STATUS OF AGRICULTURAL ENGINEERING EDUCATIONAL PROGRAMS IN THE USA

The specific sections of the paper and the respective authors are:

I. Overview
Zachary A. Henry, PE, PhD, Professor Emeritus, Department of Agricultural and Biosystems Engineering, University of Tennessee, Knoxville, Tennessee, 37901-1071, email: zhenry@utk.edu

II. Work Areas of ASAE Members
John E. Dixon, PE, PhD, Professor Emeritus, Department of Biological and Agricultural Engineering, University of Idaho, Moscow, Idaho, 83844-0904, email: jedixon@uidaho.edu .

III. Engineering Accreditation in the United States
Paul K. Turnquist, PE, PhD, Professor and Head Emeritus, Department of Biosystems Engineering, Auburn University, Auburn, Alabama, 36849-5417, email: turnquis@eng.auburn.edu . (He served as EAC Commissioner of ABET 1992-97 representing The American Society of Agricultural Engineers.)

IV. Technology Programs
Jack L. Schinstock, PhD, Professor and Assistant Dean, Biological Systems Engineering Department, University of Nebraska, Lincoln, Nebraska, 68583-0726, email: jschinstock1@unl.edu

Overview

Zachary A. Henry, PE, PhD

Approximately 50 Universities in the USA have Departments of Agricultural Engineering. Each Department maintains its autonomy with an individualized program. Yet, the field of Agricultural Engineering in the USA, and, especially, Agricultural Engineering educational programs, are composed of a close knit group of engineers and scientists with common goals. This permits and cultivates a climate for unifying a direction for higher quality. The total field of Agricultural Engineering covers many diverse sub-fields, yet there is a common bond that brings the apparently diverse specializations into focus. That focus is the application of engineering principles to the production and delivery of food and fiber to the world under safe working conditions while protecting the environment. Thus, all undergraduate educational programs provide a very standard engineering foundation that begins to specialize in the third year with a more direct emphasis on specialization in the fourth year. Graduate programs continue this specialization and, at the same time, permit an interaction across specializations that result in a diversified graduate.

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The accreditation system that is administered by a cooperative effort among all engineering fields is a control that insures quality. Additionally, this allows each Agricultural Engineering Department to benefit by the strengths of every other Department. Many professional organizations contribute to the enhancement of the educational programs. The two most prominent are the American Society of Agricultural Engineers and the American Society for Engineering Education. The latter brings educators from all engineering disciplines together and the former allows educators, not only to be in contact with other educators in Agricultural Engineering, but to, also, have direct association with practicing engineers.

Many agricultural engineering departments have dual programs. (1) A fully accredited engineering program that requires all the fundamental engineering science foundation and produces a qualified engineer. (2) A technology based program directed to the student whose interest is in applying technology to the agricultural sciences or business. There is an industry need for graduates from both programs. The meaningful test of quality is the placement of graduates and their performance in the world of engineering and technology.

Educational programs in Agricultural Engineering in the USA are primarily limited to State Universities. It is significant to the quality of the programs that most, but not all, of these universities are those that have been designated as 'Land Grant' Universities that administer the primary agricultural research and extensions programs for their particular state. The research programs relate primarily to the needs of each specific state and secondarily to a larger need of the total country and to the world. The extension programs have the charge to relate the latest scientific findings to practical application that can be used to enhance and optimize agricultural production. The sponsoring and financing of these programs are supplemented by government, private, foundation, and industry grants and contracts.

Often, teaching faculty are jointly associated with one or both of these two programs. This greatly enhances both the undergraduate and the graduate programs. Both undergraduate and graduate students are led by faculty that remain current in the latest scientific and engineering advances. Additionally, this permits graduate students to be involved in research programs that are on the cutting edge of science. Also, students have an opportunity to see the practical application of the scientific advancements to the real world of industrial development and agricultural production.

This paper identifies the status of agricultural engineering and technology programs in the USA with respect to departmental strengths, special areas of emphasis, and specialized programs. In most cases these emphasis areas and special programs are the same for both the engineering and the technology programs. In addition, the fields of employment for the graduates are identified.

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Work Areas of ASAE Members

John E. Dixon, PE, PhD

The Database

Most people who graduate with a degree in Agricultural Engineering from a university in the United States and follow the profession belong to the American Society of Agricultural Engineers (ASAE). Some people with agricultural engineering technology training also join ASAE. This being the case, the ASAE membership database was used to determine the type of work agricultural engineers and agricultural engineering technologists do. When a person applies for membership in the Society, they are asked to supply information about themselves. In addition to the usual name, address, telephone number and e-mail address, they are asked to supply information such as *major job function, employer type, primary work area, and technical interest*. Based on qualifications and other factors each member is assigned a membership number and grade. This information, minus the membership number and name data, was used for this analysis.

Of the 8678 members of record in November 1999, 7055 listed a mailing address within the USA. There are seven membership grades listed; two records failed to show a membership grade. The number of members (records) listed in each grade is shown in Table 1.

Table 1. Number of members by grade

Fellow	225	Student member	1419
Honorary	1	Student engineer	2
Member	1020	(left blank)	2
Member-engineer	4322	Grand total	7055
Senior member	34		

The grades of membership need to be defined. Student Members have finished all but one year of college and have submitted their membership application through a university student branch of ASAE. Those students that have completed the first part of the professional engineer's (license) examination may apply for the membership grade "student engineer". The grade "Senior Member" is no longer offered for membership; under earlier rules a member could apply for this grade after about 20 years of membership. A "Member Engineer" is a membership grade assigned to a person by the ASAE Membership Development Council based on their qualifications in the field of engineering. Usual minimum qualifications are an engineering degree from a university agricultural engineering program that has been accredited by an engineering accrediting agency. For the United States this agency is the Accreditation Board for Engineering and Technology (ABET). The grade "Member" is assigned to a person with interest and qualifications in a field of agriculture, food processing, mechanization, system management, environmental systems, aquaculture, biosystems, or a similar field. Minimum qualifications are usually a university baccalaureate degree. A "Fellow" is a member with at least twenty years of

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membership and elected to that grade by the Board of Trustees after examination of nomination material submitted by peer members. Honorary membership is self-explanatory.

It should be noted that the individual member selected the classifications such as job function and employer type from a list provided on the membership application form. The count numbers presented here represent what the individual member felt best represented what she or he was doing at the time the person completed the form. Each member is given an opportunity to update his or her classifications each year at dues payment time.

An evaluation of the age of members will be helpful in evaluating the data. The birth date is requested with membership applications. In many cases only the year is given and for some records (37) the birth date field was blank or the field corrupted. The age values given here are calculated from the given birth date.[1] Table 2 classifies the ages of members into ten-year groups and shows the number of members in each group. The numbers of student members in the three youngest age groups are 1160, 164, and 81, respectively. There are nine student members in the remaining groups.

Table 2. Number of members in each age group

Less then 29	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	80 – 89	90 - 99
1550	1089	1481	1250	965	426	205	52

Employment and Technical Interests

Tables 3, 4,and 5 give a count of members marking the listed classification within the three work and technical categories which are the **Employer Type,** the **Primary Work Area,** and the **Primary Technical Area** respectively. The **Employer Type** tells the type of business or operation in which a member is employed or involved. The **Primary Work Area** indicates the main job function carried out by the individual. For each of the three categories some members failed to make a selection. For these members the field is blank in that record. The counts for the fields left blank are 1867 for employer type, 2547 for primary work area, and 412 for primary technical area.

Discussion of Count Results

When reviewing the tables presented below, it should be noted the numbers are independent counts of a tick mark in a data field. This means an individual member could indicate his or her employment category as *processor,* the primary work area as *crop production,* and primary technical interest as *forest engineering.* These three selections seem unrelated, but are possible.

[1] Although it will not impact the analysis, it was noticed the calculated data for those records with year only data were about two years older than should be.

As noted above 1421 members listed themselves as students. It is unlikely that many of the student members are employed within the profession. They most likely left the "employer type" and "primary work area" fields blank, when completing the membership application form. When the raw data were visually scanned, almost all student records viewed were blank in the two fields thus verifying this assumption. Most student members *did* mark their "primary technical area". This analysis implies the blank count for "employer type" can be reduced to about 446 (1867-1421) and for the "primary work area" to about 1126 (2547-1421). This means the presented data is more representative of the real situation than the raw count might initially indicate.

The employer type (Table 3) with the highest percentage of members (26.33%) is equipment manufacturers. The second highest percentage (19.45%) is schools (universities). Consulting firms are third with 17.68 percent. The lowest percentage of members work for libraries.

Table 3. Employer type – The kind of business where employed

Employment Category	Number of Members	Percent of Total
Agri-business	350	6.75
Association	37	0.71
Consultant	917	17.68
Distributor	51	0.98
School	1009	19.45
Experiment station	117	2.26
Producer/farmer	114	2.20
Government agency	756	14.57
Library	3	0.06
Manufacture, components	276	5.32
Manufacture, equipment	1366	26.33
Processor	140	2.70
Supplier	52	1.00
TOTAL	5188	100.00

Machinery design (Table 4) was the work area most often designated by ASAE members. More than thirty-one percent work in this area. The next most designated work area (18.88%) was water quality and management. The least often listed work area (less than one percent) was food processing. The low count for food processing may possibly be attributed to the fact that many food engineers that graduate from Agricultural Engineering programs choose other organizations as their primary techinal society such as the Institute of Food Technoligsts (IFT) or the American Institute of Chemical Engineers (AIChE).

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Table 4. Primary work area – A member's main job function

Primary Work area	Number of Members	Percent of Total
Crop processing	142	3.15
Crop production	238	5.28
Electronic & Control systems	218	4.84
Electronic distribution & applications	109	2.42
Environmental quality	133	2.95
Environmental systems, livestock & crops	347	7.70
Farmstead engineering	218	4.84
Structural Design	304	6.74
Food processing	21	0.47
Irrigation equipment & systems	318	7.05
Machinery design	1404	31.14
Safety	151	3.35
Turf & landscape	55	1.22
Water quality & management	850	18.86
TOTAL	4508	100.00

Most members (39.59%) selected power and machinery as their primary technical interest (Table 5). The soil and water technical interest area was the second most often selected area (28.78 %). Since food processing was selected as a work area by less than one percent of the members, it is worth noting that food and process engineering is in forth place for technical interest.

Table 5. Primary technical area – The ASAE classification of member's interest

Primary Technical Area	Number of Members	Percent of Total
Aquacultural engineering	115	1.73
BE	9	0.14
Bioengineering	208	3.13
Forest engineering	55	0.83
Food & process engineering	565	8.51
Information & electrical technology	421	6.34
Power & machinery	2630	39.59
Structures & environment	728	10.96
Soil & water	1912	28.78
TOTAL	6643	100.00

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Engineering Accreditation in the United States

Paul K. Turnquist, PE, Ph.D.

Introduction

The rapidly expanding global economy will result in a significant increase in national and multinational companies and governmental agencies hiring university/college graduates for employment in a global market. A graduate from an agricultural engineering undergraduate education program (and similarly named engineering programs) in one country may be employed in another country by either a governmental agency or multinational company. Employers of graduates need assurance of the quality of the graduate based on some minimum qualifications. Likewise, educational institutions selecting international students for graduate study need assurance of quality of the degree. Accreditation of engineering programs in the United States by the Accreditation Board for Engineering and Technology, Inc. (ABET) since 1936 provides a model for agricultural engineering educators world wide to consider.

Brief history of engineering accreditation in the United States

ABET was formed in 1932 as the Engineers' Council for Professional Development (ECPD) to promote the status of the engineering profession and to enhance the quality of engineering education. In 1980, the ECPD became the Accreditation Board for Engineering and Technology (ABET), focusing its efforts on the accreditation of educational programs. ABET is a federation of 28 professional engineering and technical societies, including ASAE. Representatives from these societies are practicing professionals from industry and academe, and form the body of ABET through its Board of Directors and three working Commissions: Engineering Accreditation Commission (EAC), Technology Accreditation Commission (TAC) and Related Accreditation Commission (RAC). ABET now accredits some 2,300 engineering, engineering technology and engineering-related educational programs at more than 500 colleges and universities in the United States. Currently (Year 2000) there are 45 agricultural engineering (and similarly named engineering programs) accredited at 40 universities in the United States.

ABET began international activities in 1979 with an agreement with the Canadian Engineering Accreditation Board in which both countries accepted their accreditation criteria as "substantially equivalent." During the 1980's, a six-nation agreement now known as the Washington Accord, was established involving the United States, Australia, Canada, Ireland, New Zealand, and the United Kingdom. Recently Hong Kong joined the group. Each signatory to the Accord defines its own approach to educational quality assurance for graduates entering the engineering profession or those seeking initial professional recognition. This does not mean identical format and method of delivery in either systems or educational experience. It does mean that the engineering programs are comparable in content and educational experience and that the graduates possess similar competencies to begin engineering practice at the entry level. ABET has evaluated 66 programs in eight countries since 1989 (none are agricultural engineering programs) which are "substantially equivalent" which means they are comparable in program content and educational experience, but such programs may not be absolutely identical in format or method of delivery.

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Framework for accreditation

ABET criteria, policies and procedures developed over the years are excellent models for defining a framework for accreditation of agricultural engineering programs on a worldwide basis. Accreditation of engineering programs is a voluntary process that institutions choose to undertake. Accreditation is important because it helps many people make important decisions. 1. It helps students choose an educational program. 2. It assures parents of a quality education for their child. 3. It helps institutions improve their programs. 4. It helps employers recruit well-prepared students. 5. It allows industry to voice its educational needs to institutions. 6. It provides a base for registration, licensor and certification boards screening applicants for entry into professional practice. A program of study is accredited, not the department or administrative unit that offers the program.

Criteria

Criterion for accrediting engineering programs has gone through many changes over the last 64 years. A major and revolutionary change in criteria, Engineering Criteria 2000 was approved in 1995. Criteria 2000 will be fully implemented in the 2001-2002 accreditation cycle. The new criterion represents a major philosophical shift in that the institution has to establish program educational goals, identify program outcomes that state what competencies the graduates will acquire and how assessment of these competencies will be made. It is an ongoing quality improvement process with a number of feedbacks to the faculty and administrators. This approach calls for greater involvement by faculty and administrators and increased feedback (assessment) from employers of the graduates, graduates and current students. There are nine Criteria as follows:

Criterion 1. **Students** are central to the education process and therefore, qualifications for entering and transfer students must be established and enforced. Likewise standards for graduation must be established and enforced. In total these requirements insure that all students meet the program requirements.

Criterion 2. **Program Educational Objectives** require the faculty and administrators to establish and publish the programs educational objectives and curriculum. To maintain and improve the program, periodic inputs must be obtained and utilized from the program's various constituencies.

Criterion 3. **Program Outcomes and Assessment** identifies 11 specific abilities that the graduates must demonstrate. The institution must develop suitable tools to assess that the graduates achieve the specific abilities defined. Assessment should occur during the educational process, upon graduation and as the graduate practices his or her engineering speciality.

Criterion 4. **Professional Component** identifies the overall curriculum content for a four-year program. Curriculum content is broadly defined to give the institution flexibility and opportunity for creativity in program development and maintenance. The general education

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component will be consistent with the overall university requirement which at many institutions, is the "core curriculum" required of all students.

Criterion 5. **Faculty** requirements are broadly defined. It should be noted that number of faculty is not specified. However, the institution must document the number and qualifications of the faculty, their time allocation for teaching, research, advising, etc. and demonstrate that an adequate number of faculty exist to meet the program objectives.

Criterion 6. **Facilities** requirements are broadly defined. However, the institution must have adequate classrooms, laboratories, associated equipment, and modern computing and information infrastructures in place appropriate for the engineering program.

Criterion 7. **Institutional Support and Financial Resources** calls for constructive leadership that is committed to providing financial resources to insure the quality and continuity of the engineering program. Documentation is required of faculty salaries, funds for maintenance and equipment, library holdings and financial support for faculty professional development.

Criterion 8. **Program Criteria** for individual engineering programs must be met. These requirements are limited to curricular topics and faculty qualifications. ASAE has developed program criteria that identifies curricular competencies for the various engineering programs it has under its purview. For additional information on criteria, policies, and procedures, the reader is encouraged to visit the web site of ABET at www.abet.org.

Benefits of global accreditation of Agricultural Engineering Education Programs

The success of ABET accreditation in engineering programs in the United States and the related international activities of accrediting "substantially equivalent" programs provides an opportunity for agricultural engineering educators working cooperatively within CIGR and ASAE for establishing agricultural engineering program accreditation for programs outside the United States. Global economic and cultural activity among nations are increasing rapidly which will demand more and better educated agricultural engineering graduates.

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Technology Programs

Jack L. Schinstock, PhD

Prior to the early 1990's, most of the technology programs were simply called agricultural engineering technology, agricultural mechanization, or mechanized agriculture. Many of the 29 universities currently offering technology programs recently changed the scope of their programs to focus on emerging technologies, as they apply to food and agricultural systems and to address society's need to efficiently utilize natural resources and to protect the environment. The names of the respective programs reflect the philosophy of the school in responding to these issues. So although they may have different names, these programs are really quite similar. Program names currently in use are:

- Agricultural and Environmental Technology
- Agricultural Engineering Technology
- Agricultural Operations Management
- Agricultural Systems Management
- Agricultural Systems Technology
- Agricultural Technology Management
- Agricultural Technology and Systems Management
- Bioresources Engineering Technology
- Mechanized Systems Management
- Technical Systems Management

Most universities offer only a Bachelor of Science degree and one university offers only a Master of Science degree. Less than 20 percent of the universities offer both an undergraduate program and an active graduate program. This lack of two degree programs is not the result of the need for both, but is related to the resources that the universities are capable of providing for the complete program.

Today, engineers and systems management graduates both work with the same types of buildings and equipment, the same crops and animals and the global society, yet there is a distinct difference in the work they do. The engineer is trained to analyze and design a process, system or mechanism, while the agricultural systems specialist is able to identify system problems, formulate possible solutions, analyze the impact of alternatives (including social and economic dimensions) and then implement the best solution. When comparing systems management to engineering, the systems programs are less theoretical and more practical. Emphasis is on application experiences and most courses have laboratory or recitation sections.

An agricultural systems management degree combines an understanding of the agricultural, biological, and physical sciences with managerial and technical skills. This understanding of science, systems management and applications engineering can be used in a career in the production and processing of food, fiber, feed, and fuel. Students focus on the application of engineering principles, the study of agricultural technology and the integration of business management concepts in the food and agricultural industry. This degree is ideal for students interested in technical sales or being a technical manager for an agricultural related business involved in production, processing, service or manufacturing.

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Each department has its own particular situation and emphasis, with most departments offering specializations within the major, i.e., business, processing, production, testing and environmental systems. The "core" curriculum integrates a comprehensive liberal education with expertise in the agricultural sciences, applied technology and business management. Core courses provide the foundation of mathematical, chemistry, computer, economic and communication skills. Specializations allow students to gain an in-depth knowledge of integrating and applying advanced agricultural technologies and equipment by completing courses in machine and power systems, food and materials processing and handling, environmental resources management, computer applications, electrical/electronic system and information/decision support technology. This common core with specialization allows the various institutions to respond to society's needs in a manner that reflects the respective institution's philosophy.

Systems management graduates are in great demand. The average starting salaries are highly competitive and are among the highest of the college of agriculture graduates, averaging in the mid to high $30,000 range. Employers and career opportunities are vast and varied. Prospective employers include ConAgra, Deere & Company, Valmont Industries, Techmark, Purina Mills, Rain Bird, Pioneer Hi-Bred International, Caterpillar, Cargill, and Government agencies. Possible career opportunities for systems graduates are Plant Production Supervisor, Product Testing, Grain Merchandiser, Irrigation Management, Food Processing Plant Manager, Operator or Manager of a Farm or Agribusiness, Territory Sales or Service Manager, Energy Use Advisor, Loan Appraiser and Soil Conservationist.

Listing of Educational Programs

Educational programs in Agricultural Engineering and related fields in the USA and Canada are listed in the American Society of Agricultural Engineers (ASAE) web site: http://asae.org. In addition, the following link provides a more complete International Directory of Agricultural Engineering Institutions.

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Web Page Links

The World Wide Web (WWW) links below will lead to many other links with respect to Agricultural Engineering and related interests.

American Society of Agricultural Engineers
- Agricultural, Biological, and Environmental Information
- Engineering on the Internet
- International List of Agricultural Engineering Societies
- Other Organizations

International Search Directory of Agricultural Institutions

International Directory (list) of Agricultural Engineering Institutions

International Commission of Agricultural Engineering (CIGR)

Worldwide Agricultural and Machinery Directory

Food and Agriculture Organization of the United Nations (FAO)

Accreditation Board for Engineering and Technology, Inc. (ABET)