee that is responsible for young faculty development.

Other assessment tools include the following: The ICES questionnaires, a "feedback session" run by the Undergraduate Materials Organization in which students provide comments in individual classes which are then relayed anonymously to the faculty through the Head and Associate Heads. Students also provide comments directly to the Head. The department produces its own senior exit surveys on various topics including the outcomes of the program and the advising the students received. The Chancellor's Survey provides more indirect feedback. We also take into account comments received from alumni on the performance of their education in their employment, from employers of our students, and the performance of our students on the Fundamentals of Engineering, Professional Engineering, and Graduate Record Examinations. The employment rate of our students and their acceptance rate into graduate school provide a measure of their quality and the value of their education.

Graduate program

Assessment of students at the M.S. level consists of a review by the Thesis Advisor and Department Head of their research, in the case of a thesis Masters, or of their performance in courses in the case of a non-thesis Masters degree.

Assessment tools at the Ph.D. level include the major examinations, the Qualifying Examinations, the Preliminary Examination, and the Thesis Defense. The Qualifying Examination consisting of two oral examinations on subjects relevant to the student's research, and the results of the student's coursework in the graduate Thermodynamics course, which is the only graduate class common to all of our graduate students. The purpose of the Qualifying Examination is to test the student's knowledge of their field at the advanced undergraduate and early graduate level and shows proficiency in subjects that are the background to their advanced study. The Preliminary Examination and Thesis Defense require students to demonstrate a successful research project and that they have gained an understanding of research science or engineering appropriate to the Ph.D. level. The Preliminary Exam is to identify a problem, propose a potential approach to address it, and to present preliminary data supporting the applicability of the proposed approach. The Final Defense gives the student an opportunity to present their findings and defend their conclusions before a committee of faculty. They must demonstrate that they have conducted a body of work at a level appropriate to a Ph.D.

Additional assessment tools for both the M.S. and Ph.D. level are similar to those at the undergraduate level, including ICES surveys and student feedback concerning individual courses, exit interviews, surveys, performance in their career after leaving the department, and comments by their employers. The quality of incoming students and number of applications provides a measure of the reputation of the department externally and continues to be very high. At this level personal feedback and evidence of the quality of the student's training is much more evident than for the undergraduates where we are less likely to be in continuing contact over the course of the student's career. Much of the feedback on coursework by the graduate students is passed on directly to the faculty advisor and from there to the appropriate course instructor.

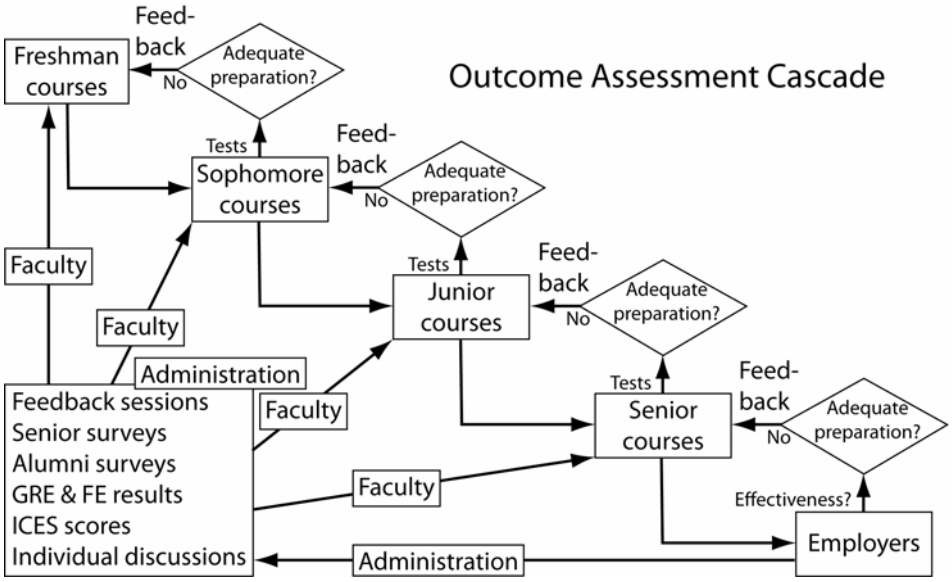
SECTION 3 : PLANS FOR USING RESULTS

(a) PLANS: Brief description of plans to use assessment results for program improvement.

Undergraduate program

The MSE department assesses the outcome of its curriculum through a variety of methods outlined here. A student's ability to perform according to established criteria is enforced primarily through the courses taken and the assignments and examinations associated with those courses. In addition to coursework, the performance of our students is judged through formal (e.g. in class question and answer discussions or required student presentations) and informal (e.g. one-on-one discussions during office hours) interactions with them by the faculty and through their participation in team-based programs throughout the College. It is also judged through the structural expectations of the first-two-years general science and mathematics courses (such as team-based laboratory experiments and encouragement to work together on homework and other projects in the first two years), and through discussion with employers of our students. Various survey tools are also employed to judge the effectiveness of the curriculum as preparation of our students for engineering careers. The assessment tools provide feedback on the performance of individual courses and faculty members as shown in Figure 1. Additional discussion is provided in Section 2.c.

Figure 1: The outcomes assessment feedback structures.



The structure and content of courses in the Department are reviewed by the Curriculum Committee and the faculty update their courses continuously to keep them relevant to modern materials science and engineering. The University of Illinois MSE department makes every effort to track the final knowledge of materials science and engineering achieved by all students individually. The best venue for this is the senior courses, which have small enrollments such that the instructor is aware of the capabilities of each student. At the graduate level this is best tracked through the performance of individual students in the examinations related to their research and the defense of their thesis. Anyone who is seriously deficient in their understanding of the material is easily identified. The students who appear to be failing to understand the concepts are encouraged to meet individually with their instructors and advisors. This provides students with the opportunity to remedy deficiencies and assures that everyone graduating from the MSE program at the University of Illinois has an acceptable understanding of materials science and engineering in general at a level appropriate to their degree. If a systemic problem with preparation of students for upper level courses is apparent for all students in a class, the faculty member responsible for that class

provides feedback to the instructors for the prerequisite classes and to the curriculum committee (Figure 1).

Graduate program

Assessment of the quality of the graduate program is primarily through the outcomes achieved by the students and feedback either from the students or their employers and through continued contacts to judge success in their careers. Changes made to the graduate program are primarily through evidence of problems with outcomes based on these evaluations. Additional changes are made in the form of ongoing upgrades to keep specialized courses at a high level for the graduate students up to date. We anticipate continuing this type of update and adjustment of the graduate program.

The performance of students in the combined programs will be assessed as these dual degree programs become more mature. Changes will be made as necessary as more experience is gained about the performance of the programs and the effectiveness of the student training and outcomes.

(b) TIMELINE FOR IMPLEMENTATION:

Evaluation of the progress of students to meet the outcomes of the MSE degree programs is ongoing. Revisions of the undergraduate and graduate curricula, testing, and achievement requirements has been in place during the entire accrediation period from 2000 to the present. In particular, the recognition of the need for students in materials engineering to obtain intern-co-op experience has resulted in the development of a proposal for a BS/ME non-thesis degree, complementing the BS/MS degree, that will require 30 weeks of internship and or co-op experience.

Topics of MSE Qualifying Exams

Title	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Atomic Processes on Surfaces				x		x	x	x	x	x	
Biomaterials					x	x	x	x	x	x	x
Ceramic Processing				x	x	x	x	x	x	x	x
Colloids and Complex Fluids				x		x	x	x	x		x
Composites										x	
Computational/Simulation Methods in Materials Science				x	x		x	x		x	x
Crystal Physics and Structure			x	x	x	x	x			x	
Defects in Crystals					x			x	x	x	
Dielectric Properties of Materials			x	x	x	x	x	x			
Electron Microscopy and Scattering			x	x	x			x	x	x	
Electronic Materials Processing	x	x	x			x	x	x	x	x	x
Macromolecular Liquids				x		x	x	x	x	x	x
Macromolecular Solids					x	x	x	x	x	x	
Mechanical Properties				x	x		x	x		x	x
Materials Characterization	x	x									
Metals Processing	x	x							x	x	
Optical Properties of Materials								x	x	x	x
Phase Transformations	x	x									
Physical Materials		x	x								
Physical Metallurgy	x	x	x	x		x	x	x	x		x
Physical Properties					x						
Polymer Engineering									x	x	x
Polymer Synthesis			x	x		x	x		x	x	x
Quantum Mechanics	x										
Solid State Physics	x	x	x	x	x	x	x	x	x	x	x
Solid State Transformations				x			x		x		x
Surface Physics					x	x					
Surfaces and Colloids									x		x
Surfaces and Interfaces			x	x	x	x	x	x			
Thermo/Mechanical Properties	x	x	x								
Tribology of Materials							x	x	x		
X-ray Diffraction and Scattering							x	x			x
Other (one only, approval of the DGS required) Biophysics								x			

A Year	Grad Applications Total # Accepts		Quals #Taken Passed	#	Prelims #Taken #Passed		Finals #Taken #Passed		Total Grad Enrollment MS PHD	
2008	312	25	27(as of 1/08)	21 (as of 1/08)	13	13	20	20	13	172
2007	300	24	18	18	31	31	30	30	6	160
2006	369	33	40	36	27	27	28	28	15	162
2005	331	28	38	35	22	22	31	31	11	161
2004	341	41	31	26	18	18	14	14	13	170
2003	448	47	34	30	17	17	23	23	15	143
2002	353	40	22	19	14	14	28	28	13	124
2001	280	34	27	23	17	17	27	27	11	124
2000	251	25	21	16	27	27	24	24	15	100
1999	220	13	20	16	10	10	20	20	28	77
1998	264	28	19	17	11	11	29	29	48	59