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ISO Certified Biological and Agricultural Engineering Tertiary*

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This paper deals with the ISO 9001 certification and implementation of the new curriculum for Biological and Agricultural Engineering education at the Bachelors level at the Universiti Putra Malaysia. The paper outlines the goals behind the intentions to pursue the ISO certification, the method of formulation of the relevant teaching and academic procedures and the associated quality records. An assessment of the effectiveness of the ISO 9001 system in further enhancing the standard and quality of biological and agricultural engineering program is also demonstrated.

Keywords: ISO 9001, biological engineering, curriculum.

INTRODUCTION

THE OBJECTIVE of this paper is to explain the adoption and implementation of the ISO 9001 in an academic setting. The scope of this paper is the implementation of these ISO procedures at the Department of Biological and Agricultural Engineering in particular and at the Faculty of Engineering, Universiti Putra Malaysia, in general. Incorporated within the ISO system is the review of the curriculum which is mandated to be carried out every 5 years and the current round of the review coincided with the students in the four-year program completing their program in 2004. The major purpose of this review is to ensure that current training and education of future biological and agricultural engineers is on par with current global standards while meeting national and local needs. The challenges in formulating the revised curriculum become more challenging in the light of globalization and dismantling of trade barriers between countries. The future graduates should not only be prepared to work within national boundaries but have the basic preparations to lead and contribute to the biological and agricultural engineering sectors at international levels. This paper highlights the salient points of the review from the perspective of an ISO-based system. This paper will be of interest not only to biological and agricultural academicians but also to academics from other disciplines as it provides an excellent insight into the implementation of ISO 9001 quality control for teaching

The current four-year curriculum was started in the year 2000 and replaced the interim 3.5 year curriculum which in turn had replaced the three-year curriculum which had been abolished and where, the Institute of Engineers Malaysia (IEM) had a significant contribution in constructively criticizing for a positive change to take place. The curriculum is subjected to a mandatory review every 5 years by the Ministry of Higher Education. A review was carried out in 2004. The Department of Biological and Agricultural Engineering, UPM took proactive steps in gathering feedback and preparing the review documents. The current four-year curriculum is modeled after the Malaysian Engineering Education Model (MEEM). The MEEM was commissioned by the Malaysian Council of Engineering Deans (MCED) and the Institution of Engineers Malaysia (IEM), arising from the numerous issues plaguing the local tertiary engineering education [1].

The development of this model took into account the following criteria in the education and development of a graduate engineer: scientific strength, professional competency, multi-skill ability, well respected and potential industry leader, morally and ethically sound [2]. The model envisaged six skills and competencies as shown in Table 1 [2] that a graduate of these engineering programs will achieve.

The implementation of this model for the Bachelors of Biological and Agricultural Engineering is reflected in Table 2.

As can be seen from Table 2, the current curriculum had been carefully planned and implemented to meet the needs of producing a well balanced engineer. All the six areas of skills and competencies are addressed. As this is a minimum requirement model, students are given the freedom to choose additional courses to further improve their knowledge and skills.

* Accepted 14 August 2006.

Table 1. Recommended skills and competencies in MEEM

Skills & competencies	Characteristics
Global & strategic	These skills enable students to adapt easily within the borderless world that is experiencing rapid expanding knowledge.
Industrial	Skills that go beyond the scientific and professional and which are necessary in the advanced phase of the graduate's career.
Humanistic	These skills help create a balanced engineer with high ethical and moral standards.
Practical	These enable students to be directly involved with hands-on activities or real-life situations, thus providing the basis for integrating the intra and inter engineering and non-engineering knowledge
Professional	Such skills cover technical competency aspects required to perform specific engineering tasks.
Scientific	They enable students to have a firm foundation in engineering science, thus enabling them to realign themselves with the changes in emphasis in the scientific field and to develop an interest in R&D and design.

QUALITY CONTROL IN THE IMPLEMENTATION OF THE CURRICULUM

In 2001, the Faculty of Engineering attained the ISO quality certification for undergraduate teaching. This preceded the trial implementation that had been embarked upon the year earlier. The certification obtained in 2001 and was based on the ISO 9001 ver. 1994 [3] and it has now been upgraded to the version 2000. Among the salient points of this system in the educating of undergraduates is that there is a formal requirement to plan the lectures and practical in advance for a particular semester, tests and assignments have to be given and marked on schedule, there is monitoring of attendances whereby a student who does not attend 80% of the lectures can be barred from taking the final examination, monitoring and mentoring of the student by the students Academic Advisor and tutorials for courses where these extra classes will benefit the students. An exhaustive list

Table 2. Biological and Agricultural Engineering curriculum with respect to skills and competency requirements

Skills & competencies	2000 curriculum courses	Credit loading
Global & strategic skills	English for Academic Purpose	
	Writing for Academic Purpose	
	Interactive Speaking	12
	Bio-resources Engineering	
Practical skills	Workshop Management & Practice	
	Computer Aided Drafting	
	Industrial Training	15
	Final Year Project	
Industrial skills	Economics Principles	
	Financial Decisions	
	Engineer and Society	12
	Project Management	
Humanities	Asian Civilization	
	Development of Science in Islamic Civilization	7
	Malaysian Nationhood	
Scientific courses	Engineering Mathematics I	
	Engineering Mathematics II	
	Engineering Statistics	52
	Computer Programming & Applications	
	Electrical Technology & Electronics	
	Engineering Mechanics	
	Strength of Materials	
	Thermodynamics	
	Fluid Mechanics	
	Engineering Surveying	
	Structural Analysis I	
	Structure Analysis II	
	Engineering Properties of Agricultural Materials	
	Biological and Agricultural Systems	
	Thermal and Fluid Power Systems	
	Machine Design	
	Crop Production and Mechanization	
Professional	Transport Phenomena and Preservation of Bio-materials	
	Soil Engineering	
	Applied Hydraulics	39
	Hydrology	
	Soil and Water Conservation	
	Unit Operations for the processing of Bio-materials	
	Agricultural and Recreational Infrastructure	
	Instrumentation for Bio-Systems	
	Free Elective (1 course)	
	Technical Electives (1 course)	
	Options (3 courses)	
	TOTAL	137

of ISO-controlled academic activities can be referred from the ISO Procedure Manual of the Engineering Faculty, UPM. Based on the early implementation of this system, several tangible benefits for students have become evident. Students who do well and make it to the Dean's list have increased and the number of dropouts from the Faculty has been reduced. As the minimum CGPA entry requirement has been set at 2.8, the quality of entrants has also increased. The mean CGPA of the last intake was 2.9. The current graduates are indeed fortunate as they received their undergraduate training under this internationally certified system. Although the implementation of rigid procedures have brought about positive change for the students, it is only fair to state that there has been an increase in the administrative duties of the academic staff. It is a tribute to the academicians and support staff at the Department of Biological and Agricultural Engineering in adapting themselves to carry out the extra duties required under the formal quality system.

Table 3. Performance indicators and monitoring

Quality Measure	Year 2001		Year 2002		Year 2003	
	Target	Achievement	Target	Achievement	Target	Achievement
Student:staff ratio	16	10 (171/17)	15	16.9 (270/16)	14	11.35 (193/17)
Staff with Ph.D. (%)	55	71 (12/17)	60	68.8 (11/16)	65	70.59 (12/17)
Professors per department	1 person	2	1 person	4	10 (%)	29.41 (5/17)
Rank of associate professor (%)	30	47 (8/17)	35	31.3 (5/16)	35	29.41 (5/17)
P. Eng. (%)	18	23.5 (4/17)	20	43.8 (7/16)	24	47.06 (8/17)
No. of journal papers or books per staff per year	0.7	2.6 (25/17)	0.8	1.44 (25/16)	1.2	1.59 (27/17)
Training / conference per staff per year	1	0.9 (34/35)	1	1.9 (41/34)	1	0.93 (29/31)
No. of students per computer	9	2.1 (171/80)	8	3.4 (270/80)	4	2.41 (193/80)
No. of students per equipment per lab session	6	6	6	6	5	5
No. of relevant book titles in library	500	>500	500	>500	500	>500
No. of technicians per lab	1	0.5 (7/14)	1	0.77 (7/9)	1	1.0 (9/9)
No. of support staff per department	2	2	3	2	3	6
Accreditation by engineering accreditation council	Full Accreditation	PB	Full Accreditation	PP	Full Accreditation	PP
Frequency of program review	Every 5 Years	Begins 2003	Every 5 Years	Begins 2003	Every 5 Years	Begins 2003
Overall assessment by the external examiner; satisfactory (S)	S	S	S	S	S	S
Online courses per department (%)	—	—	40	0	50	34.04 (16/47)
No. of officers sent to ICT training per year per department	—	—	60	11.8 (4/34)	80	91.67 (22/24)
Lecturers / computer ratio	1	1	1	1	1	1
No. of software per department	5	10	5	10	5	10
No. of Internet connections per lab	1	4.2 (57/14)	1	6.3 (57/9)	12	ADK
No. of servers per department	1	1	1	2	2	2
No. of department website updates per semester	—	—	1	1	2	2
Tutorial courses/ lab/design (%)	30	13.3 (6/45)	30	22.2 (10/45)	25	29.79 (14/47)

PERFORMANCE INDICATORS AND MONITORING

An important feature of the ISO system that has been implemented is the ability to have vital managerial information that is current and easily accessible. This managerial information helps not only in the future planning of the department but also provides an important source of information when bidding for funds and in the daily running of the department.

A selection of the main items used for performance measurement and monitoring are given in Table 3. A study of this table will reveal the state of health of the department and help in the planning of appropriate action where necessary. As an example, the student to staff ratio can be seen to have increased from 1:10 in the year 2001 to 1:17 in the year 2002 and reduced to 1:11 in the year 2003. The primary reason for this change was because of the increased enrollment in the year 2002, when the student enrollment was 270. The total staff for this period had remained stable at 17 for the year 2001 and 2003 and 16 in the year 2002. The tabulation of information helps in planning the size of new students to be admitted and in planning the departments teaching size.

Basic information on research can be obtained from the number of journal articles or books published per staff, through the number of projects per lecturer and through the number of graduate students per lecturer. Training and attendances at conferences is also monitored.

The provision of facilities and library books for students is monitored through the number of computers per student, number of students per equipment during lab/practical sessions and the number of book titles per program. These indicators certainly help when justifications are being made to purchase more computers, equipments and books.

An important aspect of this monitoring table is the need to update the figures. This is carried out several times a year as changes occur. A management review meeting is held once a year to review the achievements made during the preceding year and to set new targets for the coming year.

THE TEACHING FILE

Quality control and monitoring of lectures is carried out through the use of teaching files that are centrally maintained at the department. These teaching files are opened for each course that is offered by the department and it is primarily the duty of each lecturer assigned to the course concerned to maintain and update the file for the semester involved. The teaching file will contain the letter of appointment to the lecturer who will teach the course concerned, the syllabus and teaching/lab schedules. Lecturers will have to file in their lecture notes, lab assignment tasks, tutorial questions, quiz, test questions and answer schemes for marking. Student's attendance sheets and letters from students to be excused from classes will also be filed into the teaching files. The Head of Department is formally required to check these teaching files at least twice a semester to ensure that the lectures are proceeding in an efficient way and at a level of high quality. Essentially, the teaching files become a window to the course implementation and by reading through these files the department head gets a good grasp of the situation. As such, preventive and remedial action that may be necessary in some cases can be taken expeditiously.

This system also allows the detection of students who are constantly missing from lecturers to be identified and called upon for advise/counseling from the academic advisers.

ACHIEVEMENTS OF THE ISO-BASED SYSTEM

One of the benefits of the ISO system is that the results of measures implemented are quantifiable. Statistics and figures have been compiled at the Faculty of Engineering level, which is the home of eight different bachelors of engineering programs, including the Biological and Agricultural Engineering program. The scenario at the faculty level is a fair reflection of the Department of Biological and Agricultural engineering as well.

The mean value of the teaching assessment of lecturers has risen significantly from being less than 4.0, prior to the implementation of the ISO in the year 2000 to a value of 4.26 in the year 2003 (Fig. 1). This increase is attributed to the increased awareness of the need to deliver high quality lectures and training programs on teaching methodology for lecturers whose teaching assessment is lower than 3.5.

Student's performance in obtaining a higher class degree had also increased significantly as shown in Table 4. The percentage of students

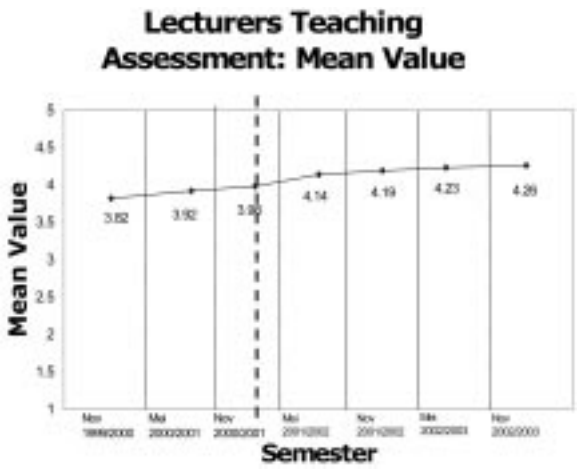

Fig. 1. Lecturer's teaching assessment.

Table 4. Students' performance before and after ISO implementation

	1st Class and 2nd Class Upper		2nd Class Lower and 3rd Class	
Year	Total	%	Total	%
2000 (Before ISO)	96	24.5%	296	75.5%
2001 (After ISO)	121	41.6%	170	58.4%
2002 (After ISO)	233	49.3%	240	50.7%

who obtained 1st class and 2nd class upper prior to the implementation of the ISO system was 24.5 % and this rose to 41.6 % (2001) and to 49.3 % (2002) after the ISO system was implemented.

Another major accomplishment of the introduction of the ISO-based system is the reduction in the number of students who dropped out of the programs at the Faculty of Engineering. The dropout numbers had reached a peak of 158 students out of a total student population of 2633 undergraduates in the year 2000, that is before ISO implementation, representing 6% of the total undergraduate enrollment to just 14 students out of 1881 students, representing 0.7% of the students enrolment in the year 2003 (Fig. 2). This significant improvement is a major contribution of the ISO implementation to the academic well being and achievements of the students.

CURRICULUM REVIEW

In order to maintain the high quality of the Bachelor in Biological and Agricultural Engineering program, detailed procedures have been laid out in the ISO system to carry out the review, which is mandatory every five years. The procedure for the curriculum review begins with the identification of user needs and ends with the updating and formulation of a revised curriculum and related syllabi for the courses offered. Based on the set procedures, this exercise involves evaluating the following information:

1. Human resource requirements of the relevant Ministries/agencies/industry.
2. Human resource development in engineering education.
3. National Education Policy's requirements.
4. Faculty of Engineering strategic plan.
5. Customers' requirements or industrial survey.
6. Report from the external examiner and assessor.
7. Report from the accreditation body.
8. Report from external advisory panel.
9. Any other relevant information.

MALACCA WORKSHOP ON FUTURE DIRECTIONS OF BIOLOGICAL AND AGRICULTURAL ENGINEERING EDUCATION

At the end of January 2003, the Department of Biological and Agricultural Engineering retreated to the historical city of Malacca and had an

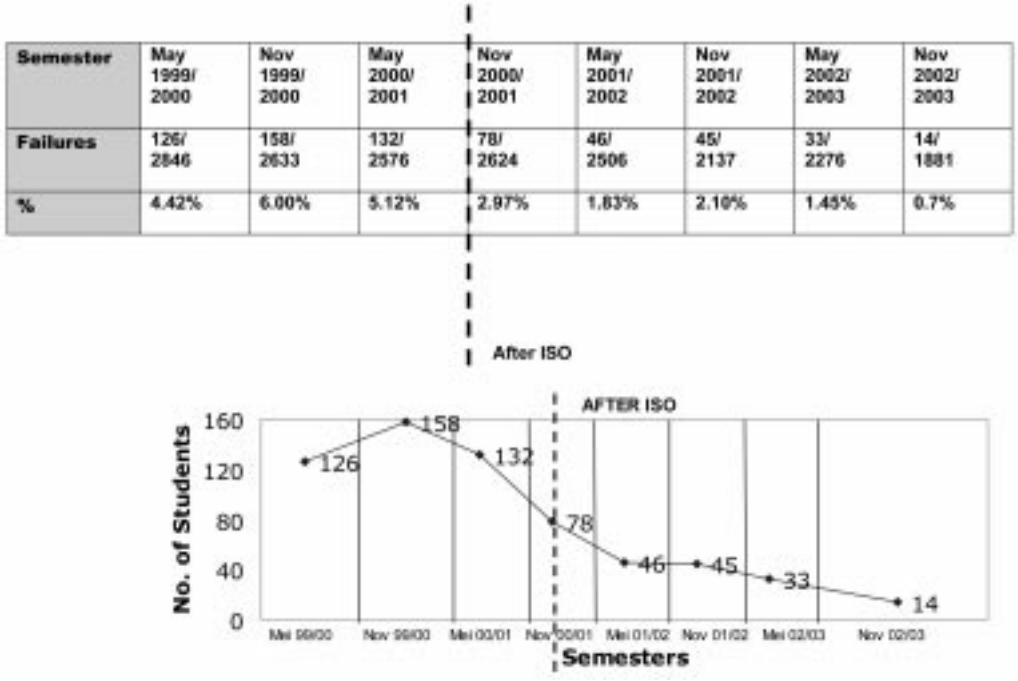

Fig. 2. Dropout rate.

intensive brainstorming session on restructuring the curriculum. In order to stay in touch with current developments and progress, representatives of private and government sector were also invited to present papers and provide feedback. Among the major observations of this workshop are:

- Good employment among Biological and Agricultural Engineering (BAE) graduates. In fact, the 2002 Institute of Engineers Malaysia (IEM) employment survey showed that the highest paid new engineering graduate was a Biological and Agricultural engineer.
- New entrants to the Biological and Agricultural engineering program had good entry qualifications and the recent trend has shown an increase of candidates from the Life Sciences background.
- The BAE program had sufficient number of takers to fill all seats to be taken up.
- Communication, entrepreneurial skills of BAE graduates, not unlike other local graduates, needs improvement. This is not just a phenomenon confined to BAE undergraduates but a general observation of our society. Empirical evidence of this had been demonstrated by a multinational company **[4].**
- IT, Automation and Robotics option are options towards the end of the study period. In the current curriculum these areas of studies can chosen by the candidates and thus candidates not choosing these option subjects will be handicapped later in their career as the needs for these skills become indispensable.
- There is a lack of effective marketing of both the program and its graduates.

Based on these observations, the following preliminary recommendations were made:

- Aggressive marketing needed:
  - intensify visits to schools
  - greater participation in high profile student competitions
  - regular distribution of flyers and information to schools
  - media articles and exposure
  - lobby agricultural companies/plantations to offer scholarships for BAE program;
- Repackage the program:
  - assimilate core IT, Automation/Robotic subjects into the early years of the curriculum
  - greater emphasis on communication, entrepreneurial skills
  - re-structure the options to be more friendly and attractive

DISCUSSION

Based on the above-mentioned activities, the department gained valuable pointers for the review exercise. Discussions with students have also revealed some interesting findings, for example students find difficulty in explaining what is a Biological and Agricultural Engineer to prospective employers. Based on this feedback, some students have also suggested a name change such as Integrated Engineering. On the issue of language, students are very enthusiastic about the recent move by the government to reemphasize English in our teaching. There has been feedback from students to have more public speaking classes and sessions for learning English language, beyond the current requirements of the curriculum [5].

Feedback from the industry on the ability of our graduates has considerable impact on the curriculum reviews final recommendations. However, recent achievements of the Biological and Agricultural Engineering undergraduates have been superb. In 2001 and 2002, our students participated at the ASAE quarter scale tractor design competition and achieved two awards each during both occasions. They not only made themselves and their parent's proud but brought glory to the nation, profession and department. We have also had success with national competitions whereby our students' team were ranked in the top ten in the Students IT Entrepreneur competition organized by Hong Kong and Shanghai bank while another team of our students successfully participated in a national Bridge Design competition.

CONCLUSION

Based on our experiences with the current students, we are optimistic that future Biological and Agricultural Engineering graduates will be able to contribute positively to the development of the nation. Nevertheless, in keeping up as a world class department in its field and in producing graduates that are locally suited and globally adaptable, the staff members at our department are very receptive to changes that can help us grow further on our success.

The implementation of the ISO system, though requiring greater effort and commitment from the staff in maintaining quality records, has helped make the department much more efficient and vibrant. The Department of Biological and Agricultural Engineering today is respected internationally as a quality department producing quality graduates in Biological and Agricultural Engineering [6].

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