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Status and Evolution of Accreditation for Materials Programs in the U.S.

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ABSTRACT

Undergraduate materials education in the United States is healthy and growing. The number of students graduating with B.S. level materials degrees increased by 18% from 2004 (817 graduates) to 2007 (963 graduates). Materials programs continue to evolve and diversify, with an increasingly wider variety of program titles. Nearly all of these programs are accredited by ABET, the accreditation agency in the U.S. for engineering, technology, applied science and computer science. Accreditation criteria were changed significantly during the period 1999 - 2001, to be less prescriptive and to be more outcomes based. This new approach to accreditation has resulted in both benefits and burdens. The post-2000 accreditation requirements and procedures have facilitated diversification, with each program developing its own Program Educational Objectives and having wide latitude in deciding how to achieve the ABET-required Program Outcomes. The ABET Program Criteria for materials and related engineering fields also allow programs to vary widely in their emphasis and focus, while requiring that the program titles realistically describe their topical coverage. Although a study commissioned by ABET reported a “positive, sometimes substantial, impact on engineering programs, student experiences, and student learning” of the new approach to accreditation, some faculty members feel burdened by the formality, documentation, and self-study reports required by ABET, and they question whether these efforts are worthwhile and actually lead to improvements in educational programs.

Introduction

College and university education in the U.S. is a heterogeneous mix of public “state” institutions, private not-for-profit institutions, and a much smaller number of private for-profit institutions. “Accreditation” is a process by which institutions and educational programs are reviewed and certified as meeting certain quality, performance and accountability standards. The accreditation system for materials programs in the U.S. is described in this paper. Materials programs in the U.S., like the college and university systems, are quite diverse and are evolving with time, influenced in part by changing accreditation requirements and processes. Several aspects of this diversity and evolution, and forces driving the changes, are discussed. ABET accreditation requirements and procedures are described, as well as their effects on materials programs in the U.S. A discussion of some of these topics was published in 2004 [1].

College and University Level Accreditation in the U.S.

There is no Federal Government-sponsored systematic review and evaluation of U.S. colleges and universities [2]. Accreditation in the U.S. is carried out by non-profit, non-governmental organizations, which are members of the Council for Higher Education Accreditation [3]. About 3,000 individual colleges and universities are accredited by five Regional Institutional Accreditation agencies. Many programs within these institutions, including B.S.-level engineering programs, are accredited by Special Area, or Programmatic, Accreditation agencies. ABET, Inc. [4] is the recognized accreditor for engineering programs in the U.S.

ABET is a not-for-profit organization of professional engineering societies, with 28 institutional members [5] including TMS, MRS, and NICE for materials, which provides accreditation for about 2,200 engineering, technology, applied science and computer science programs at 550 U.S. colleges and universities. ABET has recently expanded its accreditation reviews and recognitions to engineering programs in non-U.S. institutions that make a request for review.

Within the U.S., there are several reasons for engineering programs to seek ABET accreditation. In many public colleges and universities, the sponsoring state governments require that engineering programs be ABET accredited. Also, ABET accreditation is closely linked with licensing of Professional Engineers [6]. In most states, graduation from an ABET accredited B.S. level engineering program is one of the requirements for becoming a licensed or registered Professional Engineer. In some fields of engineering being recognized as a Professional Engineer has great practical importance, particularly in Civil Engineering, and to a lesser extent in Mechanical and Electrical Engineering, as a requirement for someone to give official approval to construction plans, or to provide other "professional engineering services." For these reasons, ABET accreditation is very important for civil, mechanical and electrical programs, in both public and private colleges and universities. Whether or not required by state legislatures, in most colleges and universities with engineering programs, senior administrators feel strongly that all of their engineering programs should have ABET accreditation. Although qualification as a Professional Engineer is much less important for most materials program graduates, unless they are in private practice or provide testimony as "expert witnesses," these additional factors generally require that materials programs seek and maintain ABET accreditation.

Profile of Materials Programs in the U.S.

Undergraduate materials education in the United States is provided mostly by programs at 65 universities which offer 75 different B.S. degrees in Materials Science and Engineering (MS&E), Materials Engineering, Metallurgical and Materials Engineering, Ceramic Engineering, Metallurgical Engineering, Polymer Science and Engineering, Plastics Engineering, Glass Engineering Science, or Composite Materials Engineering, as listed in Table I. Nearly all of these programs are accredited by ABET [7]. Only three of the B.S. degree programs, all with small enrollments, are not ABET accredited: Rice University, Stanford University, and the University of Connecticut. A larger number (92) of institutions offer Ph.D. degree programs in materials, including many which do not offer B.S. level degrees. In fact, only three of the institutions offering B.S. level materials degrees do not also offer Ph.D. degrees: California Polytechnic State University, San Jose State University, and Winona State University (MN) [8].

Many factors influence the directions of materials education in U.S. colleges and universities. One of the most important is building and sustaining undergraduate enrollments. Most students know little about materials science and engineering when they enter college. Civil, mechanical, electrical and chemical engineering are much more familiar to beginning students and their parents, and these departments often need to do little to attract undergraduate majors, and they usually have much larger undergraduate student-to-faculty ratios than do materials departments. To maintain viable undergraduate programs, and to justify institutional support for them, materials programs must attract and retain undergraduate majors. This necessity affects course offerings, teaching methods, and marketing of undergraduate materials programs. For example, increased emphasis on nanomaterials or biomaterials may increase enrollments, if these areas are more attractive to students than more traditional materials areas of metals, ceramics and polymers.

Another factor that affects materials programs is the type of employment opportunities available to its graduates, which may be both historical and regional. A program with historical strength and reputation in a particular area, e.g. metallurgical engineering, may have its graduates sought after by employers in this area, which encourages continued emphasis on this area in its undergraduate curriculum. A program that draws its students from a particular region and seeks to serve the region's industrial needs may tailor its program to emphasize a particular materials area, e.g. electronic materials or composite materials, to increase regional employment opportunities for its graduates.

As noted earlier, nearly all B.S. level materials programs are in departments that also offer Ph.D. level materials degrees. Most faculty in these departments are expected to be active in research as well as teaching, and to raise grant and contract funds to support graduate students, provide summer salaries, and generate indirect cost funds to support their institution's infrastructure for research. The research areas of most current interest, funding potential, and attractiveness to graduate students may, or may not, be well matched to the needs of the department's undergraduate program. Tension can arise about whether the undergraduate program should emphasize topics of current research interest, topics more relevant to historical or regional B.S. level employment opportunities, or topics better matched to the interests of prospective students and their parents.

It is not surprising that B.S.-level materials programs in the U.S. are quite diverse, in size, curriculum, and topical focus. As noted above, these programs are in both public and private colleges and universities, most are in Ph.D. granting institutions, but some are in mainly undergraduate colleges. Some draw students nationally and internationally, and others have students mainly from the same region or state. See [9] for a discussion of the pre-2000 development and trends in materials education in the U.S. and in Europe.

The numbers of U.S. B.S.-level materials program graduates are an important indication of the health of this field. Figure 1 shows materials program graduation numbers from 1965 to 2007. From 1965 to 1975 and from 1995 to 2007, the number of materials graduates was between 800 and 1,000 per year. Between 1976 and 1994 this number increased to 1,700 and then gradually decreased to 1,000 per year. The increase may reflect the national emphasis on advanced materials described in several studies and reports, including the 1989 Flemings and Chaudhari NRC report "Materials Science and Engineering for the 1990s: Maintaining Competitiveness in the Age of Materials" [10]. It is interesting that the number of materials graduates has recently shown a modest increase, from 814 in 2004 to 963 in 2007, reversing the general decrease from 1981 to 2003. This reversal may reflect the growing public attention to nano- and biomaterials.

From ASEE graduation data [8] six materials programs had between 35 and 60 B.S. graduates in 2007: University of Illinois—UC 60, Colorado School of Mines 48, Iowa State University 39, MIT 39, and University of Michigan 36. More than 30 programs had fewer than 10 B.S. graduates in 2007. Materials programs at four schools each had 6% or more of the B.S. level engineering graduates in their respective institutions in 2007: Colorado School of Mines 8.8% or 48/547, University of California—Berkeley 8.0% or 67/839 combining graduates from Berkeley's six different materials programs (see Table I), MIT 6.7% or 39/578, and Carnegie Mellon University 6.1% or 22/358. Figure 2 shows a distribution plot of numbers of B.S.-level graduates for 2007.

Diversity in curricula is more difficult to quantify and to describe. For example, we have attempted to compare B.S. level materials curricula at five different public institutions, University of Illinois—UC (UIUC), University of Florida (UFLA), Michigan Technological University (MTU), Colorado School of Mines (CSM), California Polytechnic University (CALPOLY), and three private institutions, MIT, Lehigh University (LU), and University of Pennsylvania (UPENN), in Table II. All but two of these are "Materials Science and Engineering (MS&E)" programs; CSM is "Metallurgical and Materials Engineering" and CALPOLY is "Materials Engineering."

Table II lists frequently occurring topics and course titles in the categories *Mathematics*, *Science*, *Other Engineering*, and *Materials*. In the column for each of the eight programs, *R* indicates that the program has a required course with this title or topic, *R2* indicates two required courses, etc., and *E* indicates that one or more elective courses are available to undergraduates with this title or topic. Where nothing is entered in the table, the program's curriculum does not appear to include the corresponding course or topic. However, in some cases coverage of the topic may be divided among several other courses.

At the bottom of Table II the numbers of technical electives and of free electives are listed for each of the programs. "Technical electives" are for materials, engineering, science or math courses, beyond those listed as "required." Different programs have different restrictions concerning technical electives. “Free electives” may be used for technical or nontechnical courses. Generally programs with larger numbers of required courses have fewer technical electives and *vice versa*.

All of the programs except CALPOLY are on the semester system, with two class sessions per academic year; CALPOLY is on the quarter system, with three class sessions per academic year, so its curriculum lists about 50% more courses than curricula based on the semester system.

Coverage in mathematics is very similar among all of the programs, with most programs explicitly including the four topics listed in the table, albeit with from nine at CSM to five at UPENN and CALPOLY ($7 \times 2/3 = 4.7$ semester equivalent courses). Coverage in science includes two or three courses in physics, and one or two courses in chemistry in all programs, but with three programs (MIT, UIUC and UFLA) now requiring one course in organic or biochemistry, while MIT also requires a course in biology for all of its materials majors.

Required courses in engineering areas other than materials are listed as *Other Engineering* in Table II, with five of the seven programs requiring courses in circuits, usually offered in electrical engineering, and one course in strength of materials, statics, or a related topic, usually offered in mechanical engineering. Some courses in other engineering disciplines were required by the pre-2000 ABET rules, but not in the new ABET criteria.

The courses or topics listed under *Materials* are included as required or elective courses in most of the materials programs. However, the list is not exhaustive; some of the programs have required or elective courses in environmental materials, corrosion, professional practice and ethics, and other areas, which for simplicity were not listed.

There are some interesting differences among the listed curricula, even for programs that designate themselves as MS&E. LU and UFLA have similar curricula, with required courses in most of the same materials topics, including courses in metals, ceramics, polymers, and electronic materials (listed as Elec., Opt., Mag. Prop./Devices in Table II). and other “traditional” MS&E topics (thermodynamics, kinetics, crystallography and microstructure, materials selection, and design).

The MTU MS&E program curriculum is similar to the LU and UFLA curricula, except that it has no required courses specifically in “metals” or “ceramics,” although elective courses are available in these areas and their basic required courses in materials emphasize metals and ceramics. Also, it has more required coverage of kinetics, phase transformations, materials characterization and materials processing. The UIUC MS&E program curriculum has elective rather than specifically required courses in metals, ceramics or polymers, but is otherwise similar to the MS&E programs at LU, UFLA and MTU.

The MS&E program at MIT has fewer required materials courses and a larger number of technical electives than most of the other MS&E programs. Elective courses include all of the traditional MS&E topics, as well as courses in nano- and biomaterials, materials modeling and simulation, and many other materials topics. As noted above, the MIT curriculum has required courses in organic/biochemistry and biology.

The MS&E program curriculum at UPENN emphasizes nano- and biomaterials topics to a greater extent than in the other MS&E programs, with two required courses in nanomaterials and one required course in biomaterials, as well as having more coverage of nano- and biomaterials in many of the other more traditional MS&E courses.

The materials program at CSM is designated “Metallurgical and Materials Engineering,” indicating its greater focus on metallurgical topics and on engineering aspects of metals and other materials. Its curriculum has heavier required coverage of thermodynamics and materials processing. There are no required courses in electronic materials or in metals, ceramics or polymers, although metals are emphasized in many other courses. The materials program at CALPOLY is “Materials Engineering” with greater emphasis on materials-related environmental and sustainability topics, although this is not apparent from the course listings in Table II. The CALPOLY curriculum was particularly difficult to match up with the categories in Table II, because of the way it groups topics its required and elective materials courses.

All of these eight materials programs have ABET accreditation, although they are quite diverse in their curricula and topical emphases. The inclusiveness of the post-2000 ABET accreditation criteria is one of its greatest strengths. As discussed below, ABET accreditation requires that programs adopt Program Educational Objectives that are “broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve” after graduation from the program.

The Program Educational Objectives (PEOs) of the eight materials programs discussed above are compared in Table III. The scope and level of detail in these Educational Objectives vary greatly from one program to another. LU’s Educational Objectives refer to success in careers and graduate studies. MIT’s PEO’s enumeration skills and abilities needed for professional success. UIUC’s describe the preparation needed for success in industrial careers and advanced study. UFLA’s enumerate career paths and goals. UPENN’s refer to success in materials and other careers, advanced study, leadership, and in addressing societal needs. MTU’s enumerate materials-related skills and knowledge. CSM’s enumerate general skills and knowledge for successful careers. CALPOLY’s PEOs enumerate activities for effective and responsible engineering professionals. In only a few cases are there clear links between a program’s Educational Objectives and the program’s curricular focus, for example MTU’s emphasis on materials production, processing, selection, and engineering applications; and CALPOLY’s emphasis on global challenges and social and environmental responsibilities.

Accreditation Requirements and Procedures

ABET accreditation requirements and procedures were changed substantially in the 1999-2001 period, with a move from detailed specification of required numbers of courses in different areas, particular courses, credits, etc., to seven "general criteria" involving outcomes, objectives, assessment, and evaluation that are common to all B.S. level engineering programs, plus an eighth criterion that is discipline specific [11]. Under the post-2000 ABET criteria, programs have had much more flexibility to choose their focus and to shape their curricula.

The titles of the eight ABET Criteria are listed in Table IV. Criterion 1- Students involves advising, monitoring, and evaluating academic performance of students. Criterion 4 - Professional Component gives requirements for numbers of courses in mathematics, basic sciences, and engineering, without specifying particular courses or subtopics, as well as a "general education" requirement and the requirement for a "major design experience" for each student. Criterion 5 - Faculty, Criterion 6 - Facilities, and Criterion 7 - Institutional Support and Financial Resources require adequacy in these areas, without specifying numbers of faculty, types of facilities, or amounts of support. Criterion 8 – Program Criteria gives curriculum and faculty qualification requirements for different disciplines. The ABET Criteria that have the most impact on, and provide the greatest challenges for, materials programs are Criterion 2 – Program Educational Objectives, and Criterion 3 – Program Outcomes and Assessment.

Criterion 2 requires that each program determine "Educational Objectives," which are professional and career goals for its graduates, with input from the program's "constituencies," which usually are considered to include employers, alumni/ae, and students. Examples are given in Table III, as discussed earlier. As part of the accreditation process, programs must demonstrate that their graduates are achieving the program's Educational Objectives.

Criterion 3 specifies eleven "Program Outcomes," (a) – (k), listed in Table V, that students must accomplish before graduation. Each materials program may add to this list, but few do so. Programs must demonstrate that their students are achieving the listed Program Outcomes. The most common approach is to link each of the Program Outcomes to one or more of the program's required courses, and to show that students' performance in these courses, or in particular assignments in these courses, demonstrate students' attainments of the particular Program Outcome. Difficulties are encountered particularly with outcomes (f) - (j), which are not easily identified with particular engineering courses.

Additionally, requirements for Outcomes and Faculty, are given as Program Criteria that are specific for each type of engineering. Those for materials programs, listed in Table VI, require that the title of the program describe its topical coverage, e.g. that a Materials Science and Engineering or a Materials Engineering program include coverage of the full range of materials types, ceramics, metals, polymers, etc., but that a Metallurgical Engineering program need cover only metals. However, all materials programs must include coverage of structure, properties, processing, and performance, as well as materials selection and design, and experimental, statistical and computational methods.

Also, program faculty must provide expertise in materials structure, properties, processing, and performance.

Programs must demonstrate that assessment and evaluation are being carried out for their Program Educational Objectives and for Program Outcomes, and that results are being used to improve the program. This requirement of "continuous improvement" based on assessment and evaluation is included as a separate criterion in the 2008-2009 version of ABET accreditation rules, which contains nine separate, renumbered "criteria" [11],

In preparing for the ABET review, each program prepares a "self-study" with supporting documentation (see "Engineering Self-Study Questionnaire" [12]). A "program evaluator," from TMS or NICE for materials programs, visits for two days in the Fall, as a member of an evaluation team with a "team chair" and program evaluators for other engineering programs being reviewed at the same time. Based on the self-study and the two-day visit, the program evaluator and team chair identify any "shortcomings" in meeting the ABET criteria, and the program has opportunities for making and documenting corrections during the Fall and Winter. The program evaluator and team chair make a recommendation for action on the program's accreditation, and ABET Engineering Accreditation Commission makes final accreditation decisions during the following Summer.

The most common outcome is a six year continuation of accreditation. Unresolved minor shortcomings may require a report and possibly a visit, focusing on the particular shortcomings, after two years to continue program's accreditation. Unresolved major shortcomings result in a one-year probation, followed by further review and possible non-accreditation, which is very, very unlikely. Most shortcomings involve inadequate statements, assessments, or evaluations of Criterion 2—Program Educational Objectives and Criterion 3--Program Outcomes and Assessment, or inadequate "major design experience" for students as required by Criterion 4—Professional Component.

Effects of and Attitudes about Accreditation

There are many varied opinions, both positive and negative, about the ABET accreditation process. On the plus side, most would agree that the ABET process causes engagement of department chairs and faculty in review of their program's goals, curriculum, and effectiveness. The process also increases involvement of advisory committees, alumni/ae, and students in providing guidance for the program. Sometimes the accreditation process helps departments secure badly needed institutional support for additional faculty, facilities, and other resources, to meet ABET requirements.

On the minus side, the ABET accreditation process is paperwork intensive (see "Engineering Self-Study Questionnaire" [12]). Self-studies typically consist of more than 100 pages, and required backup materials on assessment, evaluation, and course contents fill many notebooks or file folders. Although assessment and evaluation are critical parts of the process, there is little agreement about which assessment and evaluation methods are needed to satisfy ABET requirements, and which actually lead to program improvements. Many program evaluators from industries or from private practice do not understand the B.S. level educational system, and many faculty members do not understand accreditation requirements and procedures.

There are often disagreements between program faculty and program evaluators about interpretation of the "major design experience" requirement. These disagreements have been a particular problem for materials programs, because both science and engineering are important in many programs and "design" of an experiment differs from design of a component or system; design of a material differs from design with materials. To improve understanding of this ABET requirement for materials programs, the University Materials Council, which is the organization of U.S. materials department chairs, and the accreditation committee of TMS, representing materials program evaluators, jointly drafted a white paper on "design in materials programs" [13, 14].

ABET sponsored a research project by the Center for the Study of Higher Education at Pennsylvania State University, to examine whether or not the post-2000 ABET requirements and procedures improved engineering education generally, compared with the pre-2000 ABET requirements and procedures. The results of this study are summarized in "Engineering Change: A Study of the Impact of EC2000" [15]. This study compared student opinions, from 1994 and 2004 graduates of all types of ABET accredited B.S.-level engineering programs, about their educational experiences. Faculty members, department heads, deans, and employers also were surveyed about whether the new ABET criteria and procedures had led to improvements in curricula, teaching and learning styles, and assessment and evaluation of student skills and knowledge. The study concluded that "The weight of the accumulated evidence collected for Engineering Change indicates clearly that the implementation of the EC2000 accreditation criteria has had a positive, and sometimes substantial, impact on engineering programs, student experiences, and student learning." However, these conclusions were based largely on students' self-reporting of skills and knowledge gained. Differences between 1994 graduates (pre-2000) and 2004 graduates (post-2000) were small but at some level statistically significant.

The study also reported that "The greatest differences in student learning before and after EC2000 are in recent graduates' better understanding of societal and global issues, their ability to apply engineering skills, group skills, and understanding of ethics and professional issues." This result is not surprising, since these abilities are contained in the educational outcomes (d), (e), (f), and (h) required by Criterion 3 of the post-2000 ABET requirements, but were not listed explicitly in the pre-2000 ABET requirements.

However, employers had mixed views about whether the 1994 graduates were better prepared in various areas than the 2004 graduates. Twice as many (26%) reported that graduates' abilities "to apply problem solving skills" had <u>decreased</u> than (13%) reported that these abilities had increased, the rest (51%) apparently reporting no change. Employers were about equally divided on the question of the graduates' abilities to "use math, science and technical skills," 18% reporting a <u>decrease</u> and 19% reporting an increase. More employers saw increases than decreases in two other abilities, to "learn, grow, and adapt" (28% vs. 13%) and to "communicate and work in teams" (32% vs. 17%).

Since this study included all ABET-accredited engineering disciplines, only a very small fraction of the students, department chairs, faculty and employers were from materials disciplines. It is not clear how well the study's conclusions are applicable to materials programs.

Conclusions

B.S.-level materials education in the U.S. is healthy, judged by the number of students graduating from these programs, which increased by 18% from 2004 (817 graduates) to 2007 (963 graduates), as shown in Fig. 1. Materials program continue to evolve and diversity, with a spectrum from traditional metallurgical engineering programs, to now more common MS&E programs, to programs that emphasize nano- and biomaterials. The post-2000 ABET accreditation requirements and procedures have facilitated this diversification, with each program developing its own Program Educational Objectives and having wide latitude in deciding how to achieve the ABET-required Program Outcomes. The ABET Program Criteria for materials and related fields also allow programs to vary widely in their emphasis and focus, while requiring that the program title realistically describe its topical coverage. Beyond these benefits, it is unclear whether post-2000 ABET accreditation requirements and processes actually lead to improvements in educational programs that justify the amounts of faculty effort and time that they require.

Acknowledgements

Although we gratefully acknowledge useful discussions on these and related topics with colleagues on the TMS Accreditation Committee, on the University Materials Council, and on the ABET Engineering Accreditation Commission, we take personal responsibility for the content of this paper. Except where noted and cited, the characterizations and conclusions in this paper do not necessarily represent the views of our colleagues or of TMS, UMC, or ABET.

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Figures

Tables

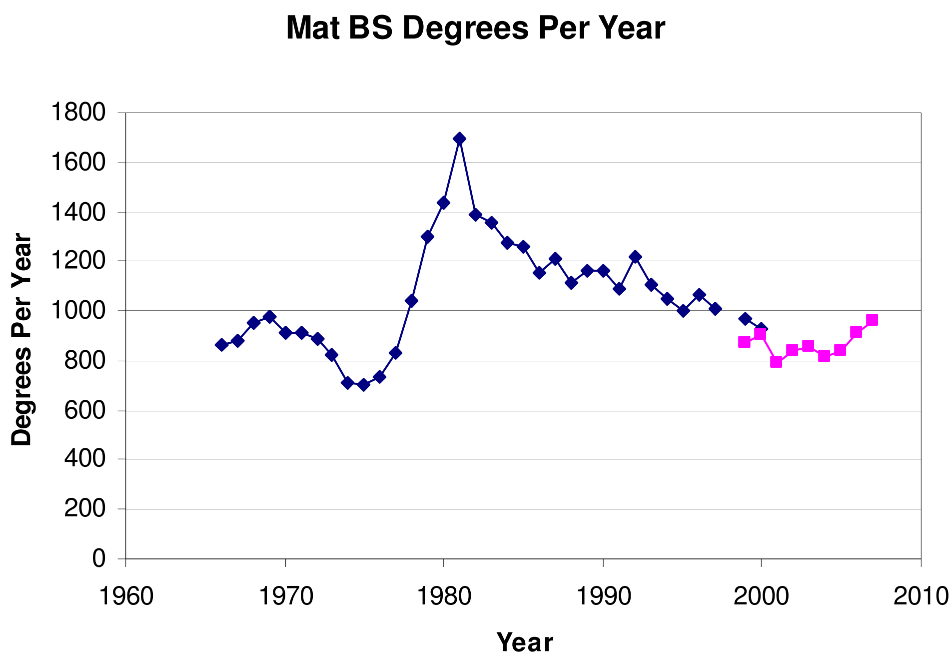

Fig. 1. Numbers of materials program B.S. graduates from 1965 to 2007.

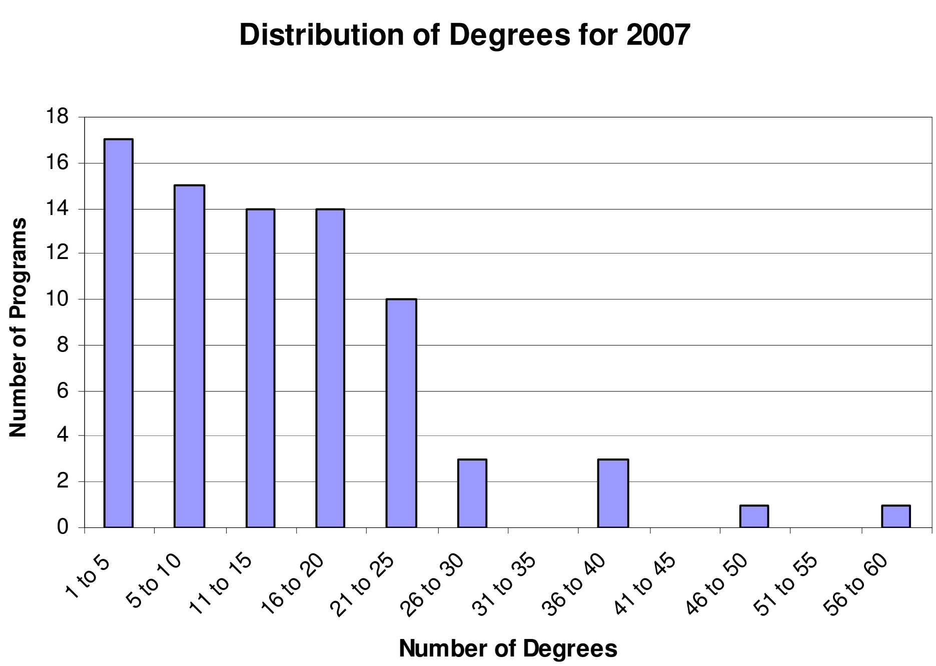

Fig. 2. Numbers of 2007 B.S. materials graduates from different programs.

Table I. List of U.S. B.S.-level Materials Degree Programs with and without ABET Accreditation, and Number of Degrees Awarded in 2007 (from ABET and ASEE).

BS-level Materials Degree Programs with ABET Accreditation		
Institution	**Program Name (Degree) [first year accredited]**	**Degrees in 2007**
Alfred University	Ceramic Engineering (BS) [1936]	15
Alfred University	Glass Engineering Science (BS) [1976]	7
Alfred University	Materials Science and Engineering (BS) [1976]	11
Arizona State University	Materials Science and Engineering (BS) [1998]	13
Auburn University	Materials Engineering (BS) [1975]	5
Boise State University	Materials Science and Engineering (BS) [2007]	1
Brown University	Materials Engineering (BS) [1967]	0
California Polytechnic State University, San Luis Obispo	Materials Engineering (BS) [1971]	21
Carnegie Mellon University	Materials Science and Engineering (BS) [1936]	22
Case Western Reserve University	Materials Science and Engineering (BS) [1936]	6
Case Western Reserve University	Polymer Science and Engineering (BS) [1936]	3
Clemson University	Ceramic and Materials Engineering (BS) [1955]	16
Clemson University	Materials Science and Engineering (BS)	10
Colorado School of Mines	Metallurgical and Materials Engineering (BS) [1936]	48
Cornell University	Materials Science and Engineering (BS) [1951]	24
Drexel University	Materials Engineering (BS) [1953]	13
Georgia Institute of Technology	Materials Science and Engineering (BS) [1942]	23
Georgia Institute of Technology	Polymer and Fiber Engineering (BS) [1949]	18
Illinois Institute of Technology	Materials Science and Engineering (BS) [1949]	7
Iowa State University	Materials Engineering (BS) [2001]	39
Lehigh University	Materials Science and Engineering (BS) [1936]	14
Massachusetts Institute of Technology	Materials Science and Engineering (BS) [1936]	39
Michigan State University	Materials Science and Engineering (BS) [1987]	19
Michigan Technological University	Materials Science and Engineering (BS) [1965]	22
Missouri University of Science and Technology	Ceramic Engineering (BS) [1936]	17
Missouri University of Science and Technology	Metallurgical Engineering (BS) [1936]	17
Montana Tech of the University of Montana	Metallurgical and Material Engineering (BS) [1937]	N/A
New Mexico Institute of Mining and Technology	Materials Engineering (BS) [1993]	N/A
North Carolina State University at Raleigh	Materials Science and Engineering (BS) [1969]	14

Northwestern University	Materials Science and Engineering (BS) [1976]	16
Pennsylvania State University	Materials Science and Engineering (Ceramic Science and Engineering Option) (BS) [1938]	
Pennsylvania State University	Materials Science and Engineering (Electronic and Photonic Materials Option) (BS) [1997]	
Pennsylvania State University	Materials Science and Engineering (Metal Science and Engineering Option) (BS) [1988]	
Pennsylvania State University	Materials Science and Engineering (Polymer Science and Engineering Option) (BS) [2003]	
Pennsylvania State University	Materials Science and Engineering	24
Purdue University at West Lafayette	Materials Science and Engineering (BS) [1941]	23
Rensselaer Polytechnic Institute	Materials Engineering (BS) [1938]	10
Rutgers, The State University of New Jersey	Ceramic Engineering (BS) [1949]	25
San Jose State University	Materials Engineering (BS) [1962]	4
South Dakota School of Mines and Technology	Metallurgical Engineering (BS) [1936]	16
The Johns Hopkins University	Materials Science and Engineering (BS) [1982]	10
The Ohio State University	Materials Science and Engineering (BS) [1994]	28
The University of Akron	Mechanical-Polymer Engineering (BS) [2002]	9
University of Alabama at Birmingham	Materials Engineering (BS) [1983]	9
University of Alabama Tuscaloosa	Metallurgical Engineering (BSMtE) [1949]	5
University of Arizona	Materials Science and Engineering (BSMSE) [1950]	12
University of California, Berkeley	Material Science and Engineering (BS) [2007]	16
University of California, Berkeley	Bioengineering and Materials Science and Engineering	4
University of California, Berkeley	Chemical Engineering and Materials Science and Engineering	26
University of California, Berkeley	Electrical and Computer Engineering and Materials Science and Engineering	4
University of California, Berkeley	Materials Science and Engineering and Mechanical Engineering	16
University of California, Berkeley	Materials Science and Eningeering and Nuclear Engineering	1
University of California, Davis	Electrical Engineering/Materials Science and Engineering (BS) [1995]	1
University of California, Davis	Materials Science and Engineering (BS) [1992]	6
University of California, Davis	Chemical Engineering and Materials Science and Engineering	11
University of California, Davis	Civil Engineering/Materials Science	0
University of California, Davis	Materials Science and Engineering/Mechanical Engineering	0
University of California, Davis	Mechanical Engineering/Materials Science	12
University of California, Irvine	Materials Science Engineering (BS) [2004]	13

University of California, Los Angeles	Materials Engineering (BS) [1985]	18
University of Cincinnati	Materials Engineering (BS) [1948]	15
University of Florida	Materials Science and Engineering (BS) [1971]	25
University of Idaho	Metallurgical Engineering (BS) [1938]	4
University of Illinois at Urbana-Champaign	Materials Science and Engineering (BS) [1996]	60
University of Kentucky	Materials Engineering (BSMAE) [1936]	10
University of Maryland College Park	Materials Science and Engineering (BS) [2000]	8
University of Massachusetts, Lowell	Plastics Engineering (BS) [1978]	22
University of Michigan	Materials Science and Engineering (BS) [1936]	36
University of Minnesota-Twin Cities	Materials Science and Engineering (BMatSE) [1984]	19
University of Nevada-Reno	Materials Science and Engineering (BS) [1955]	7
University of Pennsylvania	Materials Science Engineering (BSE) [1949]	10
University of Pittsburgh	Materials Science and Engineering (BS) [1988]	11
University of Tennessee at Knoxville	Materials Science and Engineering (BS) [1964]	3
University of Texas at El Paso	Metallurgical and Materials Engineering (BSMME) [1947]	17
University of Utah	Materials Science and Engineering (BS) [1970]	12
University of Utah	Metallurgical Engineering (BS) [1936]	6
University of Washington	Material Science and Engineering (BS) [1936]	30
University of Wisconsin-Madison	Materials Science and Engineering (BS) [1995]	13
University of Wisconsin-Milwaukee	Materials Engineering (BSE) [1969]	2
Virginia Polytechnic Institute and State University	Materials Science and Engineering (BS) [1948]	19
Washington State University	Materials Science and Engineering (BS) [1936]	8
Winona State University	Composite Materials Engineering (BS) [1994]	16
Wright State University	Materials Science and Engineering (BS) [1979]	4

BS-level Materials Degree Programs without ABET Accreditation		
Institution	**Program Name**	**Degrees in 2007**
Rice University	Materials Science and Engineering	1
Stanford University	Materials Science and Engineering	3
University of Connecticut	Materials Science and Engineering	3

Table II - Materials Program Curriculum Comparisons

	LU	MIT	UIUC	UFLA	UPENN	MTU	CSM	CAL POLY*
Mathematics								
Calculus	R3	R2	R3	R3	R4	R3	R3	R4
Lin. Algebra/Diff. Eqns.	R	R2	R2	R		R	R	R
Probability/Statistics	R		R	R		R	R	R
Comp./Num. Methods	R	R2	R	R	R	R		R
Science								
Physics	R2	R2	R3	R2	R2	R2	R3	R3
Chemistry	R	R	R2	R2	R2	R2	R2	R3
Organic/Biochemistry		R	R	R				
Biology		R						
Other Engineering								
Circuits (EE)	R		R	R			R	R
Mech. of Matls. (ME)	R		R	R2		R	R	R
Materials								
Introduction/Survey	R	R	R	R	R	R	R	R
Mechanical Prop	R	R	R,E	R	E	R	R	R2
Elec., Opt., Mag. Prop./Devices	R2	R,E	R,E	R,E	E	R,E	E	R
Thermodynamics	R	E	R2	R	R	R	R2	R2
Kinetics/Phase Transf.	R		R	R	E	R2	R	R
Matl. Struct./Char.	R	E	R	R	R	R2	R	E
Metals	R,E	E	E	R,E		E	E	
Ceramics	R,E	E	E	R,E		E	E	E
Polymers	R,E	E	E	R,E	R,E	R	E	R
Nanomaterials	E	E			R2			
Biomaterials	E	E	E	E	R			E
Composite Materials	E					E		R
Matls. Modeling/Simul.		E	E		E			
Materials Processing	E	R,E	E	E	E	R,E	R2,E	R,E
Mat. Select./Fail. Anal.	R			R	R	R		R,E
Design Project/Thesis	R2	R	R	R2	R2	R	R,E	R3
Microstr. Evol./Design		R				R	R	
X-ray Diffraction	E							E
Electron Microscopy	E		E			E	E	
Technical Electives	3	8	5	5	5	7	3	6
Free Electives	3	4	2	0	2	3	3	0

***Note: CALPOLY is on the quarter system, with three class sessions per academic year, while the other schools are on the semester system, with two class sessions per academic year.**

Table III. Program Educational Objectives for Different Materials Programs.

Educational Objectives are "broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve."

LU – describe success in careers and graduate studies:

- Our graduates will have the knowledge and experience needed to advance to successful careers and, where appropriate, for graduate study, in materials-related fields.
- Successful careers will be reflected in continuing employment, personal satisfaction, professional recognition, and advancement in responsibilities.
- Success in graduate studies will be indicated by admission to highly ranked graduate programs, timely completion of degree requirements, and recognition by competitive fellowships and other awards.

MIT – enumerate skills and abilities needed for professional success:

To produce graduates who

- develop a solid foundation in the fundamentals, methods and tools of the field, and be prepared to apply it to the practice of materials science and engineering through exposure to and mastery of state-of-the-art methods of materials design, processing, analysis, modeling and computation.
- are able to creatively balance practical and industrial needs with materials science and engineering fundamentals in addressing engineering problems encountered in engineered systems.
- are able to communicate and work in teams and be prepared to assume positions of leadership in materials science and engineering.
- understand that materials are enabling and integral to the design and fabrication of engineered systems that serve society and the larger world.
- develop an appreciation for the potential impact of materials choices, design and applications on the everyday lives of people, the economic structure of business and industry, and the health of populations.
- are prepared to function knowledgeably, competitively and responsibly in a global professional environment.
- are prepared to become lifelong learners in recognition of the diverse career paths followed by DMSE graduates.

UIUC – describe preparation for success in industrial careers and advanced study:

- Provide students with the necessary foundation for entry-level industrial positions in materials related industries or advanced study programs by a comprehensive education that includes in-depth instruction in both materials as a whole and in their chosen concentration, with an emphasis on analysis, problem solving, exposure to open-ended problems and design methods.
- Provide students with an introduction to team work, communication techniques and individual professionalism, including ethics and environmental awareness, to prepare them for advanced study programs and/or successful, productive careers in industry.

- Provide students with the opportunity to broaden their education in engineering and science or expand their knowledge in a particular technical area by offering a choice of technical and free electives. To provide students with the opportunity to participate in the Co-op and Study Abroad programs.
- Provide students with opportunities to learn and grow as individuals, contribute to society and to appreciate the ability to achieve their goals through life-long learning and leadership.

UFLA – enumerate career paths and goals:

To produce graduates who are

- problem solvers, using their technical skills to advance society, science and technology.
- designers, using their knowledge to improve systems, components or processes.
- professionals, using their professional skills to create solutions and advance their ideas.
- role models, creating solutions that meet the needs of society

UPENN – describe success in materials and other careers, advanced study, and leadership, and in addressing societal needs:

To produce graduates who

- excel in careers in materials science and engineering practice and research in materials-relevant industries, such as biomedical, electronics, energy, telecommunications, and transportation.
- make use of the rigor and creativity of our materials science and engineering program to excel in diverse career paths.
- excel in top ranked engineering graduate programs and professional schools.
- are quantitative, critical, creative and independent thinkers who direct their technical expertise towards addressing the needs of society.
- are recognized as leaders in their chosen fields.

MTU – enumerate materials-related skills and knowledge:

To produce graduates who

- have a sound understanding of the basic concepts of science and engineering in the areas of primary materials production, materials processing, and the properties of materials;
- are able to apply basic science and engineering concepts in the refinement, selection, processing, and design of modern materials used in engineering applications; and
- are able to communicate skillfully and effectively, both orally and in written form.

CSM – enumerates general skills and knowledge for successful careers:

To produce graduates who

- have a broad knowledge base of materials.
- can apply fundamental materials-concepts to solve problems.

- have written and oral communication skills as well as teamwork skills to be successful in their careers.
- understand the importance for self-acquisition of knowledge and continuing education.
- can employ their breadth of knowledge so that they are able to provide a range of solutions to a wide range of materials-engineering problems, and ultimately an optimal choice.

CALPOLY – enumerate activities of effective, socially and environmentally responsible engineering professionals:

To produce graduates who

- apply engineering principles and design to identify, analyze and confront global challenges.
- communicate and perform as effective professionals in both individual and team-based environments
- develop intellectually through continuous learning
- live in a socially and environmentally responsible manner

Table IV. ABET's Eight Criteria Topics
(Starting in 2008-2009, the number of ABET Criteria will be increased from eight to nine and renumbered, with "Continuous Improvement" as a separately listed topic.)

1. Students
2. Program Educational Objectives
3. Program Outcomes and Assessment
4. Professional Component
5. Faculty
6. Facilities
7. Institutional Support and Financial Resources
8. Program Criteria

Table V. ABET Program Outcomes from Criterion 3

Engineering programs must demonstrate that their students attain:

(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 within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

(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, economic, environmental, 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.

Table VI. Program Criteria for Materials

1. Curriculum

The program must demonstrate that graduates have:

- the ability to apply advanced science (such as chemistry and physics) and engineering principles to materials systems implied by the program modifier, e.g., ceramics, metals, polymers, composite materials, etc.;
- an integrated understanding of the scientific and engineering principles underlying the four major elements of the field: structure, properties, processing, and performance related to material systems appropriate to the field;
- the ability to apply and integrate knowledge from each of the above four elements of the field to solve materials selection and design problems;
- the ability to utilize experimental, statistical and computational methods consistent with the program educational objectives.

2. Faculty

- The faculty expertise for the professional area must encompass the four major elements of the field.