Agricultural Engineering Education in Indonesia

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Abstract

This paper describes the development of agricultural engineering education in Indonesia. Originally two universities, i.e., Bogor Agricultural University and Gadjah Mada University, offered educational program under the name of Agricultural Mechanization. Along with the national policy in increasing agricultural production, the agricultural mechanization has played a significant role in expanding new agricultural lands and in building related infrastructures. Later on, having influenced by the global trend, the name was changed into agricultural engineering. Wiser approaches were then sought in producing and processing food and agricultural products in sustainable ways. The emerging task for agricultural engineers is how to produce agricultural products more competitive in international markets. Agricultural Engineering Education program, now offered by seventeen universities in Indonesia, is now being developed further through the support of competitive grants from the government. This paper also discuses one of the projects being conducted in Bogor Agricultural University.

Keywords: Education • Agricultural mechanization • Agricultural engineering • Development

1. Introduction

In 1967, a national symposium was held in Ciawi-Bogor with one of the main concerns was to define the role of Agricultural Mechanization. The definition formulated then was: *"a discipline of science that explores natural resources and energy for the development of human creativity in agriculture for the prosperity of human being"*. By the definition, the roles of the Agricultural Mechanization were stated as follows: 1) to increase the efficiency of man labor; 2) to elevate the status and living standard of farmers; 3) to assure the increase in quality and quantity of agricultural production; 4) to enable the development of farming type from subsistence to commercial; 5) to accelerate the transition of economical nature from traditional to industrial based agriculture. The Agricultural Mechanization program was then divided into six fields: 1) Agricultural Machinery which studies the utilization of power and equipment in agriculture; 2) Soil and Water Engineering which studies water uses in agriculture and soil conservation; 3) Agricultural Structures and Environment which studies the problems in the utilization of agricultural buildings, infrastructures and related environment; 4) Agricultural Electrification which studies the problems of utilization of electrical energy in agriculture; 5) Agricultural Product Processing Machinery which studies the problems in the utilization of machineries in conditioning and processing of agricultural products to be stored or be consumed directly; 6) Food Processing Machinery which studies

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the problems in the utilization of machinery and pre-condition requirements for food processing.

Using the concept resulted from the symposium two Agricultural Mechanization Departments were developed in two main national universities, i.e., Bogor Agricultural University (BAU) in Bogor and Gadjah Mada University (GMU) in Yogyakarta. As state-universities, both were obliged to conduct three activities known as 'Tri-Dharma' comprising education, research, and outreach programs. The activities of AM education programs were: 1) to conduct an education program based on agricultural mechanization sciences, technical skill of agricultural mechanization, entrepreneurship skill to manage agribusiness; 2) to conduct research focused on adaptive research to support education and agricultural development; and 3) to convey and disseminate the research results to farmers and other stakeholders. For some time thereafter, agricultural mechanization took a lead in the extension agricultural production, including the opening of new agricultural fields while at the same time preparing land for the new community transmigrated from Java to Sumatera, Kalimantan, and Sulawesi. One of the achievements was that Indonesia achieved rice self-sufficiency in the early 80s.

2. External Environment

Later on the development of Agricultural Mechanization education took different forms as Indonesia facing rapid population growth, food and energy crises, as well as environmental degradation. The mechanization activity was widely claimed as causing damage to soil and environment. The other was the economic reason since, until recently, Indonesia has never been successful in developing agricultural machinery. This country has been relied mainly on imported machinery that has generally been unsuitable for soil types and infrastructures in Indonesia. Nowadays, opening new agricultural land or constructing dams for agriculture is like trying to stand up a wet thread. This condition more or less limited the development of the Agricultural Mechanization Education. Several attempts were then conducted to improve the image or to make a new image of agricultural mechanization, which evolved into Agricultural Engineering. This term was of course not new to Indonesian ears, since many lecturers or instructors at BAU were graduated from western universities. The term *Agricultural Engineering* is translated into Indonesian word as *Teknik Pertanian,* i.e., *Pertanian* stands for Agriculture and *Teknik* for Engineering. However, the word *teknik* could be confused with the word technique in English, which has different meaning. *Teknik* as the translation of engineering has for long been widely adapted by other disciplines such as *Teknik Sipil* (Civil Engineering), *Teknik Kimia* (Chemical Engineering), *Teknik Fisika* (Physical Engineering), and so on.

In the 90s, there were three state universities (including Brawijaya University in Malang) and two private universities that develop Agricultural Engineering Departments. Five other universities use the Agricultural Engineering discipline as a supporting program. Only two universities (BAU and GMU) have graduate programs in Agricultural Engineering. At each of the three state universities, the Department of Agricultural Engineering is under the Faculty of Agricultural Technology. Whilst, at the other five universities, the Undergraduate Study Program of Agricultural Engineering belongs to the Department of Agricultural Technology, under the Faculty of Agriculture. The slow development of Agricultural

Engineering program might be attributed to the following conditions. In Indonesia, a study program is grouped according to the national consortium of sciences. Up to this time, it is not clear whether Agricultural Engineering as a study program is grouped into engineering or agricultural sciences even though the curricula have met with the minimum requirements of the Engineering Consortium. Most of the lecturers are called engineers and are involved in engineering professional society. This condition may result in a situation that Agricultural Engineering is less recognized by the publics and accordingly has decreased student enrollment both in term of quantity and quality. As a result, the Department of Agricultural Engineering in two private universities (Mercu Buana University and Indonesia Institute of Technology) was closed due to limited numbers of students enrolled. The other condition that also might cause the decrease in the student enrollment in Agricultural Engineering is the introduction of Information Technology (IT) as a new discipline, which is globally more trendy and popular. Almost all universities offering IT or computer program (CP) have received enormous numbers of applicants.

By the end of the 90s, while the country was experiencing very difficult economic crises which caused widespread lay-offs and unemployment especially in industrial and business sectors, the agricultural sector was mostly undisturbed and played a significant role in stabilizing the rural economy. Increase in the US Dollar exchange rate raised the competitiveness of the prices of plantation products in international markets. Instantaneously, prosperity came to the progressive farmers. This phenomenon attracted many others to find fortune in agribusiness. At the policy level, it has been clear that future national development will be based on the exploitation of renewable resources with an intensive and wise approach to the utilization of environmentally friendly technology.

Several supports from the government provide significant encouragement for agricultural education by allocating competitive grants for the development of some study programs in the form of projects. For example, some of the projects are the RAISE (Relevance, Academic Atmosphere, Internal Management, Sustainability and Efficiency and Productivity); QUE (Quality Undergraduate Education); DUE-Like (Development for Undergraduate Education); and other following projects. Improving infrastructure and applying intensive and appropriate technology in agriculture has resulted in higher productivity. For example, after the decline in rice production in the time of crises in 1998 and rice imports continued until 2001, the production of rough rice in 2003 hit an all time high of 52.1 million tons, and it was forecasted in 2004 that the production would increase to 53.7 million tons or equal to 33 tons of milled rice, exceeding the national consumption of 31 tons as attributed to the improved irrigation systems, integrated pest management and technology application especially the use of fertilizer. However, the remaining problem is that the price in the international market is still lower than that in Indonesia, which gives a potential threat when the import bans are removed. At that moment, the national price of rice was between 2,500 and 3,000 RP (about one-third of a USD), whilst, the international price was between 2,000 and 3, 000 RP per kilogram[1]. The real challenge now and for the future is how to produce agricultural products or by-products more competitively, i.e., cheaper than the international price while maintaining proper benefits to the farmers.

[1] Jakarta Post, August 10 and 11, 2004.

3. Trends of Development

There has been no new definition of Agricultural Engineering in Indonesia, but it is already accepted as a field of science that explores and utilizes biological resources and energy in sustainable ways for the prosperity of Indonesian people and human being as a whole. This trend, which is also attributed to global trend, supports the development of Agricultural Engineering. It took shapes in the form of updated programs and curricula. Intelligent approach has become supporting parts of all fields of study. As a signaling result, the number of student enrolled increases in terms of quantity and quality almost in all universities offering the study program of Agricultural Engineering, not only undergraduate but also graduate programs. To develop a curriculum is not just a matter of introducing the national consortium for those universities becoming autonomous such as BAU and GMU. The development of a curriculum should consider the global trend and be based on objective tracer studies on how graduates could fill the requirement of the job markets in country as well as abroad. Competency and competitiveness are of the main concerns to make a clear identity of the graduates, at the same time, capable of acting as a social entity that has moral and social responsibility. Fields of Agricultural Engineering study become broader by the emerging of the agricultural engineering and technology, such as those fields of Aquacultural Engineering, Sericultural Engineering, Renewable Energy, Intercropping in Agroforestry, Bioenvironmental Control, etc.

The Department of Agricultural Engineering at BAU is preparing a new system, which is called major and minor programs. Of course, agricultural engineering is the major program of the department, while a special arrangement of courses is offered as minor for other departments within the university. The Agricultural Engineering students have some options to take minor program from other departments at BAU. This concept opens the opportunity for the students to have broader knowledge. The benefits of AE education among others are the possibility to develop collaboration programs with other disciplines such as Aquacultural Engineering, Sericultural Engineering, Landscape Engineering, Biological Engineering, Environmental Engineering, etc.

4. National Curriculum

In general, the national curricula classify five categories of courses as follows: (a) developing personality (9 credit units out of 144~147 cu[2]); (b) learning to know (58 cu); (c) learning to do (55-56 cu); (d) learning to be (17 cu); and (e) learning to live together (7 cu). The terms (b) through (e) of the categories are adopted from those used by UNESCO. Learning to know refers to sciences and skills. Learning to do refers to specialization or expertise. Learning to be refers to attitude. Learning to live together refers to interaction in society.

The first category, developing personality, is applied for education at national level, which occupies about six percent of the total 144 credit units. Courses grouped in this category are Religion Education, State Ideology and Civics, Introduction to Sociology, Physical Education,

[2] The minimum total credit unit for undergraduate education is 144 cu. Mostly, engineering education is more than that number.

and Arts. The government of Indonesia acknowledges the existence of several religions such as Islam, Christian, Hindu, and Buddha.

The second category, *learning to know* (40%), is optionally given according to the consortium. For agricultural consortium, it consists of courses given in freshman level in the first and second semester and basic courses for Agricultural Engineering education. The courses in the freshman level (18%) are Introduction to Agriculture, Biology, Physics, Chemistry, Mathematics, Calculus, Climatology, and Economics. The basic courses for Agricultural Engineering education (22%) are Engineering Mathematics, Statics and Dynamics, Fluid Mechanics, Engineering Statistics, Engineering Drawing, Thermodynamics and Heat Transfer, Engineering Materials, Workshop, Agricultural Materials, Surveying, and Soil Properties.

The third category, *learning to do* (38%), consists of Agronomy, Computer Application, Instrumentation, Strength of Materials, Systems Analysis, Engineering Economics, Energy and Electrification in Agriculture, Engineering Design, and two to four courses elected by students for more specialization in AE fields. Elective courses are generally offered by every laboratory or division in the department.

The fourth category, *learning to be* (12%), consists of Introduction to Agricultural Technology, Principles of Management, Entrepreneurship, Field Works, and Research or Special Problem. It is an obligation for the student of Agricultural Engineering to spend about 2 months to take a close look at the real activities or real world either in community, private estates, or industrial sectors. The students choose and determine by themselves what sectors they are interested in. Many companies are also offering opportunities to be filled by the students in this respect. The students may take part actively in the production activities guided directly by a supervisor from the company. During the field work some students may find some topics that are suitable for their research or special problem. In this case, they can extend their stay in the company to carry out his or her final assignment.

The fifth category, *learning to live together* (5%), consists of Indonesian Language, English, Scientific Presentation and Seminar. In this respect, they are given guidance on how to prepare good scientific papers and to present them orally in class or in poster, and how to act properly in scientific gatherings. Participation of undergraduate students in the annual seminar of the Indonesian Society of Agricultural Engineering is highly encouraged. Yet, it becomes mandatory for the graduate students to present their original scientific papers in the seminar.

Each course has a syllabus, i.e., in the form of guideline of teaching program which consists of course name, course code, credit units, brief description, main instructional objectives, and materials for course and laboratory work, if any. It is also necessary to list some prerequisites needed. Materials for course/lab-work are organized into specific instructional objectives, main topics, sub-topics, time allocation and references. This teaching guideline should be clear enough for the student to understand. It is also necessary to explain to the student about how many assignments and examinations are given, and the percentages for determining the final grade. Mostly, the student will be given two evaluation tests (mid and final exams), lab-

work evaluation and other assignments such as home works, papers, etc. An example of a syllabus of a course can be seen in the Appendix.

5. Curriculum Development

The Ministry of National Education has inaugurated an independent board of educational accreditation (BAN) by the end of the 90s. Up to now, BAN is the only board authorized to do accreditation for all study programs in the country. Every study program is obliged to apply for accreditation by means of submitting relevant documents such as port-folio, self-evaluation, and subjected to site visit by the board staffs. For undergraduate programs, BAN grants three categories or ranks of accreditation of A for excellent, B for fair and C for poor. For graduate programs, there are only 2 ranks, i.e., A and B. Table 1 shows the accreditation of undergraduate and graduate AE study programs in several universities.

Table 1 Accreditation of Agricultural Engineering Programs in Indonesia (1998-2004)

No	Name of University	Year	Grade	Rank
1	Pajajaran University, West-Java	1998	Undergraduate	A
2	Andalas University, West-Sumatera	1998	Undergraduate	B
3	Jember State University, East-Java	1998	Undergraduate	B
4	STIPER Agriultural Institute, Central-Java	1998	Undergraduate	B
5	Sam Ratulangi University, North-Sulawesi	1998	Undergraduate	C
6	Hasanuddin University, Makassar	1998	Undergraduate	C
7	Bogor Agricultural University, West-Java	2000	Undergraduate	A
8	Bogor Agricultural University, West-Java	2000	Graduate	A
9	Lampung University, Lampung	2000	Undergraduate	C
10	Udayana Univesity, Bali	2000	Undergraduate	C
11	Muhammadiyah University, Mataram	2000	Undergraduate	C
12	Brawijaya University, East-Java	2001	Undergraduate	B
13	Gadjah Mada University, Yogyakarta	2003	Undergraduate	A
14	North-Sumatera Univesity, North-Sumatera	2003	Undergraduate	B
15	Sriwijaya University, South-Sumatera	2004	Undergraduate	B
16	Indonesia Institute of Technology, West-Java	2004	Undergraduate	B
17	Gadjah Mada University, Yogyakarta	2004	Graduate	B

The Ministry of National Education of the Republic of Indonesia has introduced competitive grants for the development of curriculum including educational facility in various study programs. One of the projects, namely DUE-Like, has been awarded to the Department of Agricultural Engineering at Bogor Agricultural University for the period of 2002-2006. This program has main objectives to increase relevance, efficiency, productivity, and academic atmosphere of a study program in a state university awarded the grant. Followings are some results of performance indicated by the Department of Agricultural Engineering at BAU through the project.

5.1 Increase Relevance

In connection to the DUE-Like Project, the Department of Agricultural Engineering proposes to increase English proficiency, technical capability, and managerial and entrepreneurship skills of the students.

English Proficiency. The purpose of this activity is to improve student capability in deciphering course materials and assignments given in English. Each year, some selected courses, lab-works, and assignments are given in English. Students who get low grade in a pre-test (less than 480 in TOEFL standards score) are given special tutorial or should go to an additional English course. There is also an English Club for those who are interested in joining. At this moment, there are 8 courses available in English version and at the end of the project there would be 20 lectures. About 35% of the students managed to pass the assignments.

Technical Capability. The purposes of this activity are to enrich laboratory works with the installment of new facilities, and to intensify the use of computer networks. The activities are to upgrade laboratory manual, to procure new instruments, equipments and PCs, and to assign senior students as laboratory assistants. So far, 42 manuals have been upgraded and by the end of the project it is projected to be 60 manuals. About 86% of the students received grades of equal to or higher than 70 (0 ~ 100 scale). The target is 90% by the end of the project in 2006.

Entrepreneurship and Managerial Skills. The purpose of this activity is to equip graduates with entrepreneurship and managerial skills for better adaptation to the real world environment. In this context, a course in entrepreneurship is offered, giving alternatives to initiate a new business entity, and to cooperate with the university's supporting undertakings to place students for temporary employment for their final assignment. Up to this time, there are 40 students who made proposals to create business entities and five of which were approved by BAU and the Directorate General of Higher Education to be financed and implemented. About 10% of the graduates in 2004 opened new business entities. There are two groups of students to create business entity, and five students are now temporarily employed in small and medium industries for their final assignments.

5.2 Increase Efficiency and Productivity

The purposes of this activity are to increase the interest of best high school graduates to enroll in AE Study Program, and to increase quality of learning system so the graduated students are ready to enter into job markets. Following are the activities conducted in order to reach the goals.

5.2.1 To make broad promotions in any possible means such as booklet distribution, homepage updating, road-show, talk-show in radio and television, open-house, student participation in various scientific competitions, etc. It is targeted that by the

end of the project, the ratio of enrolled to applicant is 1/12. At present time, the ratio is 1/7.

5.2.2 To give competitive grants to create innovative learning methods. Four grants are awarded each year. Most of them use interactive multimedia and develop Self-Access Center (SAC).

5.2.3 To give competitive grants for research incorporating students and contributing to the accomplishment of their final assignments. Four grants are awarded each year.

5.2.4 To send lecturers to conduct comparison study to other well-known universities in the country.

5.2.5 To invite prominent experts to give presentations on fresh information on teaching system and methodology.

5.2.6 To give appreciation to the best lecturer evaluated and voted by the students at the end of each semester.

5.3 Increase Academic Atmosphere

The objective is to increase the interaction between lecturers and students in order to improve academic atmosphere and subsequently to increase the motivation of the students to study and complete their final assignments in due time. The activities are:

5.3.1 To conduct *studium generale* with a target of at least once in each semester by inviting speakers from other related institutions or industries.

5.3.2 To conduct field trips to industries and research centers. This is an optional program but at least the students have experience to conduct field trip to industry or other related fields.

5.3.3 To involve more students in research activities carried out by the faculty members. About 23% of the students involved in research carried out by their academic advisors. By the end of the project, it is expected to reach at least 25%. The results show that participated students were faster in accomplishing their final assignments (6 months) as compared to those who finance their assignments by themselves (9 months).

5.3.4 To involve more students in scientific meetings and competitions. Students are more active to participate in scientific competitions, which now the numbers are exceeding the target of 15% by the end of the project. Two groups succeeded to win gold and silver medals in a recent national competition. Some of them (10%) participate as presenters in the annual seminar of Indonesian Society of Agricultural Engineers (ISAE).

5.4 Other Programs

Inclusive to these programs is to develop cooperation with alumni, governmental institutions and private sectors. Finding an effective networking is enhanced. It is of interest to secure places for field trips, field research, and to experience in working environment. The activities are:

5.4.1 To identify and communicate with potential partners and then to make Memorandum of Understanding. Now, about 81 partners have been recorded, exceeded the target of

80. Among them, six have been established in term of Memorandum of Understanding. The target is 10 memorandums by the end of the project.

5.4.2 To intensify communication with the partners through any means such as visiting, formal discussion, exchange of information, etc.

5.4.3 To update the data of alumni and put them as spearheads in developing networking or cooperation with private sectors.

5.5 Performance Indicators

There are five main performance indicators to see the success of the project as presented in Table 2 below. Almost 80% of the candidates are usually invited based on their performance in high school. The rest is accepted through the national entrance examination. There are seven main subjects to be tested: Mathematics, Physics, Chemistry, Biology, Indonesian and English. As shown in the Table 2, the final marks of graduates increased considerably from 21% in 2001 to 33% in 2003. Length of study within less than 5 months, increase significantly and have passed the target in 2002 as well as in 2003. Waiting periods within less than 6 months also increased significantly and have passed the target in 2001. TOEFL-*Like,* even decreased in 2001 but then increased gradually to 32% in 2003.

It is concluded that the progress of the project has resulted in significant developments and it is predicted that it would continue to achieve the targets. However, future development after the end of projects or the sustainability is still unknown when the grants and incentives are removed.

Table 2. Performance Indicator of DUE-Like Curriculum Development Project

No	Items	Baseline 2001	Achievement 2002	Achievement 2003	Target 2005
1	Cumulative Marks of Incoming Students (>48.0)[3]	25%	22%	36%	30%
2	Final Marks of Graduates (>3.0)[4]	21%	33%	33%	40%
3	Length of Study (<5 months)	17%	43%	45%	35%
4	Job Waiting Periods (<6 months)[5]	50%	78%	71%	60%
5	TOEFL-*Like* (>500)	20%	6%	32%	40%

[3] Averaged from 7 main subjects (max. 70)
[4] Maximum is 4.0
[5] Averaged from 99 graduates, by sampling

6. References

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Appendix: Guideline of Teaching Program

Title of Lecture : Environmental Measurement
Code of Lecture : TEP 362
Credit Unit : 3(2-3)[6]
Prerequisite : Physics, Mathematics, Calculus, Statistics and Thermodynamics

Brief Description
Methods in measuring environmental entities and their applications in agriculture. Scopes of learning are: measuring movement, velocity, acceleration, strain and stress, flow, temperature, light and sound; accuracy and precision of measurement; and data statistical analysis; and analog and digital instruments; and data acquisition system.

Main Instructional Objective:
To understand how to and be able to utilize standard instruments to measure and to record environmental entities, and to analysis the results of measurement properly.

Materials for Lecture

No	Specific Instructional Objectives	Main Topics	Sub-topics	Allocation Time (minutes)	References
1	To understand rules of lecture and the importance of environmental measurement in agriculture.	Introduction	Rules of lecture Environmental entities Measurement in agriculture	100	
2	To understand basics of measurement and enable to understand and to present scientific data.	Basics of Measurement	Accuracy and precision. Error analysis Statistical design Replication Selection of instrument Data collection Data analysis Data checking Generalization	100	1 (Ch. 1) 2 (Ch. 1)
3	To understand and enable to use varieties of sensors and transducers for environmental measurement.	Sensors and Transducers	Movement Velocity Acceleration Strain Flow Temperature Light Sound Hall-Effect	200	2 (Ch. 2) 1 (Ch. 2- 9) 3 (Ch. 5- 8)
4	To understand and enable to analyze circuitry of signal	Signal Conditioning	Circuit bridge o Direct current o Alternating Current	200	2 (Ch. 3) 1 (Ch. 10)

[6] TEP is the abbreviation for the Department of AE; 3(2-3) means 3 cu consists of 2 lecture time (2 x 50 minutes) and 3 practice time (3 x 50 minutes).

No	Specific Instructional Objectives	Main Topics	Sub-topics	Allocation Time (minutes)	References
	conditioning		Op-Amplifier: o Analysis o Inverting o Non-inverting o Differential o Integrator		3 (Ch. 4)
5	To understand and enable to analyze circuitry of analog filtration.	Analog Filtration	Order of Filtration Class of Filtration Filtration of Op-Amplifier: o 1st order o 2nd order o 3rd order o 4th order	200	2 (Ch. 4)
6	To understand and enable to analyze circuitry of signal conversion.	Signal Conversion	Electromechanical ADC Frequency ADC Voltage ADC Digital to Analog	100	2 (Ch. 5) 1 (Ch. 13)
7	To understand and enable to analyze circuitry of digital processing.	Digital Techniques	Logic counting systems Logic gates. Flip-flop BCD Seven Segments Display	400	1 (Ch. 6) 2 (Ch. 13)
8	Enable to design and apply proper techniques to measure environmental entities.	Applications	Measurement Designs: Temperature, Light Etc.	200	1 (Ch 15)

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Evaluation:

1. Final Value = 0.25 (Middle Test + Final Test + Practice + Assignments)
2. Grade: A ≥ 85; 70 ≤ B < 85; 55 ≤ C < 70; 40≤ D <55; E≤40

Instructors:

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