An Assessment of the Current Engineering Education System with a View towards Self Sufficiency or Sustainable Development: Thailand Perspective

Rajesh.S.Kempegowda [a], Virak Bol, Chanun Chakatis, Chaiyaporn Hopornsiri, Tavee Rattanasangchok

Mechanical Engineering Department, Faculty of Engineering and Technology
89 Moo 12 Highway 331, Banglamung, Chon Buri 20150, Thailand, http://www.asianust.ac.th,
Corresponding author: [a] rkempegowda@asianust.ac.th

Abstract

The three pillars of sustainable development – society, environment and economy – are interconnected through the dimension of culture. Education is a central aspect of culture also, as well as the prime medium through which a country creates the capacity – the knowledge, values, skills and living practices – for achieving social, environmental and economic goals. Linking social, economic, cultural and environmental concerns is a crucial aspect of sustainable development. In analogy to sustainable development, Thailand self sufficiency is a means towards community empowerment and the strengthening of communities as a foundation of the local economy. To achieve this goal you need to know current status of country's education system. To amend the local economy or to achieve the sustainable development for specific objectives might need a radical change in the education sector. A case study has been developed for Thailand's engineering education system. This paper assesses present curriculum practices and possible changes to build sustainable development education system as well as to understand his Majesty's policy **"self- *sufficient economy***" and to implement it in to the engineering education system.

Keywords: sufficiency; self-sufficiency economy; engineering education;

1. Introduction

There are many ways to manage communities, societies, countries, and the world. **Globalization** refers to increasing global connectivity, integration and interdependence in the economic, social, technological, cultural, political, and ecological spheres. Globalization is an umbrella term and is perhaps best understood as a unitary process inclusive of many sub-processes (such as enhanced economic interdependence, increased cultural influence, rapid advances of information technology, and novel governance and geopolitical challenges) that are increasingly binding people and the biosphere more tightly into one global system. There are several definitions and all usually mention the increasing connectivity of economies and ways of life across the world. The Encyclopedia Britannica says that globalization is the "process by which the experience of everyday life ... is becoming standardized around the world." While some scholars and observers of globalization stress convergence of patterns of production and consumption and a resulting homogenization of culture, others stress that globalization has the potential to take many diverse forms [1].

However, His Majesty the King of Thailand has his own visions and philosophies in managing the country. One of his very well-known philosophies is "**Sufficiency Economy**". In order to understand "Sufficiency Economy", let us firstly look what does sufficiency mean? "Sufficiency" means moderation and due consideration in all modes of conduct, as well as the need for sufficient protection from internal and external shocks. "Sufficiency Economy" is a philosophy that stresses the middle path as the overriding principle for appropriate conduct by the populace at all levels. This applies to conduct at the level of the individual, families, and communities, as well as to the choice of a balanced development strategy for the nation so as to modernize in line with the forces of globalization while shielding against inevitable shocks and excesses that arise. To achieve this, the application of knowledge with prudence is essential. In particular, great care is needed in the utilization of untested theories and methodologies for planning and implementation. At the same time, it is essential to strengthen the moral fiber of the nation, so that everyone, particularly political and public officials, technocrats, businessmen and financiers, adheres first and foremost to the principles of honesty and integrity. In addition, a balanced approach combining patience, perseverance, diligence, wisdom and prudence is indispensable to cope appropriately with critical challenges arising from extensive and rapid socioeconomic, environmental and cultural changes occurring as a result of globalization [2].

His Majesty bestowed the philosophy of the Sufficiency Economy to the nation on December 4, 1997 in his royal speech given on the occasion of his birthday. It was five months after the floating of the baht and at the time when the country was almost lost in the economic crisis. Clearly, the philosophy is meant as guidance to another conceptual approach to development that, like the old route, aims for prosperity, but this time, with equity, stability and sustainability.

1.1 Sufficiency Economy: Conceptualization

The most often asked question about the Sufficiency Economy concerns whether it opposes globalization and liberalization. Although the philosophy of the Sufficiency Economy stresses self-reliance, it by no means favors self-sufficiency and isolationism. Self-reliance here refers to the ability to assess strengths and weaknesses with wisdom and knowledge, and to foster appropriate tools to immunize the country and society against internal and external volatility. The Sufficiency Economy emphasizes the middle path which can be achieved only through moderation, rationality, prudence, wisdom and proper and honest use of knowledge. It encourages harmonious and constructive participation in globalization and liberalization to optimally utilize appropriate knowledge and resources and benefit from them. At the same time, the Sufficiency Economy guides the country and society to assess and correct factors hindering appropriate development; these hindrances can be in the form of national policies, ways of life, ways of thinking, or even values in society.

Optimal behavior links the Sufficiency Economy to mainstream economics. In mainstream economics, human behavior is an effort to reach the optimum. In this regard, the Sufficiency Economy seeks to find appropriate behaviors for optimal benefits, taking into account limitations, risks, uncertainties and volatility. To understand the Sufficiency Economy, one needs to differentiate between optimal benefit and maximum benefit, as behaviors that aim for maximum benefits are only a starting point of non-sufficiency. The Sufficiency Economy takes into consideration market uncertainties in mainstream economics, and seeks patterns of decisions and behaviors that are based on prudence and a wise examination of the risks and uncertainties that are involved.

The Sufficiency Economy does not oppose the creation of wealth and growth. Growth and wealth are among development objectives of any society. However, growth is not the only contribution to economic development, nor is wealth the only provision of security. The ultimate goal of the Sufficiency Economy is sustainable development, and to reach sustainability, it is important that all citizens have equal opportunities and freedom despite their individual shortcomings. Equal opportunity to good education and health will lead to the ability to make optimal use of open doors in life. Citizens also need an equal opportunity to own land and other production capital, as well as to make a living within a fair and transparent environment.

In this regard, it is clear how the Sufficiency Economy transcends the economic sphere. The Sufficiency Economy embraces a holistic approach to development and takes into account political freedom and stability, economic development, social capital, cultural values and traditions, ethics, attitudes and the environment. Application of the Sufficiency Economy needs proper understanding and supporting attitudes, for instance, self-reliance and not seeking causes of problems from the outside but from one's own strengths and weaknesses. The Sufficiency Economy accords the Thai way of life and encourages the revitalization of the moral and ethical fabric of Thai society. It respects compassion, good will, mutual assistance in society, and outweighing social benefits to individual benefits.

The Sufficiency Economy is a fundamental guidance of conduct and decision-making at all levels in all sectors. It contains dynamism in line with the development of society. It encompasses at least five major components:

i. Integrity

ii. Moderation and the middle path

iii. Prudence achieved via mindfulness and wisdom

iv. Rationality that will lead to patience and perseverance

v. Balance and sustainability.

On the other hand, looking traits of non-sufficiency, Thailand has achieved many desirable goals in the course of its development that have provided for the well-being of many Thai people. However, an assessment of Thailand’s past development reveals imbalance and inflexibility in many ways. More often than not, developmental achievements are visible in the form of quantity rather than quality. While Thailand has made great progress in reducing poverty, the distribution of income is still very uneven. Basic infrastructure has expanded nationwide, but the distribution is not balanced and the quality is uneven. The country has also developed at the expense of depleting natural resources and degraded the environment. The country's forest area decreased from approximately 53 percent in 1961 to less than 25 percent in 1997[3].

Thailand's development has resulted in better health and education of a large number of citizens;

however, the quality does not match the quantity. Distribution of services is uneven and does not cover all targeted areas. At the same time, ethics, morals and disciplines have weakened. It is clear that administration and institutions, be it the political sector, the public sector, private businesses, communities or families, do not have the necessary tools to guard against internal and external volatility. While the present Constitution concretely encourages political reform and public sector reform and decentralization of power to local communities and administration are underway, tangible progress needs constant support and refinement. The economic crisis has shown shortcomings in the private sector, particularly in terms of a lack of good corporate governance. Concrete channels to empower local communities and the civil society are being implemented, but individual families remain weak and reveal patterns of lavish spending and over-consumption [4]

Implementation is needed to foster balance in many areas of development; for instance, the production structure, land and income; quantity and quality of education, information and analysis of information; knowledge and integrity; roles of the public, private and people sectors; and balance between politics, economics, society and the environment

Apart from imbalanced development, considerable pre-crisis non-sufficient behavior is believed to have significantly contributed to one of the country's worst economic stumbles. The decline in the household saving rate in less than a decade from approximately 14 percent in 1988 to approximately 5 percent in 1996 shows patterns of over-consumption. Inefficient investment was also evident. The total factor productivity growth increased from -1.27 during the period of 1981-1985 to 3.98 during the period of 1985-1990, and sharply dived to -3.07 during the period of 1991-1995. Private businesses resorted to debt rather than equity to finance investment. Private debt was massive: The ratio of foreign debt to investment sharply increased from approximately 0.4 in 1988 to 1.2 in 1995[5]. A sharp increase in the ratio of short-term to long-term private debt was also witnessed. Excessive competition in international trade also led to a situation where aggregate benefits for all traders decreased. High quantity of similar exports induced pressure on prices. Competition to attract foreign investment led to unfair and distorted industrial promotion and a situation where benefits fell into the hands of transnational companies rather than home countries. There was fierce competition in the region to become a financial center, which apparently led to policy implementation with less careful risk assessment.

At the macro level, macroeconomic policy did not provide appropriate immunization against external volatility. The country lacked mechanisms to balance risks from volatility from financial liberalization with the potential benefits liberalization offered. The pegged foreign exchange rate policy at the time of financial liberalization increased the risks for the overall system. The country lacked the necessary information for indicators and early waning signs. Imprudent management of foreign reserves also exacerbated the situation.

2. Suffiency Economy and Education Reform

The educational system should promote awareness and understanding of the Sufficiency Economy as well as the way of life in line with the Sufficiency Economy. More importantly, education should not only lead to knowledge, but to the creation of wisdom to make use of knowledge. The educational system should enrich individuals' learning processes and serve as an effective means to a good quality of life and quality of society. Education should enable individuals and communities to share such good qualities with others. Encouragement of this kind of education in local communities will lead to the sharing of knowledge and nurturing of wisdom consistent with local needs. Besides that, Ministry of Education Thailand has planed to achieve several aims such as expose teacher to the king policy, make "Sufficiency Economy" philosophy become an important element of the nation education, increase educational opportunities by ensuring equal access to quality basic free of charge, and etc. This paper assesses the current engineering education system of Thailand to know how the engineering education system to implement new course curriculum based on sufficiency economy.

3. Methodology to assess the current engineering education of Thailand

Survey was conducted by preparing the questionnaire for five top technology universities of Thailand for different of engineering fields to incorporate self sufficiency philosophy and economics as a course curriculum for undergraduate level. The questionnaires was circulated to various research experts of these universities to know how the current engineering education systems. The survey questions includes on the self sufficiency economy, its influence on the country, engineering education, research and development.

4. Results and discussion

After having done the research on several well-known universities' curriculums in Thailand, it can be seen all the engineering majors are included 2 courses of social science and 2 courses of humanities. However, it is not clear how much sufficiency economy philosophy is stressed in those courses. It is very necessary for lecturers to teach their students

about sufficiency economy, or even include sufficiency economy to as one separated course. In this way, students are provided more opportunities to expose to the philosophy.
There were 25 participants involved in the survey and all participants were assistant professors from various institutions. Among the 25 participants, their research fields are electrical, mechanical, manufacturing and energy field. The main sponsors for the research were MTEC, Thai government, and NSTDA with the budget ranging from a few a few hundred thousand to 12 million baht. The projects duration were between 1-3 years
Most of the participants seemed to be agreed with the King's policy and forecast that this policy will blend into Thai culture it is only a matter of time; however, 40% of the participants are agreed that the engineering education should follow the sufficiency economy philosophy and by looking at the current engineering curriculum in Thailand there seems to be not clear how the policy involves. Less than half of the participants agree that it is better to adapt our life to SE without investing on the research of the new technology and SE make us more competitive as an individual and as a whole.

5. Conclusions and Recommendation

The three principles of moderation, reasonableness and self-immunity together with the two conditions of knowledge and morality of the Sufficiency Economy help contributing to development theory and convey a new paradigm for development. This is a development that embraces human well-being with the support of strong institutions, environmental sustainability, and good government.

Possible solutions recommended are as following

1. The course should combine technical content together with sufficiency economy
2. Projects which are benefit local area using engineering education
3. Should be parts of engineering subjects
4. Students should social activity organization such as SIFE
5. Ministry of Education should be supportive
6. Lecturers should expose students to sufficiency economy

References

1. Globalization, http://en.wikipedia.org/wiki/Globalization
2. Adis Israngkura Na Ayuthaya. 1999. The New Theory from an Economic Viewpoint (ทฤษฎีใหม่ : มุมมองทางเศรษฐศาสตร์). Background Paper for the 1999 Year-end Conference "Sufficiency Economy" co-organized by the Chai Pattana Foundation, the National Research Council of Thailand, the National Institute of Development Administration, the Office of the National Economic and Social Development Board, and the Thailand Development Research Institute, 18-19 December, 1999. (in Thai)
3. UNDP, "Thailand Human Development Report 2007: Sufficiency Economy and Human Development" UNDP: Bangkok, 2007.
4. Sufficiency economy, http://www.sufficiencyeconomy.org/show.php?Id=475
5. Bank of Thailand, Monetary Policy Group. 1999. Philosophy of the Sufficiency Economy and the Inflation Targeting Framework (กรอบนโยบายการเงิน Inflation Targeting กับปรัชญาของเศรษฐกิจพอเพียง). Background Paper for the 1999 Year-end Conference "Sufficiency Economy" co-organized by the Chai Pattana Foundation, the National Research Council of Thailand, the National Institute of Development Administration, the Office of the National Economic and Social Development Board, and the Thailand Development Research Institute, 18-19 December, 1999. (in Thai)

Manufacturing Engineering Education in IIUM

M. Y. Ali [a], A. K. M. N. Amin, M. M. Haque

Department of Manufacturing and Materials Engineering
Faculty of Engineering, International Islamic University Malaysia
Gombak, Selangor Darul Ehsan, Malaysia
e-mail: [a] mmyali@iiu.edu.my, fax: (603) 61964477

Abstract

This paper presents how manufacturing engineering curriculum in International Islamic University Malaysia (IIUM) is designed to prepare its graduates fit for manufacturing industry. Since the inception in 1994, IIUM has been preparing its students through specialization in manufacturing engineering and precision machining. After 10 years, the curriculum has been revised thoroughly to fit with the recent trend of globalization of manufacturing engineering. The faculty is cognizant of emerging technologies such as micro and nano manufacturing and has begun to incorporate in its curriculum. In addition, the programme has also adapted the outcome based learning in producing engineers ready for industry practices in the international scene. Seminar presentations are emphasized to develop students' communication skill. All students must undergo engineering internship training in manufacturing industries to complement and reinforce their knowledge earned in classroom and laboratories.

Keywords: manufacturing curriculum; communication skill; micro/nano technology; internship

1. Introduction

Among the main economic growth segments of Malaysia, manufacturing is one of the most important drivers of its economy. Manufacturing industries accounts for as much as 30 % of GDP and employs about 27% of countries total workforce [1]. The government of Malaysia has provided a clear vision to reach the standard of living of industrialized countries by the year 2020. This plan, called Vision 2020, is accelerating Malaysia's shift to high-technology industries [2]. Moreover, the rapid globalization of manufacturing engineering is pressing the institutes to bridge macro, micro, and nano manufacturing [3, 4]. To meet this demand, universities are facing challenges in developing leading-edge curriculum. It also requires a periodical revision of curriculum every one or two years.

The enrolment of manufacturing student is increasing every year and in the present academic year 2006-2007, the total enrolment is 190 excluding the first year common engineering students. The students' population are mainly Malaysian with a mixture of 15-20% international students. The local students completed 10 years of schooling and then entered into matriculation centre for two-year pre-university schooling where they study the basic science, mathematics, language, etc.

2. Curriculum development

The faculty of engineering in IIUM has been offering 4-years bachelor degree in manufacturing engineering since its inception in 1994. The main focus was on advanced design and manufacturing, CAD/CAM/CAE, micro/nano and precision manufacturing, and management skills with moral and ethical values. After 10 years, the curriculum is revised in 2005 towards current and future trends in advanced manufacturing technology. In addition to continual refinement and development, this review was crucial because of globalization of manufacturing engineering and Washington Accord [4]. Malaysia is the only developing nation that secured membership of Washington Accord [2].

The students have to earn 142 credits for graduation where 17% common engineering and management courses, 60% core courses, 7% elective courses, and 16% university required courses which includes Islamic knowledge, ethics, language, co-curricular activities, etc. Student must carry an academic load of 16-18 credit hours every regular semester of 14 weeks. There is a short semester of 7 weeks every year after two regular semesters. Students can take up to 6 credit hours to reduce their load during regular semester or to graduate earlier than 4 years.

All students undergo first year common engineering course before they select any discipline of engineering. The top scored students usually opt for Biotechnology and Mechatronics Engineering. Manufacturing engineering is usually the third choice. Selected core courses, as listed in Table 1, are to be taken by manufacturing students from second year through final year. Students also have to select three electives from a wide variety of courses as listed in Table 2. The university required courses, as listed in Table 3, are compulsory to enhance professional and ethical values. In addition, students also have to take laboratory, industrial internship, seminar and final year project.

2.1. Laboratory courses

There are 6 laboratory courses in the revised curriculum. Previously these were hidden inside the theoretical courses and now have been shown explicitly. Usually one laboratory has 12 experiments based on two theoretical courses which are also pre-requisite of the respective laboratory course. Each laboratory carries one credit hour. The performance grade is awarded based on experiments, report, and a final quiz.

2.2. Engineering internship training

All students in their third year of study undergo 12 weeks of engineering internship training (EIT) attachment in industries. Every intern is treated as regular employee and gets a typical monthly stipend of about RM 500-1000. Students work on projects assigned by their industrial supervisors who are a graduate professional engineer. Projects that showed promises are further investigated by the same intern in his/her graduating year. This gives the company a substantive piece of work that can be implemented immediately. Faculty and industry supervisor together evaluate the student's performance. A final grade is awarded based on combined assessment. In addition to students' experience, EIT also makes a relationship between university and industry.

2.3. Seminar and project

All students in manufacturing engineering undergo two seminar courses of 0.5 credit hour each. These are to develop students' communication skill. In seminar I, students attend the seminar presented by invited academia and professional. The presentations are conducted every week for the whole semester. Students submit a short report after each seminar. The student's performance is evaluated based on attendance and report. Students attend seminar II on research methodology, report writing, presentation skill, etc. Then each of the students must find a topic from their interest and present seminar. The topic must be approved and supervised by a faculty member. Grade is awarded based on their report, presentation, and attendance.

The final year projects, an stimulating research and hands-on training, of 6 credit hours is spread over the two final semesters as project I and project II which are aimed at integrating the knowledge gained over the entire period of study. Each project is supervised by a faculty member. The student submits a final report and presents a seminar. The performance is evaluated by supervisor and two external examiners.

3. Outcome based learning

The Programme was first accredited in 1998 by the Board of Engineers Malaysia for a period of five years. The Programme was then reaccredited for another five years in 2003. In addition, the programme also aims to follow Washington Accord and outcome based learning in producing engineers for industry practice in the international scene. To comply with Washington Accord, a programme must formulate its educational outcomes (the broad goals).

The manufacturing engineering programme in IIUM has set 13 educational outcomes based on Accreditation Board of Engineering and Technology (ABET) requirements as listed in Table 4 [5]. In light of the programme educational outcomes, the outcomes of each individual course are also set. These are statement of things students who complete this course should be able to do. Each outcome of an individual course must satisfy at least few of the programme outcomes. Most of the core courses contributed to the first several, e.g., 1-8, educational outcomes. The others acquired by enrichment i.e., there is no direct means for evaluation. The outcomes 11-13 are mostly achieved through the university required courses (Table 3). As an example, the assessment matrix for a course MME 4142 is presented in Table 5. It shows how this course is contributing towards the educational outcomes of manufacturing programme.

4. Conclusions

The manufacturing engineering curriculum at IIUM features the basic and advanced manufacturing courses. The senor year specialization focuses on micro manufacturing, precision machining, plastics processing, metal cutting and metal forming. The top students in first year common engineering do not opt manufacturing engineering. It is not because of that the programme is less attractive or not advanced, but because of its about 50% hard-skill courses and practices in real life. More than half of the student population is female and their scores are also higher than the male students. The female students usually prefer soft-skill engineering. So, to stay competitive and attract female students with high score, the programme has to be enhanced with more soft-skill and micro/nano technology courses. Entrepreneurship is taught in management course but considering the global competition it should be a complete elective course for the interested students.

In the present system students select only three electives, this number should be increased to at least four or five.

Table 1. Selected manufacturing engineering related core courses and their synopsis

Code	Course	Brief Synopsis
MME 2104	Manufacturing Processes I	Fundamentals of metal casting, pattern and core print, sand and other casting, properties of moulding sand, casting quality and inspection, product manufacturing from powder materials, metal forming fundamentals, bulk deformation, sheet working, joining, assembly, adhesive bonding, welding, brazing and soldering.
MME 2105	Manufacturing Processes II	Chip formation, force relationship, tool life, Taylor's equation, cutting fluids, lathe operations, drilling, milling, shaping, planning, grinding, buffing and polishing, gear and thread manufacturing, machining of composites, non-traditional machining processes, surface integrity and treatment, economics of machining processes.
MME 2106	Processing of Non-metallic Materials	Structure, properties, processing and application of ceramics, polymers and composites, Preparation of plastic films and fibers and fabrication of shaped objects, Health, safety and environmental issues, Strengthening and deformation mechanisms of non metallic materials, degradation of polymers and ceramics.
MME 3107	Design of Machine Components	Design process, energy methods in design, failure criteria and reliability, design of shafts, gears, welded and riveted joints, splines, keys, knuckle joints, brakes, clutches, springs, power screws, fasteners and connections, rope, belt and chain drives, bearing design and selection and lubrications.
MME 3108	Quality Control	Quality concepts and philosophies, quality management systems, ISO9000 and TQM, statistical process control through control charts for attributes and variables, specification limits and tolerances, methods for quality improvement, basic experimentation and reliability, acceptance sampling and sampling plans.
MME 3109	Computer Aided Design and Manufacturing	Design paradigms, computer generation of geometric models, standards for CAD, computer-aided optimal design, surface modelling, CAE for simulation, rapid prototyping and manufacturing, principle of numerical control, CNC and DNC systems, manual and automated part programming using CAM software.
MME 3110	Metrology and Measurement Systems	Concepts of metrology, measurement methods and standards, fits and tolerances, measuring tools and gauges, measurement and analysis of torque, temperature, surface texture, profile and contour, gear and thread, fluid flow measurement, coordinate measuring machine, laser interferometry and non-destructive testing .
MME 3111	Production Tooling	Types of tooling, tool materials, economics and selection of tooling, single point cutting tools for turning, hole making, shaping and slotting, classification, selection, design and manufacture of multi-point cutting tools: drills, taps, dies, milling cutters, gear cutters, broaches and grinding wheels, principles of jig and fixture design, design and manufacture of tools and dies for forming molding, and forging.
MME 3112	Manufacturing Automation	Introduction to automation, industrial system sensors, use of sensors and actuators in automation, image and vision for product inspection, industrial robotics and discrete control using programmable logic controllers and personal computers, safety in working environment, web based monitoring of manufacturing systems.
MME 4113	Machine Tools Technology	Introduction, classification of machine tools, gearing diagrams, mechanisms, transmission ratios, typical parts, bearings, slide ways, drive systems and elements of control systems, detailed study of engine lathe, turret lathe, milling, grinding, gear-shaping and gear-hobbing machines, installation and acceptance test.
MME 4114	Production Planning and Control	Manufacturing and service strategies, operations and productivity, forecasting and inventory systems, process strategy, capacity planning, layout strategy, assembly line balancing, aggregate planning, master production schedule, bill of materials, materials requirement planning, scheduling, just-in-time, lean production systems.
MME 4115	Computer Integrated Manufacturing	Introduction, automation principles and strategies, production concepts and mathematical models, material handling, automated storage and retrieval systems, automatic data capture, manufacturing systems, group technology, flexible manufacturing, automated assembly, process planning and concurrent engineering.
MME 4116	Product Design and Development	Procedure and evaluation in product design, design specifications, selection of materials and processes, cost of manufacturing and engineering changes, axiomatic design, manufacturing process design rules, group technology, design for casting, welding, sheet-metal working, plastics and powder metallurgy, assembly.
MCT 3224	Instrumentation and Control	Measurement systems and instrumentation, static and dynamic characteristic of measurement system, signal conditioning, common types of sensor used in

Table 1. Selected manufacturing engineering related core courses and their synopsis…(cont.)

		manufacturing system. Control System types and effects of feedback. Mathematical modelling of dynamic systems. Transient response and steady-state error analysis. Stability analysis, PID controller design, PLC Programming.

Table 2. Selected manufacturing engineering related elective courses and their synopsis

Code	Course	Synopsis
MME 4131	FEA for Manufacturing Applications	Revision of matrix algebra, Introduction to formulating system equations for solid mechanics, heat transfer, fluid mechanics and electromagnetic fields, Introduction to various elements, Concept of shape functions, properties and usages of linear, quadratic, and cubic shape functions, Detailed training on ANSYS to solve problems from various disciplines.
MME 4132	Ergonomics and Workstation Design	Goals of ergonomics, musculoskeletal system of human body, engineering anthropometry, biomechanical bases of ergonomics, work physiology, workstation design, cumulative trauma disorder, materials handling, work-tool design, man-machine systems, thermal, light, radiation, noise and vibration, ergonomic assessment.
MME 4141	Metal Cutting	Introduction, essential features of metal cutting, mechanics of orthogonal and oblique cutting, shear stress and strain in cutting, forces and dynamometry, heat generation and cutting temperatures, tool wear and tool life, cutting tool materials, machinability and work material considerations.
MME 4142	Micro-manufacturing Technology	Introduction, miniaturization and MEMS, silicon processing, fabrication of silicon wafers and integrated circuit (IC) processing, electronic packaging, lithography, etching and thin film processes, silicon micromachining and energy beam micromachining, microreplication, and introduction to nanotechnology.
MME 4143	Metal Forming	Stress and strain analysis, work-hardening, yielding criteria, slip-line field theory, deformation geometry, effect of strain rate and temperature on flow properties, rolling mills, torque and power requirement, forces and pressures in forging, extrusion and drawing, stamping, cup-drawing, spinning, embossing, stress forming, high-energy-rate forming.
MME 4144	Processing of Plastics	Commodity and engineering plastics, polymer composites, fabrication of thermoplastic and thermosetting polymer by injection moulding, blow moulding, hot embossing, extrusion, PET processing, gas assisted injection moulding, heating and cooling design, selection of polymer, recycling, health and safety issues.
MME 4145	Precision Machining	Diamond tooling in precision and ultra-precision machining, machining to achieve nano surface roughness, ductile regime machining, characterisation of precision and ultra-precision machined surfaces, applications of precision machining processes: grinding, lapping, polishing, precision measurement systems.
MME 4146	Joining and Casting	Principles and advances in joining processes, metallurgy of welding, solid and liquid state welding, bonding, adhesive bonding, weldability, principles and advances in casting processes, solidification of metals and alloys, gating and riser, directional solidification and feeding distances, design for casting, melting practice, cupola charge calculations, ductile and malleable iron production, casting defects.
MME 4151	Manufacturing Strategy	Methodology of developing manufacturing strategy, corporate manufacturing decisions, strategies for order winners and order qualifiers, process choice, product profiling, technology strategy, focus manufacturing, principles of economics of scale, product life cycle, make or buy decision, strategic positions, manufacturing infrastructure development issues, accounting and financial perspective..
MME 4152	Quantitative Techniques	Linear programming: duality and sensitivity analysis, allocation models: transportation, assignment, transhipment, game theory, network models: project networks, maximal flow, minimal spanning tree, goal programming, dynamic programming, queuing systems: queuing models, birth-and-death process, decision making using queuing models, modelling using computer packages.

University required courses are thought to be a burden for students compared to other institutions. However, this requirement is unique in IIUM according to its mission of integration of knowledge. As a results, students need to carry about 15-20 credit hours more compared to other universities in Malaysia and abroad. But it seems that these extra credit hours are not a critical issue rather than a motivation for the students.

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Table 3. University required courses and their synopsis

Code	Course	Synopsis
UNGS 2030	The Islamic Worldview	This course focuses on the meaning, characteristics & kinds of worldviews including some selected Western ideologies. Such as materialism, secularism and post modernism. It also discusses the overview of Islam and its main characteristics. Furthermore, it elaborates the main elements of the Islamic worldview, which includes the concept of al-Tawhid, Prophethood, Sunnatullah, al-Akhirah, Man, Nature & the Contemporary challenges faced by man & society.
UNGS 2040	Islam, Knowledge and Civilisation	This course deals with the basic issues, which lead to true understanding of the concept of the theory of knowledge from Islamic and non- Islamic perspective, the contribution of Muslim scholars and scientists in different fields of knowledge and science, and the challenges facing the Muslim Ummah today.
UNGS 2050	Ethics and Fiqh for Everyday Life	This course consists of two parts: Islamic ethics and *fiqh* for everyday life. The Major theme of this course is to show the importance and the role of ethics and *fiqh* in the daily life of Muslims. The main issues to be focused on in the first part of this course include the main Islamic ethical concepts, Islamic values and ethics for different professions, inter-personal ethics. The main issues in the second part include a general view on Islamic *fiqh* and its schools, *sharÊ'ah* criteria for measurement of human needs and actions, major bio-ethical issues in medicine, and family ethics in Islam.
GEN 4100	Engineering Professional Ethics	This course focuses on engineering professional ethics from an Islamic perspective. The central theme of this course is to relate Engineering Professionalism to Islamic ethical foundations. The course also focuses on Occupational Safety and Health Administration (OSHA) and the different industrial hazards and disasters that may affect human lives and the ecological system. The role of emergency planning and controlling in circumventing the consequences of hazards and disasters is discussed. Finally, the responsibility of the engineer towards his profession, society and international community is addressed.

Table 4. Educational outcomes of manufacturing engineering programme [5]

#	Educational Outcome
1	The ability to acquire and apply knowledge of mathematics, science, and engineering fundamentals.
2	To have acquired a broad based education necessary to understand the impact of engineering solutions in a global and societal context.
3	The ability to have in-depth understanding and technical competency in relevant engineering.
4	The ability to undertake problem identification, formulation and solution.
5	The ability to design a system, component, or process for operational performance.
6	The ability to design and conduct experiments, as well as to analyze and interpret data.
7	The ability to understand the principles of sustainable design and development.
8	The ability to effectively communicate orally, in writing and using multimedia tools.
9	The ability to function effectively as an individual and in group with the capacity to be a leader or manager as well as an effective team member.
10	The ability to recognize the need for life long learning and possess the ability to pursue independent learning for professional development.
11	The ability to understand the social, cultural, global and environmental responsibilities of a professional engineer, and the need for sustainable development.
12	The ability to understand and commit to professional and ethical responsibilities.
13	The ability to understand the expectations of an engineer who practices in an industrial or governmental organization.

Table 5: Example of assessment matrix of educational outcome for MME 4142 Micromanufacturing Technology

Educational outcomes of MME 4142	**Educational Outcomes of Manufacturing Engineering Programme (Table 4)**												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1. Apply the concept of miniaturization for the fabrication of microdevices.		3		2									
2. Outline the processing techniques of electronic grade silicon, silicon wafer, electronic packaging and assembly.			3		1	2							
3. Apply lithographic technique and silicon micromachining for IC fabrication and various MEMS microstructures.			3		2								
4. Explain thin film processes for microstructuring and doping of semiconductor materials.			3		2								
5. Describe the basic concept of energy beam machining, LIGA technology, and nanotechnology.	2		2										

Objective addresses outcome slightly (1), moderately (2) and substantively (3).

References

1. S.G Lee, W.N.P Hung, Manufacturing engineering education in Singapore, Proceedings of the International Conference on Manufacturing Engineering Education, June 2005, San Luis Obispo, California, USA. ASME Transaction,
2. The future of engineering education in Malaysia, Ministry of Higher Education, Malaysia, Dec. 2005.
3. W.N.P Hung, V.J. Leon, Micromanufacturing education in the global manufacturing scenario" ASEE Gulf-Southwest Annual Conference, March 2005, Texas A&M University-Corpus Christi, Texas, USA,
4. K.D. Stephan, V. Sriraman, Globalizing manufacturing engineering education IEEE Technol. Soci. Magazine, Fall 2005, 16-22.
5. R.M. Felder, R. Brent, Designing and Teaching courses to satisfy the ABET Engineering Criteria J. Eng. Edu., 92 (2003), 7-25.

Teaching Mathematics for Future Engineers: Overcoming Issues of Educational Inadequacies

Thirunanthini d/o Manoharan, Maz Jamilah Masnan, Mohd Syafarudy bin Abu

Universiti Malaysia Perlis

Abstract

Engineering as a profession requires a clear understanding of mathematics. In the field, mathematical and scientific theories and principles are applied to real life situations and used to develop economical solutions to technical problems. Over the past years, Engineering Institutions are facing issues concerning the process of teaching and learning mathematics. These issues mainly focuses on the inexperience of the educator which includes the lacking of knowledge, skills and attitude as well as the development of an appropriate mathematics curriculum for the students whom embark in engineering courses. The first part of the paper is aimed to discuss issues involving best practices for an engineering mathematics educator to enhance their knowledge, skills and attitude with regard to training topics, methods, and resources in the process of teaching and learning mathematics. The second part of the paper is aimed to discuss issues on the suitable mathematical curriculum for engineering undergraduates to ensure that they have sufficient skills and knowledge for the solution of engineering problems which arises in the 21st century.

Keywords: best practices; mathematical curriculum for engineers

1. Introduction

Engineers apply the principles of science and mathematics to develop economical solutions to technical problems. Engineers consider many factors when developing a new product. For instance, in developing a new robot, engineers precisely specify the functional requirements; design and test the robot's components; integrate the components to produce the final design; and evaluate the design's overall effectiveness, cost, reliability and safety. The terms used such as specifying functional requirements, design and testing components, integrate and evaluate clearly indicates the importance of mathematics in engineering.

Most engineering programs involve a concentration of study in an engineering specialty, along with courses in both mathematics and the physical and life sciences. Today's world of engineering requires students not to be master of the mathematical knowledge alone but must be able to use the knowledge creatively especially in problem solving. The increasing mathematization of knowledge in the field of engineering is related to the fact that the process of learning not only widens the scope of the knowledge, but also deepens it, makes it more exact and allows the future engineers to penetrate into the inner characteristics of the phenomenon in engineering. Realizing this fact, we as mathematics educators tend to use lecturing as our principal method of instruction, where students passively take notes to encapsulate our commentary.

The phenomenon among most of the engineering undergraduates in our local universities is that most of them view mathematics only as a subject they should master in order to gain good grades rather than a powerful and flexible tool which is closely integrated into the nature of engineering itself. Being frontiers in our Mathematics Institution at University Malaysia Perlis, we highlighted few issues involving the process of teaching and learning mathematics to the engineering undergraduates. We have developed a standard presentation of mathematics, and have stabilized the content of mathematics courses for all the engineering students. As a result, we do face issues where some mathematical knowledge such as Numerical Analysis and Statistics which is required by some engineering courses is offered and taught by the engineers themselves.

This paper reviews issues involving the important attributes of teaching and learning mathematics for the future engineers generally the knowledge, skills and attitude required as mathematics educators as well as the revised curriculum that is proper to serve the needs of today's engineering professions.

2. Knowledge, Skills and Attitude

It is well-known that in the process of learning and teaching mathematics, it is not sufficient enough for a student to understand the importance of gaining knowledge that he/she can use in him/her future endeavors. It is difficult to convince him/her to give time, his/her attention, energy and interest in studying mathematics without monitoring his/her will, without involving his/her emotions and most importantly illustrating the practical needs of mathematics in engineering studies. It is not enough to state that engineers needs mathematics; this must be shown using simple examples illustrating why he needs it, and how it works in different situations. This cannot be achieved if the lecturer is only concerned with the logical unity of the course and does not attempt to relate the information presented with actual problems, if he does not show the practical applications of mathematics.

This is where the conceptual understanding of subject matter present where it requires the mathematics educators themselves to understand the central concepts of their subjects, see the relationships and be able to instill a deeper understanding in students of the central ideas and issues in mathematics. Students must be shown the relationship between mathematics courses and the actual needs of modern engineering. Therefore, mathematicians must teach what is necessary for the student and must present the material in such a way as to show him/her why he/she is studying it. But in order to understand which mathematical methods and corresponding solutions are required in an engineering field, engineering mathematics educators themselves should be able to see the connection between mathematics and an engineering field to help future engineers to understand the purpose of learning mathematics.

Let us consider complex numbers as an example. Although students are exposed to various sub-chapters in complex numbers even from secondary school, being an undergraduate engineering student, he or she should be able to see these complex numbers as part of engineering and not as a chapter in mathematics which they need to master just to get good grades at the end. For this purpose as engineering mathematics educators we should help them to see and realize the application of these chapters in their career life as well. For instance, in the field of electronics, the state of a circuit element is described by two real numbers (the voltage V across it and the current I flowing through it). Rather than the circuit element's state having to be described by two different real numbers, V and I, it can be described by a single complex number $Z = V + Ij$.

On other hands, we also know that the law of electricity can also be expressed using complex addition and multiplication. A simple introductory as this will definitely draw attention from the engineering undergraduate students as they can simply see the connection between their field of study and mathematics as a fulfillment tool to enable them to understand better. We must not forget that the purpose of why many students choose engineering is because their interests lie far from mathematical proofs and ideas. This is why, we as mathematics educators face difficulty and have to carry responsibility to structure of teaching in such away that when an engineering student master the skills and knowledge in mathematics, he/she is actually fulfilling his/her goals in the engineering fields.

Again it is an issue here; how far we as educators can show the close ties between mathematics and engineering to the students? Being just about 8 months old as an Mathematics Institute in University Malaysia Perlis, we do face difficulties in helping students to see the intersection of mathematics in the fields of engineering rather that seeing it as a complement from their area of study. There was once when I was conducting a mathematics class on eigenvalues and eigenvectors, and as I was explaining the methods involved; how to obtain eigenvalues, eigenvectors and to solve a linear equation; a student asked me the purpose of why they need to know this. I couldn't come up to a very convincing answer as I told him that they will need it in their future work especially in linear programming. If I were to put myself in his shoes as a first year undergraduate student I will still regard the answer is sufficient to kill my curiosity. This is where the issue is, if mathematics institutions is surrounded by just four walls and lack of understanding and the emphasis is placed on cramming students with large amount of mathematics material, which they often fail to assimilate then the efforts of us becoming the best institution, best professors, lecturer and tutors are all destined to failure for the situation will pass the word to the first year students that mathematics is not needed in higher years, that they can be still comfortable without it.

Mathematic for electrical students is different from mechanicals [1]. This is why we feel that it is important to establish close relation without boundaries between the mathematicians and specialized engineering disciplines to help us see what kind of mathematical knowledge that their specialization field require. We as educators require not only mathematical knowledge but also the skill in helping students to see the establishment of relationships between the mathematical courses and specialized engineering disciplines which cannot be deferred to the distant future especially in their areas of expertise. But how to provoke good communication between mathematicians and engineers is still an issue remains to be solved.

Naturally, mathematicians themselves cannot remain silent observers [2]. Experience shows that we must look deeply into various aspects of teaching mathematics to engineers. It is well known that new problems require new approaches, while old approaches, even though very well defined, often prove inadequate. The distribution of tasks among industrial equipment, the effective utilization of the labour force, the optimum use of raw materials and semi-finished products, the organization of a rational transportation system and many problems, require a serious and reflective approach and the implementation of a variety of mathematical methods. This is why the mathematical method of thinking, the ability to create proper mathematical models of processes, and to search out solution, or approximation of solutions, must become an integral part of engineering training. Future engineers should not see mathematics as an absolute logical system but as a problem solving tool to cultivate critical and creative thinking through proper understanding of mathematical knowledge [1]. Obviously this can only be achieved if we educators own highly elaborated knowledge that is, an individual who has a strong understanding of some domain is an individual who has knowledge of lots of details and lots of examples within that domain [3]. This idea has been most forcefully advocated by cognitive psychologists, who have argued that understanding, reasoning and problem solving are all dependent on detailed specific knowledge. It is possible for someone to have detailed recitation knowledge without any understanding of the central ideas [3]. In most of the teaching and learning mathematics, less often considered is the question of whether one can understand the central ideas without having large store of detailed knowledge. To the extent that an educators concept maps include numerous nodes or numerous examples within a node, one could say that the teacher's knowledge is both elaborated and conceptually organized [3].

Let's consider the example on finding determinant for this question;

Given that

$$A = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \text{ and } \det(A) = 3.$$

Find $\det \begin{bmatrix} a & b & c \\ 5d+a & 5e+b & 5f+c \\ 2a+g & 2b+h & i+2c \end{bmatrix}$

A recitation individual will merely find the $\det \begin{bmatrix} a & b & c \\ 5d+a & 5e+b & 5f+c \\ 2a+g & 2b+h & i+2c \end{bmatrix}$ by either using the row or column expansions to evaluate the determinant such as;

$$= 5(aei - afh - bdi + bfg + cdh - ceg)$$
$$= 5(3)$$
$$= 15$$

Comparatively, an individual who has understanding of the central ideas of determinant will also conclude that without using any expansions of row or column,

The $\det \begin{bmatrix} a & b & c \\ 5d+a & 5e+b & 5f+c \\ 2a+g & 2b+h & i+2c \end{bmatrix} = 15$,

by using the properties of determinant that if *B* is obtained from multiplying a row (column) of *A* by a scalar *k*, then $|B| = k\,|A|$ and also the property that to any row(column) of *A* we can add or subtract any multiple of any other row (column) without changing $|A|$. If students have an idea how various ideas in mathematics connect to each other, they can also have a sense for whether an idea that eventually started with point A can bring them back to point B [3]. Mathematics educators must not only try to transmit a certain volume of information but must emphasize the fact that mathematics is also an instrument of acquiring knowledge. As this is not sufficient as discussed earlier, but having recitation knowledge alone which is basically memorizing steps or formulas in problem solving will not help us as educators to handle inquiry-oriented classrooms.

Again having a detailed specific knowledge in mathematics is another issue to be handled as we lecturers at University Malaysia Perlis found that the detailed knowledge of a pure mathematics lecturer in teaching engineering mathematics defers from a lecturer with statistical background knowledge. Although statistical approach in engineering problem solving is not to underestimate, but when it comes to calculus vector as an example, lecturers with statistical background find it difficult to have a detailed knowledge in this area of study and often withdraw them from teaching those subjects.

Traditional undergraduate engineering programmes consisted of lectures on different mathematical topics that were supported by both tutorials and sets of problems [4].These were actually marked or discussed with students. Well designed tutoring programmes are one of the most effective methods of instruction known [5]. Tutoring requires detailed pedagogical strategies combined with university resources to conduct tutoring sessions to encourage students to participate and engage in dialogues and discussions with their tutor or lecturer in their learning experience. In tutorial classes, students are actively encouraged to participate in discussions and argumentation so that they can reason through mathematical quandaries themselves and become validates of their own knowledge [5]. Communication abilities are important because engineers often interact with specialists in a wide range of fields outside engineering [6]. Besides being a facilitator in the tutorial class, it also enables us to evaluate student's understanding of the chapters in mathematics. In order to create a "right" kind of conditions that enable students to have sufficient opportunities to practice and receive feedback on the skills and knowledge they are trying to master it is encouraged to have a tutorial class which consist 15-20 students [5]. Small group tutorials work well where students can raise any issue [2]. Again time constraints, few lecturers and tutors on hand and of course the attitude of us for just being followers rather than leaders, we end up handling about 50-60 students per tutorial class which is currently the phenomenon in our university now.

Our experience shows that, students who come to the tutorial class with some specific questions, have read assigned lectured materials and attempted the task given to them. Talking about this, not to forget that if the same tutorials are given every semester, students, including the first year engineering students obtain the solutions from their seniors and end up reading the solutions before the exams. If this is the phenomenon that students go through every semester then the main objective to instill problem solving skills in them will definitely go in vain. Furthermore it will be harder for us to have the knowledge of the "real" capability of students, whether they really master the chapters they are studying.

Additionally engineers use computer extensively to produce and analyze designs; to stimulate and test how a machine, structure or system operates; and generate specifications for parts [6]. If this is the situation, then obviously training future engineers require technology based learning as well, and we mathematics educators should master some of the mathematical packages that are available to solve mathematical problems technologically such as *Mathlab*, *Maple*, *Mathworks*, *Statgraphic*s, *S-Plus*, *SPSS* and many more. Such strategies are becoming a part of the teaching process of engineering students for many universities [2]. They provide the undergraduate with an understanding of their mathematical weaknesses and the opportunity to address them [4].

However students need to be able to determine what the problem is. Can it be solved? Is the answer a number, a set of numbers or a formula? What do solutions to differential equations mean? What is known? What is not known? Can a student put the information and equations in a form the computer can understand? We can only answer these questions if we educators provide sufficient guidance and create active learning environment during tutorial sessions and not to forget; also to master the computer knowledge ourselves before directing students to venture them.

2.1 Suggestions to Overcome Issues in Teaching and Learning Mathematics.

Addressing all these issues, we lecturers at University Malaysia Perlis, have proposed few suggestions. However, there are still more issues involved but it is beyond the scope of this project to explore all of them.

As communication between mathematics department and other engineering departments are important we lecturers at University Malaysia Perlis organize a periodic colloquia every first week of the month where we invite course-coordinators from the respective Engineering departments to determine the right kind of mathematics knowledge they require for their engineering undergraduates. This is because; we do face phenomenon whereby some papers such as numerical analysis and statistics paper that is needed by students from the Mechatronics Engineering department is taught by the engineers themselves. Underlining the phrase from Professor Kenneth V Lever from the Cardiff University that mathematics should be taught by skilled mathematicians and not engineers gives us the clear picture that we should carry the responsibility. It is extremely important that in the final years, seminars should be organized under the direction of mathematicians and engineering professors for the study and discussion of engineering problems and critical discussion of various approaches suggested in the technical literature. In this way, students do get to relate the mathematical methods they acquired to the problems encountered in their future profession.

Despite the students, it also enables us; the young mathematicians to perceive the inter-relationship between mathematics and engineering, the problems arising in engineering sectors, the creation of methodologically sound textbooks corresponding to the needs of engineering and up-to-date from the mathematical viewpoint and not to forget the members of the engineering department will be able to see mathematics as a tool in their research method for their own problem.

Attending mathematics short courses is another effect way known to enrich knowledge and communication between mathematicians, engineers and future engineers. Mathematics short courses may include courses on statistics, algebra, calculus, numerical analysis, discrete mathematics, Fourier integrals, cryptography and other new mathematics field which we mathematicians find appropriate and important to help emerge interest in students as well as lecturers.

By this way, besides serving the needs of the engineers as well as the undergraduates, the statisticians do stand the chance to perceive pure mathematical knowledge and the pure mathematicians with the statistical knowledge.

Mathematicians should also seek advice and guidance from the skilled technology expertise in mathematical software to enrich their technology based knowledge in mathematics. Traditional math's skills are needed since if lost never be regained [2]. Realizing the fact, mathematicians should take full responsibility by actively doing everything in a tutorial session to cause students learn and help to build their confidence.

By observation, we found that initiative to prepare among students increased if appropriate incentive is given to students such as giving extra or bonus marks for outstanding tutorial works, active participation during tutorial lessons and giving a simple and short assessable quiz before tutorial session commences. If the tutorial class consist big number of students then giving group work assessment is the best way to ensure the participation of all the students during tutorial session.

New and experienced educator should involve in regular interactive intellectual discourses so that they share similar idea in teaching. So do in providing examples in teaching process. There are certain topics that require less than three examples for students to understand what is being taught, while other may need more than five different examples to be discussed in detail. Some students may understand the concept taught during discussion on the example. Thus, every stage in teaching the future engineers are equally important, and leaving the students to go through the example on their own should be avoided. The same goes to appropriate applications to be presented and discussed in the class. The mathematics taught must be seen by the students to be relevant to their branch of engineering. Therefore, this fact must become a guide for educator to choose appropriate application to be taught. Again, regular communication between engineering and mathematics departments to address related applications reduce the mathematics educator's burden and in some way beneficial to the engineering educators.

3. Curriculum

One thing in discussing the issues of educational inadequacies is the mathematics curriculum. Educator must be aware that mathematics is a mean to study engineering subjects. Therefore, mathematics curriculum should become a keyword to educator to teach what is necessary for the student and must present the content of learning in such a way as to show student why the subject is being studied as discussed earlier in this paper. But, in order to understand that, educators must first study some aspects from the curriculum and its importance.

Pellegrino [15] stated that curriculum consists of knowledge and skills in subject matter areas that teachers teach and students are supposed to learn. The curriculum generally consists of a scope or breadth of content in a given subject area and a sequence for learning. Standards in mathematics and science typically outline the goals of learning, whereas curriculum sets forth the more specific means to be used to achieve those ends.

3.1. Effective Mathematics Curriculum

What are the characteristic of an effective mathematics curriculum? Few descriptions by Smarandache from the University of New Mexico on the characteristics of an effective mathematics curriculum include:

1. To develop courses and programs that support the university's vision of an educated person and a commitment to education as a lifelong process;
2. To provide educational experiences designed to facilitate the individual's progress towards personal, academic, and work-based goals;
3. To encourage the development of individual ideas and insights and acquisition of knowledge and skills that together result in an appreciation of cultural diversity and a quest for further discovery;
4. To respond to the changing educational, social, and technological needs of current and prospective students and community employers.

Another characteristic of a curriculum proposed; is that the curriculum developers are assumed to know how the curriculum has to be changed and how educators have to adapt their teaching practice [8]. Thus, from this perspective, the curriculum should be designed by taking into account the educators, the students, and the culture in which the curriculum is embedded.

3.2. Revised Mathematics Curriculum

Since the curriculum functioned as a steering mechanism, as an enabling device, and as a condition of work for university educators, an effective curriculum also means that the curriculum must be revised (renewed) when need is intended. The curriculum renewal methodology has been developed to enhance efforts by a program faculty to analyze and understand an existing curriculum, to measure and assess input from a variety of informed sources, and to design an improved curriculum in response to the inputs received [12].

The methodology for curriculum renewal suggested is a five-stage process which includes:

1. Preparation. This stage is the key component of the curriculum renewal methodology. The step in this stage include leadership commitment and gaining faculty support, creating a curriculum design team, benchmarking, identifying a curriculum structure, and identifying and gathering inputs from other stakeholders. Completing these steps will help to ensure that the renewal process runs smoothly and efficiently through time.

2. Strategic Planning. The strategic plan for the academic unit, if available, should be used in setting the review criteria for the curriculum renewal process. A strategic plan involves establishing long-term goals, adopting courses of action, and allocating the necessary resources to help accomplish the goals. The goals may include desired subject area competencies, specific laboratory or classroom experiences, and/or the integration of selected curriculum elements.

3. Analyze Existing Curriculum. To compare a proposed curriculum and the existing curriculum, the existing curriculum must be documented and

its content made clear. Leonard stated two methods of curriculum analysis. Knowledge/Skills Methods is an evaluation on knowledge and skills. Knowledge can be divided into three broad categories; fundamental knowledge, core knowledge, and main knowledge. While for skills, he proposed four broad categories. However, for the purpose of mathematics curriculum, skills that would be considered are problem solving skills and organizational skills. Augmented Syllabus Method is the next hierarchical structure to analyze curriculum. It divides the curriculum into four part; foundation materials, defining elements, complementary elements, and integrating experiences. Augmented syllabus analysis documents the degree to which course-level goals are currently being accomplished with respect to student expectation, prerequisite knowledge, anticipated subsequent use of topics and analytical tools required.

4. Design New Curriculum

Leonard added that developing a modern engineering curriculum requires an attempt to optimize course offerings and other elements of the curriculum within constraints such as certification criteria, industrial advisory board recommendations, number of faculty, diversity of faculty effort and interests, number of students, and available resources. This stage should also be closely aligned with the academic unit strategic plan. It is suggested that all discussion of individual courses, credits, prerequisites, and the like to be hold until the final step of the process. The curriculum design team acts as the lead to initial discussions of the faculty to develop consensus on basic curriculum concepts. The final step in the curriculum development is the identification of specific courses and the topical coverage of each. Through feedbacks, and discussion with faculty as whole, course coverage, distribution of topics, and expected mastery of topics, resulting the overall curriculum structure and materials to be part of the curriculum.

5. Implement New Curriculum

Once the features of the course content of the new curriculum have been specified, the changes that must be made to the existing curriculum to create the new curriculum are identified.

3.3. Curriculum Related Issues in Engineering

There are few other issues that relates to the engineering curriculum. For instance, in some universities mathematics is taught in-house, that is taught by the engineering department. And in some others, mathematics is taught by the mathematics department who has developed tailored courses. Even we lecturers at University Malaysia Perlis do come across the phenomenon most of the times. These facts also lead to an argument that engineers know better the mathematics component that should be taught than the mathematicians themselves. What ever the arguments are, it is the end result that matters. It is the curriculum goals that should be assured to be attained by the students.

Again to be mentioned is that communication, cooperation and close relationship among the specialized engineering departments and mathematics department enable some education deficiencies to be overcome; for example, in addressing mathematics related skills that are required by the engineering students. The needs for related mathematical skills may change as the technology diverse, and the mathematician is unaware of that. The mathematics principles need to be linked to engineering applications to promote relevance and the understanding of mathematics for the students.

In addition, engineering faculty assume that certain concepts are taught in the mathematics courses, but they are often not familiar with the specific mathematics curriculum. It is imperative that the engineering disciplines determine which areas of mathematics are most important to them so that they can present their courses at an up-to-date scientific level. Computer Aided Design (CAD) is a core course required by the manufacturing engineering department at our university. To instill the basic geometric construction definitely the undergraduates require knowledge in geometric designing. Unfortunately these are the areas that we mathematicians do not taken into account when we design the curriculum as a result of doing our work within four walls and no communication involved.. Furthermore more and more discrete mathematic is needed due to digital requirements. Several more specialized topics are needed for particular branches of engineering. It is vital therefore, that the engineering today do only require empirical but also the abstract understanding of mathematics [4]. Since the needs of mathematical knowledge differs from one engineering specialization with the other, then cooperation from the engineering department is the only way to upgrade the efficiency of the existing mathematical curriculum.

Another issue to be discussed is the issue on technology. Technology formed the basis of the contextual approach for many academics [14]. Kent and Noss from London University commented that mathematics education for engineers has typically been about techniques, and the need in academics is shifting towards modeling. Traditionally, teaching mathematics need to perform practical calculation. Today, nearly all of those techniques have disappeared to be replaced by computer software.

Otung (2002) wrote that advances in ICT have made a revolutionary impact on the way engineers work in the 21st century. It is high time engineering academics took cognizance of these positive developments and adapted and modernized their teaching approach. Today's engineer is no longer limited to pen, paper, slide rule and mathematical or statistical tables for their calculations, but can obtain reliable solutions of mathematical problem using ubiquitous software packages.

3.4. Suggested Mathematical Curriculum

By observing the curriculum we do implement in educating future engineers in our university itself; Engineering Mathematics I which covers the basic mathematical skills of the first year students, Engineering Mathematics II which covers syllabus on Differential, Integration and Differential Equation and Engineering Mathematics III on Vector Analysis and Numerical Analysis, the course coordinators from our mathematics department suggested that rather than compressing all the needed mathematical skills under the name of Engineering Mathematics, it is time for us to explore each and every chapters in the curriculum as a trained subject in mathematics itself. For instance Numerical Analysis should be taught as a subject and not as a single chapter in the curriculum. Compressing all the knowledge of Numerical Analysis into one chapter alone will just be a road for the students to achieve good grades and not be able to explore and instill the skill of approximation in depth. As discussed earlier several other mathematical knowledge such as discrete mathematics, real analysis, finite mathematics, probability theory and engineering statistics plays an important role in engineering as well [4]. As different engineering expertise might need certain kind of mathematical knowledge than we mathematicians can organize seminars or conduct these courses as a short term course during the semester break for instance to help them achieve the skills needed.

Addressing the issues on computer technologies, therefore it is necessary for the mathematics department to conduct lab sessions to help students strengthen their problem solving skills through mathematical software. These lab sessions should be conducted as a supportive knowledge to the lecture and tutorial questions that students have mastered manually. For instance, a core course on Mass Transfer and Chemodynamics offered by the School of Environmental Engineering require students to use the MATLAB software for numerical computations of mass transfer processes and chemodynamics. If students are not introduced to the software during their mathematical sessions, then the work become harder for the engineers as they have to start teaching the numerical computations at the very basic level before going into depth to achieve their objective. Although the debate here is not on the statement on who should teach mathematics, but we as mathematicians do play an important role in educating students with technology knowledge as well to support their learning of mathematics to be more concrete and active.

4. Conclusion

As an educator, we must realize that engineering students did not choose mathematics as their subject of specialization, rather a university requirement. Therefore, there are students who cannot see the importance of mathematical knowledge that they will need for their future endeavors, what more for their engineering learning process. This is why members of mathematics department have a difficult responsible and important task before them, that is to structure their teaching in such a way that the students is always aware that by studying mathematics, he is approaching his goal in engineering.

There are many different techniques that can be implemented in mathematics education, mainly to overcome issues on educational inadequacies. This paper has dealt with but only a few and to the best of our interest.

Through our literature review, communication plays a very important role to combat most of the educational inadequacies in the engineering field. Proper communication, let it be among mathematicians themselves, or between mathematicians and engineers as well as students is the best way to connect the world of engineering with the knowledge of mathematics.

Once again, it is in vain pointing the finger to each other to solve this issue, but what does matter is the ability of us realizing and changing our very own attitude towards educating the future engineers.

References

1. A review of mathematics strategies in engineering education, Progress Project Strategy Guide: Mathematics Strategies for Engineering; a Review.http://www.hull.ac.uk/engprogress/Prog3Papers/Edward.pdf.
2. B. V. Gnedenko, Z. Khalil, The mathematical education of engineers, Educational Studies in Mathematics 10 (1979) 71-83.
3. Mary Kennedy, Defining Optimal Knowledge for Teaching Science and Mathematics, National Institute for Science Education, University of Wisconsin-Madison, April 2007.
4. S. Williamson, C. Hirst, P. Bishop, T. Croft, Supporting mathematics education in UK engineering departments, The Institution of Electrical Engineers, 2003.
5. Yeap Boon Han, Lee Fui Tong, The Craft of Effective Tutoring in Classroom Environment; School of Information Technology, Monash University Malaysia 2003.
6. A review on general engineering education and career resources; American Society for Engineering Education.http://www.asee.org.

7. P. Kent, R. Noss, Should we reassess the role of mathematics in engineering education? Learning and Teaching Support and Resources for Engineers Conference, 2002.
8. J. H. V. Driel, N. Verloop, H. I. V. Werven, H. Dekkers, Teacher's craft knowledge and curriculum innovation in higher engineering education. Higher Education 34 (1997) 105-122.
9. F. G. Hayati, A. N. Ali, Mathematics for electrical engineering programmes: An engineering perspective, METSMAC 2006.
10. K. Willcox, G. Bounova, and Mathematics inengineering: identifying, enhancing and linking the implicit mathematics curriculum, Proceedings of the American Society for Engineering Education Annual Conference and Exposition, 2004.
11. W. Middleton, Undergraduate engineering mathematics – an aspect of computing? The Institution of Electrical Engineers, 2001.
12. M. S. Leonard, D. E. Beasley, K. E. Scales, Planning for curriculum renewal and accreditation under ABET engineering criteria 2000, http://www.succeed.vt.edu/products/outcomes/.
13. S. Williamson, C. Hirst, P. Bishop, T. Croft, Supporting mathematics education in UK engineering departments, The Institution of Electrical Engineers, 2003.
14. I. Otung, Putting engineering first and mathematics second in engineering education, Engineering Education Technical Report, University of Glamorgan, 2002.
15. J. W. Pellegrino, Understanding how students learn and inferring what they know: implications for the design of curriculum, instruction and assessment, NSF Instructional Materials Development Conference, 2002.
16. H. Wankum, D. Brandt, Practice and potential in engineering education in Germany, International Journal of Technology and Design Education, 2 (1), (1993), 7-10.

A Study on Attitude towards Mathematics of First Year Engineering Students at the Universiti Kebangsaan Malaysia

Zulkifli, M. N. [a], Khamisah, J. [b], Azami, Z. [c], Halim, I. [d], Izamarlina, A. [e], & Haliza, O. [f]

Unit Pengajian Asas Kejuruteraan,
Fakulti Kejuruteraan,
Universiti Kebangsaan Malaysia
E-mail :, [a] zmn@vlsi.eng.ukm.my, [b] khamisah@vlsi.eng.ukm.my, [c] azami@vlsi.eng.ukm.my, [d] abdhalim@vlsi.eng.ukm.my , [e] emiey@vlsi.eng.ukm.my , [f] haliza@vlsi.eng.ukm.my
Tel: 03-89216681 Fax: 03-89216960

Abstract

The problem of declining mathematical skills and interest amongst university entrants to the engineering courses is a global phenomenon Academics involved in teaching mathematics to engineers using the traditional approach are unanimous in acknowledging that a good pre-university mathematics result is no longer a guarantee that students are equipped with the necessary skills to pursue studies at university level. Apart from having been raised on a mathematics curriculum, very much lacking in depth and essence, many researchers believe that the negative attitude towards mathematics of mathematically deficient students plays a big role in fostering self-doubt which in turn hampers the learning of the subject. This study investigates the attitudes of first year engineering students from four engineering departments in Universiti Kebangsaan Malaysia (UKM) who have taken two engineering mathematics courses covering the main topics of Linear Algebra and Vector Calculus. These students are from the third cohort after the introduction of the outcome-based education at the faculty. The instrument used is a self-designed questionnaire using seven-point Likert scale based on previous observations and rational approach to assess their attitude towards mathematics in general and its role in engineering. The questionnaire was distributed during a tutorial class session in the final week of their lectures and collected at the end of the session. A sample of 182 first year students from four engineering departments in UKM from the 2005/2006 academic session participated in the study. Students are divided according to their achievement in the Engineering Mathematics I course into three categories identified as High Achievers, Moderate Achievers and Poor Achievers. Data analyses indicated that all categories of students have a positive attitude towards mathematics, with the majority of the students strongly agreeing that mathematics is an important basis for engineering. On the lower end, all students felt that their pre-university mathematics were not sufficient for them to pursue studies in the engineering mathematics courses.

Keywords: engineering students; attitude towards mathematics; student performance

1. Introduction

Engineering students, arriving at Universiti Kebangsaan Malaysia, regularly have a history of success and achievement in mathematics behind them, as this is normally an entry requirement for engineering courses. Also, there exists a great variation among the students, who can be mathematically very strong to some who are quite weak.

In 1995, a study concluded that 'too many graduate engineers are perceived to be deficient in mathematical concepts and fluency' [1]. Generally, engineering students find mathematics courses to be uninteresting and difficult. Many factors have been identified to contribute to students' performance. One of the factors affecting the students' learning performance is the way they perceive the subject, namely their attitude towards the subject [2]. Also, in 2000, studies have shown that students in higher education who are not mathematics majors often have negative attitudes towards mathematics [3].

This paper focuses on the mathematical attitudes of first year engineering students at the Faculty of Engineering, UKM. In their first year of studies at UKM, engineering students are required to take two basic mathematics courses, *Engineering Mathematics 1* and *Engineering Mathematics II,* before they can continue to other topics in Mathematics. These two courses mainly cover the topic of Linear Algebra and Vector Calculus.

2. Method

Out of 392 first year engineering students from the 2005/2006 academic session, a sample of 182 respondents was randomly selected to participate in this study. They were from the Department of Civil and Structures Engineering, the Department of Electrical, Electronics and Systems Engineering, the Department of Chemical and Process Engineering, and the Department of Mechanical and Materials Engineering. The survey was conducted during a tutorial class session in the final week of their first semester. The questionnaire is divided into two parts, the first on demography while the second parts consists of 22 statements on attitudes with a seven point Likert scale (1=strongly disagree, 7=strongly agree).

3. Data Analysis

Analysis on the data was done using the Statistical Package for the Social Sciences (SPSS) and Microsoft Excel. Bar and pie chart were used to visualize descriptive statistics. Respondents were divided into three categories according to their achievement in Linear Algebra course as shows in Table 1.

Table 1. Achievement in Linear Algebra course categories

High Achievers	A+ A A-
Moderate Achievers	B+ B B- C+
Poor Achievers	C C- D+ D

4. Results and Discussions

Table 2 illustrates the distribution of students according to four engineering departments and four qualifications to enter the programmes. 63.7% of the respondent were from matriculation, 26.9% were STPM, 7.1% from Diploma and 2.2% of the respondents were from Indonesia. As shown in Fig. 1a, majority of respondents were from the Department of Mechanical and Materials Engineering (34.6%), followed by Department of Chemical and Process Engineering (31.9%), Department of Civil and Engineering (23.6%) and Department of Electric, Electronics and Systems Engineering (9.9%). On the other hand, in Fig. 1b, it is shown that almost 60% of respondents are male.

Table 2. Distribution of Respondents by Department and Qualification before Entering UKM

Departments	Total Respondent	Percentage of Respondent	Qualification	Total Respondent	Percentage of Respondent
JKAS	43	23.63	Matriculation	116	63.74
JKEES	18	9.89	STPM	49	26.92
JKKP	58	31.87	Diploma	13	7.14
JKMB	63	34.62	Special cases	4	2.20
Total	182	100		182	100

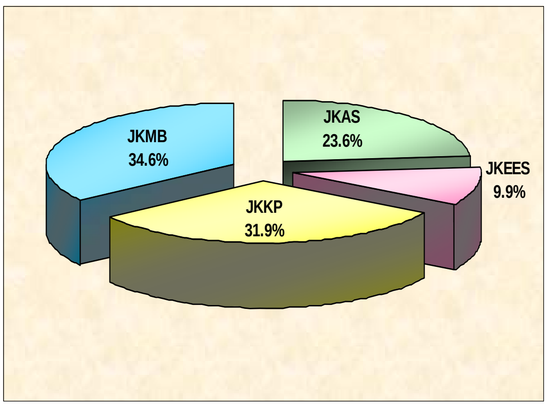

Fig. 1a. Distribution of respondents by department

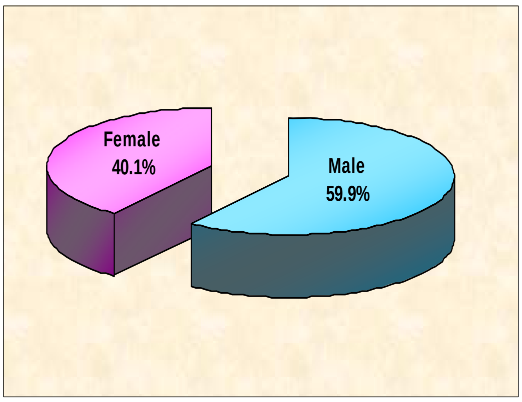

Fig. 1b. Distribution of respondents by gender.

Another interesting observation from this study is the students' performance based on achievements in Engineering Mathematics I. As shown in Fig. 2, most respondent were moderate achievers (64.8%), followed by high achievers (21.4%) and poor achievers (13.7%).

4.1. Students' Attitude

For this analysis, it is divided based on 3 subtopics:

a) Gender
b) Qualification
c) Achievement

Among the 22 statements on Students' Attitude towards Mathematics, the highest overall mean score is 6.52, that is they agreed with statement *Mathematics an important knowledge in engineering*, and the lowest overall mean score is 3.63, that is *I have sufficient mathematical knowledge obtained at school and matriculation college to enable me to do the engineering mathematics course*.

Fig. 3 shows the mean score for each attribute based on gender. Both, male and female gender agrees with statement *Mathematics an important knowledge in engineering* with the mean scores of 6.44 and 6.64 respectively. Meanwhile, both genders disagree with statement *I have sufficient mathematical knowledge obtained at school and matriculation college to enable me to do the engineering mathematics course.*

Fig. 4 above illustrates the result from the respondents based on their qualification to enter UKM. The highest mean score for the student from Matriculation and STPM are 6.63 and 6.23 respectively, obtained for the component *Mathematics an important knowledge in engineering.*

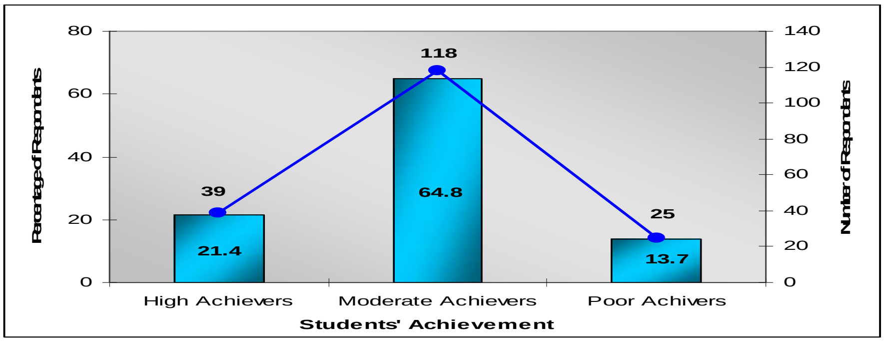

Fig. 2. Number and Percentage of Respondents based on Achievement in Engineering Mathematics I

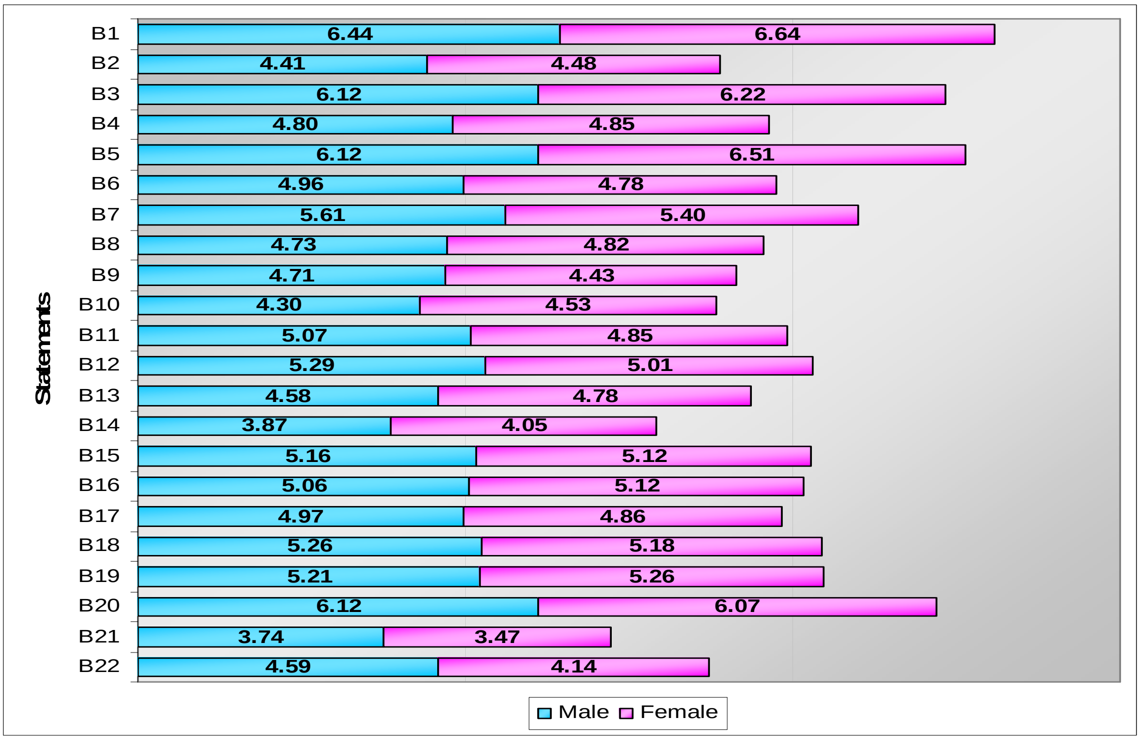

Fig. 3. Mean Score for each statement based on gender

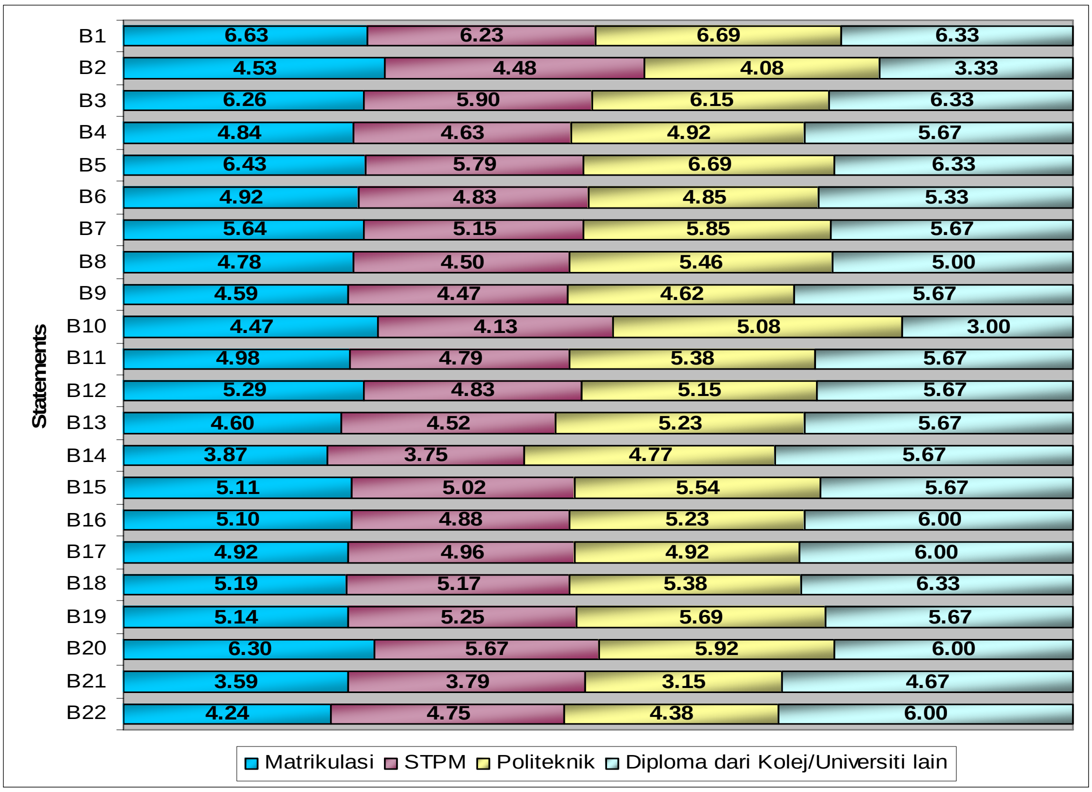

Fig. 4. Mean Score for each Statement based on Qualification

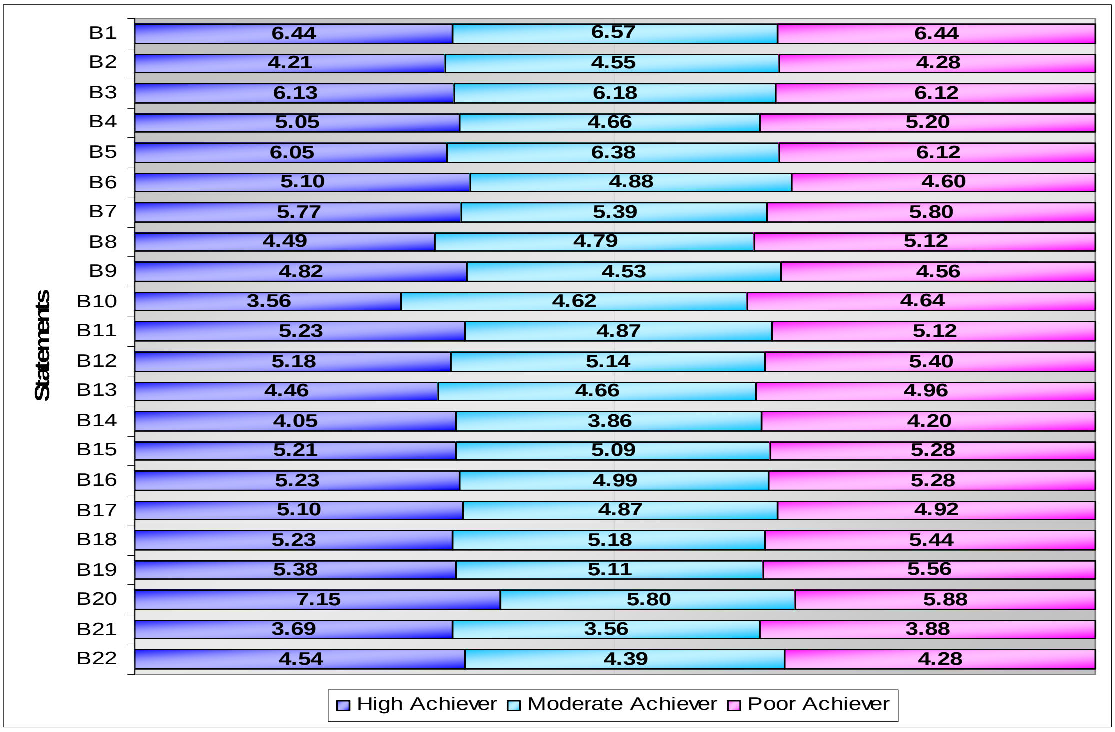

Fig. 5. Mean Score for each Statement based on Achievement in Mathematics Engineering I Course

Meanwhile, the statement with lowest mean score for Matriculation students of 6.59 is *I have sufficient mathematical knowledge obtained at school and matriculation college to enable me to do the engineering mathematics course* and the lowest mean score for STPM students of 3.75, which is *Often try to solve mathematics questions from text book or other reference besides the ones assigned by lecturers.*

Fig. 5 displays the result found from the students' achievement in Engineering Mathematics I (Linear Algebra) in their first semester in UKM. For High Achievers category, the highest mean score of 7.15 is obtained for the statement. *It makes me proud* *to be good in mathematics* while the statement with the lowest mean score of 3.56 *Compared to other courses mathematics is very difficult*. For Moderate and Poor Achievers category, the highest mean score of 6.57 and 6.44 respectively is obtained for the item *Mathematics an important knowledge in engineering,* while the lowest mean score of 3.56 and 3.88 (respectively), are for the item *I have sufficient mathematical knowledge obtained at school and matriculation college to enable me to do the engineering mathematics course.*

Key	Students' Attitude
B1.	*Mathematics an important knowledge in engineering*
B2.	*Learning mathematics takes too much of my time*
B3.	*Impossible to be a good engineer without sound mathematical knowledge*
B4.	*Enthusiastic to start math exercises as soon as possible too.*
B5.	*Very worried about failing mathematics subject*
B6.	*Very confident to pass mathematics subject*
B7.	*Would still learn math even if it is not a compulsory subject*
B8.	*Spent most time(at home) on mathematics compared to other subjects*
B9.	*I am of the type who can excel in mathematics*
B10.	*Compared to other courses mathematics is very difficult*
B11.	*Very confident that I can excel in mathematics*
B12.	*Enjoy learning new things in mathematics*
B13.	*I often ask lecturers about things I don't understand in mathematics*
B14.	*Often try to solve mathematics questions from text book or other reference besides the ones assigned by lecturers.*
B15.	*Try to understand fully every topic learnt in the mathematics course*
B16.	*Confident with my ability to learn higher-level mathematics*
B17.	*Impossible to fail my mathematics course*
B18.	*Very confident of my ability*
B19.	*When I obtain good grades for mathematics, this is due to my effort and natural talent*
B20.	*It makes me proud to be good in mathematics*
B21.	*I have sufficient mathematical knowledge obtained at school and matriculation college to enable me to do the engineering mathematics course*
B22.	*My first semester mathematics results truly reflects my understanding and mastery of the course*

Fig. 6. Students' Attitude Component.

5. Conclusion

This study focussed on mathematical attitude of first year Engineering student at UKM. On an overall basis, out of the 22 component in Students' Attitude as shows in Fig. 6, it was found that *Mathematics an important knowledge in engineering* has the highest mean score while *I have sufficient mathematical knowledge obtained at school and matriculation college to enable me to do the engineering mathematics course* as the lowest overall mean score. Between male and female, the highest mean score is 6.44 and 6.64 respectively; that is the component *Mathematics an important knowledge in engineering* while the lowest mean score is 3.74 and 3.47; which obtained from *I have sufficient mathematical knowledge obtained at school and matriculation college to enable me to do the engineering mathematics course.*

Meanwhile, matriculation and STPM students showed a positive attitude towards *Mathematics an important knowledge in engineering* with 6.63 and 6.23 respectively while, the statement with lowest mean score for Matriculation students of 6.59 is *I have sufficient mathematical knowledge obtained at school and matriculation college to enable me to do the engineering mathematics course* and the lowest mean score for STPM students of 3.75, which is *Often try to solve mathematics questions from text* *book or other reference besides the ones assigned by lecturers.*

For High Achievers category, the highest mean score of 7.15 is obtained for the statement *It makes me proud to be good in mathematics* while the statement with the lowest mean score of 3.56 *Compared to other courses mathematics is very difficult*. For Moderate and Poor Achievers category, the highest mean score of 6.57 and 6.44 respectively is obtained *Mathematics an important knowledge in engineering,* while the lowest mean score of 3.56 and 3.88 (respectively), which is *I have sufficient mathematical knowledge obtained at school and matriculation college to enable me to do the engineering mathematics course.*

In general, students have very positive attitudes towards mathematics in terms of their importance in engineering. On the contras, this ca be seen as a signal of poor mathematic teaching or curriculum rather than attitude, they feel that they are lacking in the fundamental mathematical tools and basic knowledge necessary to pursue with the engineering mathematics courses offered at the first semester study at the university.

References

1. James ,G. 1995, Mathematics Matters in Engineering :The Institute of Mathematics and its Applications, Southend-on-Sea, UK.
2. Estrada A., Análisis de las actitudes y conocimientos estadísticos elementales en la formación del profesorado, PhD., Universidad Autónoma de Barcelona, 2002
3. Evans J., Adults Mathematical Thinking and Emotion. Falmer Press: London, 2000
4. Davis, L. E., et al., 2005, Assessment-Driven Learning of Mathematics for Engineering Students, Manchester University Press, Loughborough, UK.
5. Jaime R. S. F., “Can We Reduce Students’ Negative Attitude Towards Math?” Proceeding of the 2007 Informing Science and IT Education Joint Conference, Ljubljana, Slovenia, 2007.
6. Paul E., The Mathematical Attitudes, Beliefs and Ability of Students www.mathcentre.ac.uk [26/08/2007]

The Demand and Supply Characteristics of Continuing Education in Developing Countries

Mohd Zamani b Ahmad [a], Ab. Saman Abd. Kader [a], Oladokun Sulaiman Olanrewaju [b]

[a] Department of Marine Technology, Universiti Teknologi Malaysia.
[b] Malaysian Maritime Academy (ALAM)

Abstract

Continuing education activities for practicing engineers and managers has been around for quite sometimes and will continue to be active. Providers and receivers are both capitalizing from its advantages. Education receivers use it to ascend up the career ladder while the providers are selling the services for commercial objectives. New demand continues to appear especially among developing countries leading to the appearance of providers new to the trade. The result is quite catastrophic. Purely money-making providers prepare some packages, attach themselves to local and overseas institutions of higher education to get immediate credential and sweet-talk to the potential receivers. Finally, deals are closed while most of the implementation details are not in their proper place. The system is chaotic leading to many problems on control and quality. This paper identifies the demand and supply characteristics of continuing education in developing countries and highlights the elements that need to be addressed so as to maintain quality comparable to or better than the mainstream education.

Keywords: continuing education; demand and supply characteristics; developing countries

1. Introduction

1.1. Definition

Continuing education is an all encompassing term within a broad spectrum of post-secondary learning activities and programs. The recognized forms of post-secondary learning activities include; degree credit courses by non-traditional students, non-degree career training, workforce training, formal personal enrichment courses (both on-campus and online) self-directed learning (such as through internet interest groups, clubs or personal research activities) and experiential learning as applied to problem solving It is one of the many forms pedagogy for lifelong learning (other forms are e-learning, home schooling or correspondence courses [1].

Using the term lifelong learning Haggstrom [2] defines it as all purposeful learning activity undertaken on an ongoing basis with the aim of improving knowledge, skills and competence. It contains various forms of education and training, formal, non-formal and informal, e.g. the traditional school system from primary to tertiary level, free adult education, informal search and training, individually, in a group setting or within the framework of social movements.

When the definition is tied to distance education, Holmborg [3] specifies that continuing education includes the various forms of study at all levels which are not under the continuous, immediate supervision of tutors present with their students in lecture rooms or on the same premises, but which, nevertheless, benefit from the planning, guidance and tuition of a tutorial organization. All learning activities either through formal or non-formal sources help improve the knowledge and skills of an individual throughout his lifespan. Lifelong learning helps an individual to develop his potentials to the fullest so that he could be a contributing member to his society [4].

1.2. Aim of Continuing Education

According to the European Commission [5] the three principal aims of lifelong learning are; firstly to build an inclusive society which offers equal opportunities for access to quality learning throughout life to all people, and in which education and training provision is based first and foremost on the needs and demands of individuals. Secondly is to adjust the ways in which education and training is provided and at the same time to ensure that people's knowledge and skills match the changing demands of jobs and occupations, workplace organisation and working methods. Continuing education has become so important is the acceleration of scientific and technological progress. Despite the increased duration of primary, secondary and university education (14-18 years depending on the country), the knowledge and skills acquired there are usually not sufficient for a professional career spanning three or four decades [1]. Thirdly is to encourage and equip people to participate in all spheres of modern public life, especially in social and political life at all levels of the community.

2. Concept and evolution

Lifelong learning opportunities exist in three distinct forms – formal, non-formal and informal [6]. Formal learning opportunities are provided by institutions such as schools and colleges and usually result in credentials such as diplomas, certificates or degrees. The responsibility for providing this form of learning is usually shouldered by the state or government. Non-formal learning refers to learning in organisations and agencies where the provision of learning opportunities is a secondary function. Religious institutions, health institutions, business and industry human resource development programmes, libraries, museums and a plethora of other agencies are examples of such providers. Lastly, there is informal learning which encompasses the vast majority of learning that takes place within a community. Characterised by interaction between human and media or material resources, informal learning opportunities are available from family and friends, books and forms of mass media such as newspapers, television and radio broadcasts.

The development of distance education can be divided into three phases [7]. The first generation distance education relied on written instructions in printed materials to disseminate knowledge through correspondence; the second generation made use of analogue signals of radios and TV as well as its recorders. Now the third generation has revealed its main features through interactive learning in a digital environment by using computer networks and multimedia digital technology. However, much continuing education makes heavy use of distance learning, which not only includes independent study, but which can include videotaped/CD-ROM material, broadcast programming, and online/Internet delivery. In addition to independent study, the use of conference-type group study, which can include study networks (which can, in many instances, meet together online) as well as different types of seminars/workshops, can be used to facilitate learning. A combination of traditional, distance, and conference-type study, or two of these three types, may be used for a particular continuing education course or program [1].

With the shift towards notions of lifelong learning, the emphasis moves from provision to learners and learning, and from inputs to outputs, a process associated with increased, commodification of learning and consumer relations [8]. There is fresh impetus to notions of a learning society, but reconfigured from a concern with the provision of recurrent education towards supporting diverse learning and learners. The threads of earlier meanings remain as part of the debates about lifelong learning, but they have been powerfully supplanted by different concerns. Thus, while debates have tended to focus on the vocationalising of post-school education, a more significant shift may actually be the recognition of lifelong learning and its reconstruction as part of lifestyle practices and consumer culture and in which the identity of 'lifestyle learner' overlays and displaces that of 'educated person' in certain ways

There is a general consensus that the major global shifts which have taken place have prompted a renewed interest in lifelong learning. The key features of globalizations which are commonly referred to include [8]:

1. increasing international interdependence
2. growth of regional supranational organisations
3. global ecological interdependence
4. uneven development
5. erosion of nation state and national identities
6. small dependent local economies which are linked into multinational production
7. a global division of labour
8. predominance of market forces
9. increased personal mobility

Therefore modern continuing education is characterized by five important factors. Firstly, student and teacher are separate geographically, and are not face-to-face. Secondly, it involves modern communication technology, computer network technology and multimedia technology. Thirdly, it provides for real time, two directional, interactive and multimedia functions. Fourthly, students may go to class at any time, and are not confined in time and space. Fifthly, government education branches authenticate the qualification of education organisations [7].

3. Some learning market factors

3.1. Demand, Supply and Coordination Factors

The demand-supply relationship of lifelong learning is as shown in Fig. 1. Individuals and employers are on the demand side and demand is, to an extent, characterized by the local labour market. This demand will be fulfilled by the learning providers.

On the demand side Professor John Field identifies four categories of lifelong learners: permanent, instrumental, traditional (part of a culture) and non-learners. Those that demands lifelong learning probably represents the following groups of people [4]:

i. Going back into the school system (foundation learning, higher education, university)
ii. Development of general competence, by means of alternating paid and unpaid jobs (social life, informal education, use of cultural infrastructures)

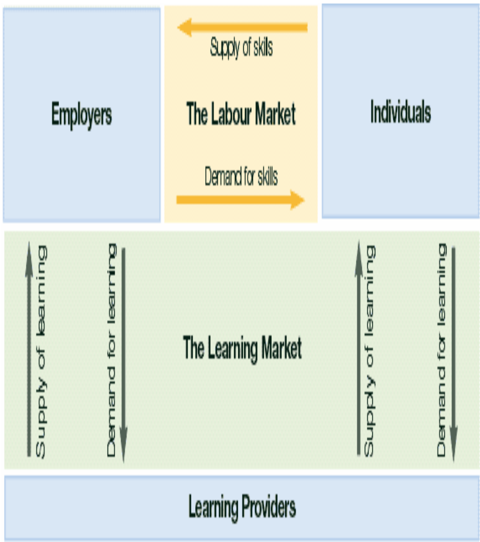

Fig. 1. The demand-supply of lifelong learning [9]

iii. Updating while in service (training at work, building up careers, changing functions and mobility)
iv. Management of all sorts of organizations, from the educational point of view (place of work)
v. Cultural infrastructures (family, institutions)
vi. Self-learning (individual, guided, of social groups)
vii. General development of civil society (rights of citizenship, ability for individual and organized initiative in civil society, building group systems)
viii. Leaving the labour market (training, retirement)
ix. Old age (creation of new roles, development of new roles)
x. Beyond old age (going beyond old age, learning for the end of life)

On the supply side the learning providers should have the following qualities [10]:

i. public commitment to provide lifelong learning
ii. policy for careers education and guidance provision which is based on the needs of all clients and contributes to whole institution aims
iii. appreciates the entitlement of all clients to careers and progression provision.
iv. programme of careers education and guidance that reflects national requirements is in place
v. written strategy on pre-entry guidance.
vi. written strategy on in-Provider support for dealing with clients unlikely to complete training programmes successfully, to assist clients at risk of terminating programmes early and for clients who leave training prematurely
vii. staff involved with careers education and guidance provision receive appropriate training or professional development
viii. provides information on destinations of former clients
ix. careers and progression provision is enhanced through provision of theoretical training and education.
x. internally evaluates performance against all accepted indicators and uses the results of evaluation to reaffirm commitment
xi. annual review of the extent to which careers and progression provision meets trainees' transitional needs.

3.2. Quality and Coordination Factors

Quality education should be the main focus in expanding education resources, improving teaching quality, and setting up information centres for learning, promoting family education and creating an atmosphere for self motivated study. [7]. Amstrong [11] highlights that the two dimensions in quality measurement for education are efficiency and effectiveness and said that weightage is given in varying proportion to the two. He further states that in the 1980s and throughout most of the 1990s, there was a definite focus on economic efficiency. Inevitably what is required is a trade off between efficiency, economy and effectiveness. We can add at least another three 'Es' to the equation equality or equity, ethics; and, environment. Table 1 summarises the different strategies that have been, and are being, used to measure quality. Amstrong [11] reminds that it will not possible to identify a set of performance indicators that could be used across the whole range of adult continuing education.

Unit for Development of Adult and Continuing Education (UK) [11] develops specific performance indicators that fitted the purposes of adult continuing education. The UDACE Performance Indicators reflect the diversity of adult continuing education and the special characteristics of the adult learner. The indicators signal the overriding importance to institutional effectiveness; that is, the service's or institutions' ability to achieve the policy goals which have been developed in response to the needs of a specified population. It gave emphasis to achievement and benefits, user satisfaction, economy and efficiency, equity and excellence, the extent to which adult learners gain qualifications and accredited success, including credits gained via 'non-traditional' accreditation. It also includes ways of measuring 'added value'.

According an EU Memorandum [5] within a regional context lifelong learning is the common umbrella under which all kinds of teaching and learning should be brought together. Implementing actions and policies to support and enhance lifelong learning will be based on shared responsibility and partnership – between Member States and the European Commission, between the Social Partners, between business and training institutions, and between different branches of education and training. It will also necessitate the merging of education and training structures, and the development of integrated policies and coherent strategies at government level However, all countries lack a high quality system for identifying need, making referrals, tracking learner progress and creating learning pathways between programmes [12].

Table 1. Strategies for assuring quality [11]

Focus	How?	Who?	Why?
Fitness for purpose	Specification of • Mission • Aims • Objectives • Learning outcomes	Organisation (self assessment)	To establish market position To derive evidence of success and achievement To ensure customers are satisfied
Industry standards	Specification of minimum standards	(Inter) national industry experts	To ensure that provision meets national or global standards. To achieve a kitemark
Best practice	Benchmarking	Researchers Organisation (self assessment)	Comparisons with those known to provide best practice
Accountability ('Best value')	Specification of performance indicators for efficiency and effectiveness	Central government Funding bodies Auditors Inspectors	To demonstrate value for money To demonstrate effectiveness

3.3. Cost Factors

Many countries try to set up life long learning systems and have encountered the common problem that only when low-cost distance education gains ground, will life long learning systems be possible [7]. Hodgson [13] develops points which illustrate that the nature of current debates on lifelong learning is very much preoccupied with economic outcomes from learning. However, Calder [14] reminds that while costs can reduce dramatically with high student numbers, at some point the question of output and achievement starts to be raised. It is a source of concern in that the development and introduction of many open and distance learning initiatives is driven by a desire to achieve simple low cost solutions to complex social and economic problems. In such contexts, the quality of the provision appears often as a fragile afterthought rather than as fundamental to its development.

4. System set up in some developing countries

According to Bax and Hassan [15] there are two main reasons why lifelong learning is becoming very important to Malaysia. Firstly, it can be attributed to the pressures of globalisation and rapid technological changes. Increased globalisation and interdependency of national economies, helped by the worldwide removal of trade barriers and the lowering of transportation costs, have put Malaysia in the homogenised international system of processes and transactions and a global structure of economic competition. The new social and economic arrangements have inevitably affected Malaysia. Manufacturing and the services sector are the major contributors to growth of the Malaysian economy. As a result, Malaysia is moving towards a more knowledge-intensive economy, focusing less on the manufacture of labour intensive mass products, and instead, emphasizing more on the production of high-quality products and services requiring knowledge inputs.

Secondly, it is due to Malaysia's changing demography. Malaysian population is expected to increase to 28.9 million in 2010 and the working age group (15-64) is expected to increase to 65.7 per cent of this [15]. The median age of the population in 2000 was 23.9 years and will increase to 26.7 years for the year 2010, indicating that Malaysia continues to have a young population age structure. The growth in the working age population also implies the need to create more employment and training opportunities for this group However, in 2000, only fourteen percent of the labour force in Malaysia possess tertiary education qualifications and this will have to be significantly increased in order to meet the needs of a knowledge-based economy.

Dharam Singh [16] states that, only a small fraction of any nation has the privilege to graduate from the higher education. He quoted that more than 80% of the Malaysian working adult population does not own a degree. His reasons are:

i. the traditional universities simply cannot cater the demands of the people due to the various constrains inherent in the system.
ii. the resources are limited as long as the conventional delivery system remains.
iii. a significant majority of the population especially those who missed their chance at entering university after schooling, do not meet the minimum entry criteria set by higher learning institutions.
iv. family constraints or economic background.

The Fifth Malaysia Plan covered the period 1986 to 1990 resolve to intensify efforts at retraining and skills upgrading of the existing workforce to address the challenges of new technology. For the Sixth Plan the country's National Skill Certification System was reviewed to ensure a more coordinated and integrated approach in the education delivery system. The review aimed to achieve amongst others the promotion of lifelong learning and upward mobility for the skilled workforce in the country placing emphasis on the achievement of previously acquired competencies, including prior work experience and on-the-job training. The Seventh Malaysia Plan introduced the National Vocational Training Council (NVTC) introduced the Accreditation of Prior Achievement (APA) approach in September 1996. The APA became part of the overall National Skill Certification System and allowed the existing work force to obtain formal certification namely, the Malaysian Skill Certificates. From thereon, the skilled worker could pursue through the formal process of education skill-based careers at higher skill levels for better status and remuneration. The APA is a strategy to facilitate working individuals to continuously undergo training and lifelong learning.

The Ministry of Human Resource established the Skills Development Fund (SDF) to assist those in need of financial assistance to undergo training. The fund caters for the needs of school leavers intending to pursue skill-based careers recognised by the NVTC. The financial assistance is also available for those intending to undergo training on a part-time basis. In 2004, a total of 460,651 training places with financial assistance of more than RM200 million was approved by the government [17].

Singapore announced the setting up of its system called the School of Lifelong Learning in 1999 [4] to help workers to study the labour market, invest wisely in continuing education, sell their skills to employers and enhance their careers. The system has five inter-connected and mutually enhancing elements comprising skills standards and recognition, incentives, information provision, learning infrastructure and promotion. The system is driven by partnerships to promote shared responsibility and personal commitment among individuals, employers, unions, community groups and the government. Its Ministry of Manpower (MOM) organised movement aims to imbue in Singaporeans the spirit of continuous learning and improvement so as to achieve lifelong employability. In August 2000, Singapore announced a S$5 billion Lifelong Learning Fund. The Fund signals the Singapore's Government strong emphasis on Lifelong Learning to support training programmes for workers and create more learning opportunities for individuals, particularly in courses to certify workers for enhanced employability.

In Thailand as part of the Lifelong Learning effort, the Ministry of Labour and Social Welfare and the Ministry of Education set up a system for transferring credit between skills and basic knowledge. The National Skill Certification System was established in 1971 and this system allows those who complete the programme be awarded higher certificates up to the degree level [4].

5. Discussion

The lifelong learning industry in developing countries is relatively new. Taking Malaysia as example, the list of training providers provided by the Human Resource Development Berhad (HRDB) [18] is fast expanding signaling the size of demand for lifelong learning. Competition among training providers is inevitable thus creating a myriad of business approaches to investment in lifelong learning. Opportunists overnight training providers joined the market many chaotic situations.

Based on the author's own observation the following scenario are evident. Firstly, training providers operate in new forms of organisation. There can be a case where a provider is a one-man registered company with no teaching staff, no offices and classrooms, no teaching materials and no teaching timetables. The owner twinned the company to a university and proposed a business plan, obtained automatic recognition via the university, started making telephone call to friends and lecturers around the country and appoints them as trainers and approach employers to market what is claimed to be tailor-made executive diploma package. There can also be a case where the one-man company is headed by a fresh graduate who successfully twinned the company with the university he was 'politically' active and graduated from to obtain easy recognition. Both could easily mislead the clients by inviting some professors from the university to his presentation sessions prepared for the potential clients.

Secondly, most small-timer but very active training providers only employ part-time trainers whose prime responsibilities are towards their true employers. They include professionals who are non academicians. Hooked to the monetary offer made by the training providers the part-timers need to prepare the teaching materials for the supposedly tailor-made syllabuses in between time. Little or no time is available for them to understudy the actual requirement of the learners. Obviously this will result in varying quality of materials produced and delivery methods. Their second employers are of course not in the position to check or evaluate their works.

Thirdly, overnight small-timer training providers did not have the instrument to effectively screen the qualification of new entries. Employers interested in their executive diploma packages discuss the proposal for a group of employees with varying level of academic qualification and professional experience. Training providers who have no instrument to filter the applications are more focused on getting the deal. Non-eligible applicants may finally be enrolled all to the disadvantage of the applicants themselves as well as the trainers. Trainers may be forced to moderate their evaluation standards so as to entertain these unqualified candidates and these non-learners might finally be forced to leave the training prematurely.

Fourthly, in trying to compromise with trainees tight day-to-day responsibilities at their job's place, training providers scheduled their training sessions in odd hours. Weekends are their favourites and sessions are stretched to late evening. Teaching and learning qualities could be seriously affected since both trainers and trainees will prefer to compress the timetable so that they can have that little time left with their families. The disadvantage will finally be on the trainees themselves as well as their employers who pay for the training.

Last but not least overnight training providers do not have the capability to keep and update proper records and database on their students. They have the tendency to depend on their twinned partners and as such they are only acting as training brokers. They are profit oriented certificate-granting companies standing outside the usual quality-coordinated education service systems. Students are not provided with other academic related services like counseling and health and recreational privileges. They would not have the time for those services but to problematic students such services may prove vital.

6. Closing

Lifelong learning industry in developing countries is new and fast growing and the opportunities for investors to participate as training providers are fully facilitated. The very nature of lifelong learning means that the boundaries to the 'field' are still changing and look likely to continue to change. Individuals and employers as clients on the demand side of the industry and training providers on the supply side should have been fully regulated so that quality could be maintained. However, at this stage the market is flooded with very active overnight small-timer training providers who are profit oriented certificate-granting education brokers. They operate with no physical infrastructure, no full-time training staff and no proper organization. They managed to twin themselves with universities who recognized the certificates awarded. The twinning arrangement failed to address quality and coordination tasks on many operating details including teaching and learning methods, learning materials, training schedules and students' affairs. They managed to draw lifelong learners away from institutions of higher education. Their lack of commitment is to the disadvantage of the trainees, the trainers and the regulating system as a whole.

References

1. Anon. (2007), Lifelong Learning, Wikipedia Foundation Inc., 01:41, 9 August, http://en.wikipedia.org/wiki/Lifelong_education
2. Haggstrom, B. M., (2004), The Role of Libraries in Lifelong Learning, Final report of the IFLA project under the Section for Public Libraries
3. Holmberg, B. (1986). Growth and structure of distance education. London: Croom Helm
4. ASEM, (2002), Thematic Report 2, Integrated Approaches in Lifelong Learning and Recognition of Prior Learning,
5. European Commission, (2002), European Report on uality Indicators of Lifelong Learning, Fifteen Quality Indicators, Directorate-General for Education and Culture, The European Commission, Brussels, June
6. Gan, S. L., (2005), A Closer Look At Lifelong Learning, The Star Online, May 1st.
7. Wei, Y., Y. Kang. Wang, Z & Huang, J (1998), The Information Institute of Hainan University, HaiKou, Hai Nan Province 570228, China,
8. Edwards, R. (1997). Changing Places? Flexibility, lifelong learning and a learning society. London and New York, Routledge.
9. Anon. (2007), The Lifelong Learning Strategy for Scotland, The Scottish Government Publication, http://www.scotland.gov.uk/Publications/2003/02/16308/17752, 6th November
10. Anon. (2007), Investor in Careers Assessment Criteria for Training Providers, Connexions Cornwall and Devon Ltd, UK, January
11. Amstrong, P., (2002), Never Mind the Quality, Measure the Length: Issues for Lifelong Learning, Berkbeck College, University of London, http://www.open.ac.uk/lifelong-learning/papers/3937C6F7-0005-6542-0000015700000157_PaulArmstrongPaper.doc
12. Heinrich and Tomoana, 2004, Demand-side factorsin adult foundation learning programmes: A review of international literature, Department of Labour, Australia, http://64.233.167.104/search?q=cache:0VEmqB8St_QJ:www.dol.govt.nz/PDFs/AdultFoundationLearning.pdf+lifelong+learning+demand+factors&hl=en&ct=clnk&cd=6&gl=my, 6th November
13. Hodgson, A. (2000) "The Challenge of Widening Participation in Lifelong Learning" in *Policies, Politics and the Future of Lifelong Learning* (Ed.) Hodgson, A. London, Kogan Page
14. Calder, J., (2000), Beauty Lies In The Eyes Of The Beholder, International Review of Research in Open and Distance Learning, Vol. 1, No. 1, June
15. Bax, M. R. N. and Hassan, M. N. A., (2003), Lifelong Learning in Malaysia, International Policy Seminar Co-organised by IIEP/UNESCO and KRIVET, Seoul, 24-26 June 2003
16. Dharam Singh, H. K., (2007), Lifelong Learning through Recognition of Prior Learning, Open University Malaysia, 20th August, http://www.oum.edu.my/portal/index.php?op=view&m=22&page=151
17. Kanapathy, V., (2006), International Migration and Labour Market Development in Asia: Fine Tuning te Policy and Institutional Framework for Managing Cross-Border Labour Flows, Workshop on International Migration and Labour Markets in Asia organized by the Japan Institute of Labour (JIL), Tokyo, Japan, February 17)
18. Anon. (2007), http://www.trainingmalaysia.com/v4/provider/prov_hrdb.php?type=H, 6th Nov.

Incorporating the Systems Approach in the Undergraduate Chemical Engineering Curricula via Process Simulation Exercises

Cheng Seong Khor [a], **Ali Elkamel** [b], **William A. Anderson** [b]

[a] *Chemical Engineering Department, Universiti Teknologi PETRONAS, Bandar Seri Iskandar, 31750 Tronoh, Perak, Malaysia*
[b] *Department of Chemical Engineering, University of Waterloo, Ontario, Canada N2L 3G1*

Abstract

In this work, we explicitly incorporate the principles espoused by the systems approach as an essential component in the ongoing movement to revamp the undergraduate chemical engineering curricula in response to major transformations that have taken place within the field and the profession. We propose to accomplish this goal by enhancing the use of commercial process simulators in classroom instructions in the form of process simulation computer laboratory exercises, in order to complement the traditional lecture format mode of teaching, by implementing the approach on a separation processes course. This work is significant judging by the value of incorporating such an industrially-relevant tool in the training of tomorrow's chemical engineers, thus providing enough incentive to develop more of such high quality educational materials.

Keywords: chemical engineering education; chemical engineering curriculum/curricula; systems approach; process simulation; process simulator; Aspen

1. Motivation: Why the Need Now for the Systems Approach in Undergraduate Chemical Engineering Curricula

In the past five years or so, there has been a great surge of efforts to restructure the chemical engineering curricula in order to move with time; even more so, to possibly stay ahead of time in anticipation of emerging trends and disruptive changes. This endeavour is of immense importance to ensure that the chemical engineering higher education enterprise can constantly meet the needs of the industry and thus, maintain the relevance of the academia in carrying out its core role as the chief provider of skilled- and professionally-trained human capital for the future workforce, especially in facing the challenges of the transformed landscape of the chemical engineering profession.

Indeed, the discipline of chemical engineering has experienced dramatic transformations over the past 40 years, most notably in terms of graduate placements and research and development (R&D) activities [1]. In the recent past decade, it has transcended its traditional focus on the oil and gas and petrochemical industry to encroach other fields, which have flourished mainly as the direct or indirect consequences of the Human Genome Project [2] and the resulting increased attention on genomics- and biology-related applications in general.

However, in the midst of all these exciting developments taking place, the same could not be said, rather surprisingly, of the undergraduate chemical engineering education, whose curricula has remained virtually stagnated over this same period of 40 years. This almost deplorable state of affairs has since been given a breath of life with the implementation of the U. S. Accreditation Board for Engineering and Technology or ABET's Engineering Criteria 2000 that stipulates, among others, a need for the integration of disciplinary knowledge within engineering [3]. This statement is targeted at remedying the traditionally segmented approach in chemical engineering pedagogy, in which students misleadingly get accustomed to solving problems within the narrow confines of individual courses, such as thermodynamics problems in the thermodynamics course and heat transfer problems in the heat transfer course, often ending up in the blind spot of not recognizing the interrelationships among the different subjects that collectively make up the field of chemical engineering. The disturbing irony lies in the fact that this approach could not be further than the reality of real-world practice as chemical engineers routinely draw on their integrated knowledge from thermodynamics, heat transfer, and the different disciplines of safety engineering, environmental science, and other relevant areas in solving practical daily problems and challenges. Thus, thermodynamics, heat transfer, and concepts from other domains ought to be seen as engineering applications of universal physical laws, and definitely not as distinct self-sufficient courses taught in different semesters by different instructors using different textbooks and material that are binded together only by the mere hollow notion of an academic study programme. To address this issue, the role of the holistic and integrated paradigm championed by the systems approach emerges as a potential enabling educational concept to be adopted throughout the undergraduate chemical engineering curricula.

2. Problem Statement and Research Objectives

In line with this aspiration, the present work is undertaken with the objective of investigating the viability of implementing the systems approach in the undergraduate curricula via process simulation computer laboratory exercises. To illustrate the proposed initiative, we incorporate such exercises into a traditional lecture-based separation processes course that is typically taken by senior students in the penultimate year.

3. Introduction

3.1 The Systems Approach in Action

Many people have an intuitive idea about the concept generally known as the systems approach. For instance, engineers have been routinely designing and constructing large-scale systems for a long time: cities, roads, dams, factories, chemical plants, dating as far back as to even pyramids, by utilizing the principles that underlie the systems approach. These systems are typically technically-complex and involve complicated man–machine interfaces and interactions. In addition, computer scientists, biologists, economists, sociologists, and even educators have all used the concepts expounded by the systems approach in one form or another.

Indeed, the systems approach has become a permanent feature in modern practices, embedded in a wide range of areas that involve complex technology, in medium-to-large scale organizations, as well as in general affairs. The systems approach has also found applications in non-technical situations and in policy-making decisions; the latter especially in cases that involve large sums of budget for which bad decision-making often entail costly consequences.

3.2. Benefits and Advantages of Implementing the Systems Approach

It has been demonstrated, time and again, that the value in considering a system as a whole is often greater than the sum of the individual parts, as espoused by the very essence of the principles underlying the systems approach. This statement is a quote that is often attributed to the great Greek philosopher, Aristotle (384–322 BC). On a more concrete level, employing the systems approach enables the conversion of scientific facts and principles of systems into useful and impactful engineering decisions [4, 5]. In the course of attaining this, the systems approach aims to seek an overall balance among the alternative choices of possible outcomes [6]. This is accomplished by replacing unscientific mere “guess work” with theoretically- and practically-sound systematic model building and mathematical optimization tools.

Within the field of chemical engineering, Armstrong [1] and Edgar et al. [7] assert that given the right emphasis, the systems approach component of the chemical engineering curricula ensures that the students would be able to realize the following learning goals, and consequently undertake the associated tasks as they enter the workforce upon graduation:

- create and understand mathematical descriptions of physical phenomena;
- scale variables and perform order-of-magnitude analysis;
- structure and solve complex problems;
- develop estimates and assumptions in facing open-ended problems;
- manage large amounts of messy and noisy data including missing data and information;
- resolve complex and sometimes contradictory issues in process design involving sensitivity of solutions to the assumptions made, uncertainty in data, “what-if” questions and possibilities, and process optimization in general; and
- perform economic analyses.

3.3. Principles of the Systems Approach

The major principles of the systems approach are embodied in the term itself. A *system* refers to a collection of different elements in regular interaction with at least one other element, forming a new whole with properties that are different from the individual constituents and which produces results that are not obtainable by considering the elements alone [8]. The *systems approach* implies a consideration of all aspects of a system as a whole, employing a holistic view instead of a reductionistic view, in which the undesirable latter is also referred to as a “piecemeal” or “compartmentalized” approach in one of the landmark articles on this subject by Jenkins [9]. The systems approach emphasizes an overall performance or outcome of a system by analyzing the interactions and interrelationships among all aspects of the system, i.e., the subsystems, as well as between the subsystems and the larger environment in which the system resides [8, 10]. In his now classic paper, Jenkins [9] further elaborates the systems approach as the science of designing and operating complex systems by efficiently making use of resources that are conveniently abbreviated as 4*M*: *men* (indicating human supply which provides information and decision), *money*, *machines* (representing energy), and *materials*.

3.4. Applications of the Systems Approach

As previously emphasized, the applications of the systems approach pervade almost every facet of our increasingly complex modern living. For the convenience of generalization, the partial list in Table 1 broadly divides the main areas that have benefited enormously from the systems approach into the realms of engineering, business, and last but not least, the public policy and social systems.

It is noteworthy that the concept and impact of the systems approach are not confined to the field of engineering alone, as it has frequently been associated with. Pertaining to this point, the term "Soft Systems Methodology" [11] has been coined to refer to an alternative version of the systems approach for application in non-technical complex problem situations; in fact, these problems tend to exhibit an even higher degree of disorderliness when compared to its more structured technical counterpart such as those often found in engineering-type problems.

Table 1. Applications of the systems approach in engineering, business, and public policy and social systems

Engineering	• Oil (petroleum) refineries • Electric power plants • Transportation systems • Automobile assembly plants • Weather satellites • Clinical information systems
Business	• Corporate planning systems • Human resource development
Public Policy & Social Systems	Regional development systems, e.g., city administration and urban planning

4. Current Status of the Systems Approach in the Undergraduate Chemical Engineering Curricula

The systems approach has also recently gained resurgence in prominence as a result of being rightfully identified as one of the three organizing principles (besides the other two principles of molecular transformations and multiscale analysis) in the Frontiers in Chemical Engineering Education (FCEE) initiative spearheaded by the Massachusetts Institute of Technology (MIT) [1, 4, 5]. The FCEE project is a series of workshops funded by the U. S. National Science Foundation (NSF) and the Council for Chemical Research (CCR) to recognize the opportunities for reform in the present chemical engineering curricula, and to correspondingly devise a master plan to address the subsequent implementation phase. The latter goal is to be achieved by harnessing the power of joint execution among the multitude of departments from different institutions that are involved in the FCEE initiative.

The systems approach has, in fact, always been a fundamental concept in the practice of chemical engineering, with the exposition of its enormous significance dating as far back as to an excellent 1972 perspective paper by Sargent [12], one of the great pioneers of the systems-approach-inspired subarea of process systems engineering, or more popularly referred to by its abbreviation PSE. While the findings from the FCEE workshops amply support the aforementioned view that the traditional chemical engineering focus on petrochemicals has evolved into other so-called frontier areas such as microelectronics, pharmaceuticals (medicine), biotechnology, nanotechnology, specialty polymers, novel materials, and chip manufacturing [13], it has not altered the fact that the systems approach continues to play a critical role for both the traditional and frontier areas of chemical engineering, as duly asserted in the initial proposal by the FCEE [4]. This conviction has been reaffirmed, for instance, in a recent article by Edgar et al. [7].

However, disappointingly, the concept of the systems approach has so far been explicitly addressed traditionally only in the capstone senior plant design course, which is typically taken by undergraduates in their final semester/term. The emerging concepts of molecular biochemistry and cellular biology, coupled with the expanding tools of molecular modelling and the increased sophistication in computational techniques, has called for a concomitant change and expansion of the current systems tools that are available in chemical engineering [4]. This present exciting developments engulfing the chemical engineering field have also entailed an increasing need for the integration of the systems approach into the curricula, both horizontally (over time, that is, over an entire chemical engineering programme) as well as vertically (that is, over courses that are typically taken at the same time).

5. Why Use Process Simulation to Implement the Systems Approach in the Undergraduate Curricula

The advent of the modern digital computers and the advancement in modelling and computational techniques has enabled the quantitative predictions of the behaviour of complex systems as a whole entity. Thus, this has prompted the adoption of computer-aided process design programs, often referred to as *process simulators* (or variably as *flowsheet simulators* or *flowsheet packages*) as a systems tool for training chemical engineering undergraduates

[14]. Another equally important motivation for bringing the process simulator into the classroom is because simulators have become increasingly commonly utilized in real-world chemical engineering industrial practice to perform various tasks involving systems analysis and synthesis.

Some of the leading commercial process simulation software packages today include Aspen Plus® (now known as aspenONE®), HYSYS® (now known as Aspen HYSYS®), CHEMCAD, PRO/II with PROVISION, and SuperPro Designer®. According to Seider et al. [14], it is relatively straightforward to switch from the use of one simulator to another once the principles of process simulation have been understood. Therefore, in a way, the choice of a particular simulator to be adopted mainly depends on a licensing agreement that meets an academic department's budget.

6. Proposed Course Design for Incorporating Process Simulation in the Undergraduate Curricula

6.1. Teaching and Learning Activities to Support the Learning Goals

We apply the integrated approach advocated by Fink [15] in proposing a course design that demonstrate the incorporation of the process simulation computer laboratory exercises into a traditional "straight-lecture"-based course of a typical third-year separation processes course in a four-year undergraduate programme. The Fink's course design model considers four major aspects of instructional design and good teaching in an effort to achieve significant learning experiences, namely: (1) situational factors which encompasses the context of the course, the students, and the instructional challenge involved; (2) learning goals that emphasize higher-level significant learning; (3) teaching and learning activities that promote active learning; and (4) feedback and assessment that are educative-focussed.

The main learning goal of the course is to didactically train students in problem-solving skills through the systematic application of the systems approach and critical systems thinking. To meet the stipulated goal, the teaching and learning activities take the form of *two* three-hour computer laboratory exercises or modules, each structured as follows. In the first hour, the course instructor provides formal instruction on using the simulator, with the students following along on their individual personal computer terminals. (A teaching assistant with adequate knowledge and experience of operating a process simulator can also be expected to perform this task.) Within this setting, the instructor functions both as a facilitator as well as an advisor (or personal tutor) by moving around and interacting openly with the students on a one-on-one or small group basis. In instances where there are common problems and misunderstandings faced by the students, the instructor can switch to delivering a mini lecture to address the issue. Edgar et al. [7] has highlighted the success of such integrated lecture–laboratory instructional approach compared to the traditional lecture mode of teaching, in which it has been revealed in numerous learning and cognitive studies of the enormous benefit in retention of knowledge by students when technology is employed to personalize learning by providing immediate feedback and engaging students via visual content.

In the subsequent second hour, a teaching assistant (TA) supervises hands-on practice for the students (more TAs will be needed in accordance with the number of students in a session). Here, it is important to stress the need for a competent TA who readily moves around the laboratory room to handle expected frustration that typically arises in learning new software, by providing immediate corrective feedback. An even more essential task of the TA is to educate students in the difference between the incorrect uses of the software as opposed to an incorrect understanding in formulating solution to a problem. Otherwise, Edgar et al. [7] have highlighted a major problem concerning TAs who provide inconsistent or wrong advice to students in such a course setting.

The final third hour is an optional self-regulated free practice for the students, in which they are encouraged to help and discuss with each other, and in so doing, achieve independent learning-by-doing, a suggestion reported with considerable success by Wankat [16].

6.2. Feedback and Assessment

The feedback and assessment of the course comprises an ungraded component and a graded component. The former is in the form of an individually-submitted one-to-two page laboratory report on the introductory first module, which is shorter and contains less technically-challenging materials compared to the second module. The intention of having this written assignment is to draw students' attention to identifying and summarizing only the most important results of a simulation study because the output generated by a computer simulator such as Aspen Plus is typically long and dense, and therefore requires some practice and conceptual understanding for the proper interpretation of the simulation results. The reports are stipulated to be due at the end of the laboratory session itself for the purpose of ensuring that students do not unnecessarily spend too much time working on the report, besides minimizing the possibility of students plagiarizing the reports of others especially in the case of students who are absent from a laboratory session.

On the other hand, the graded component of the course involves a fifteen-minute group presentation with five minutes for questions-and-answers on the second longer laboratory module, which concerns the steady-state simulation of the ammonia production process. As a side note, the groups of students are to be selected to be as diverse as possible using the procedures discussed by Wankat [17]. Finally, each student receives a grade that is achieved by his or her group, and this grade accounts for 20 percent of the student's overall course grade.

7. Advantages of Using Process Simulation to Promote the Systems Approach

The main advantage of using a process simulator in promoting the systems approach is its powerful interactive feature that allows students to specify and modify, in real-time, physical properties such as pressure and temperature, chemical properties, and other relevant process parameters of a system being studied. Subsequently, the students can observe the resulting changes not only on the individual unit operations but more importantly, on the overall system behaviour as well as the operating economics, which really are the actual aspects emphasized by the systems approach. Likewise, by using a process simulator, the students can reproduce controlled "misbehaviour" of the system [18] and in so doing, be able to study, understand, and appreciate the effects and impacts of the various process parameters on each and every component of the system.

Process simulators have also proven to be an effective teaching tool to demonstrate a multitude of chemical engineering concepts, primarily the fundamental core principles of the field, namely material and energy balances, thermodynamics (in particular, physical and thermodynamic property analysis, estimation, and regression), reactor design, transport phenomena (heat and mass transfer), multicomponent separations, and process flowsheeting [19, 20]). This point is partially illustrated by the annotated Figure 1 depicting the process flowsheet generated by Aspen Plus for the second laboratory module. Because of this, students are able to gain a big picture of the interrelationships among the concepts that have hitherto been learnt only in separate compartmentalized courses.

Moreover, it has been noted that the extensive use of process simulators can effectively solve the problem of the difficulty of integrating computing tools in the chemical engineering curricula, which is a problem that has been frequently reported by several chemical engineering departments, according to a survey by Edgar [20]. Last but not least, since process simulators are actually utilized in industrial practice, the students learn to appreciate the real-world complexities that entail in the working environment realities of chemical engineers.

8. Disadvantages and Challenges of Using Process Simulation to Promote the Systems Approach in Classroom Instructions

The major and perhaps most distressing disadvantage in utilizing process simulators in a classroom is the tendency of the students to perceive the tool as mere black box models. It has often been lamented that as a result of this misguided perception on the part of the students, process simulations end up becoming plain computing and mathematical exercises with little intuition based on actual knowledge and understanding of the process that is being simulated; instead, giving way to mindless clicking on the icons and entering of input parameters. The challenge, therefore, is for the instructor to ensure that students really learn the basic principles involved in using a simulator to carry out material and energy balances and other types of calculations that are involved throughout the design of chemical processes. In this regard, the instructor should, for instance, constantly remind himself or herself to pay particular attention in explaining to the students, the rationale of the logic of the sequencing of the unit operations based on the functions that the process units perform in the overall scheme of a process.

In addition, it is also difficult sometimes to explain the reasons for non-converging unsuccessful simulation procedures because these typically involve intricate algorithms and mathematical concepts that are usually superior to students' knowledge base. Wankat [16] also highlights the need for paying attention to minimizing the teaching time of using simulators to the students by imparting instructions only on the essential workings of the software, while leaving the details and higher capabilities of the tool for the students to explore on their own. In light of the latter, the students ought to be constantly reminded of the powerful tool that a process simulator is, which would hopefully spark the students' enthusiasm to continually acquire increasing adeptness at using it—a skill that will prove to be essential in the students' eventual careers as chemical engineers.

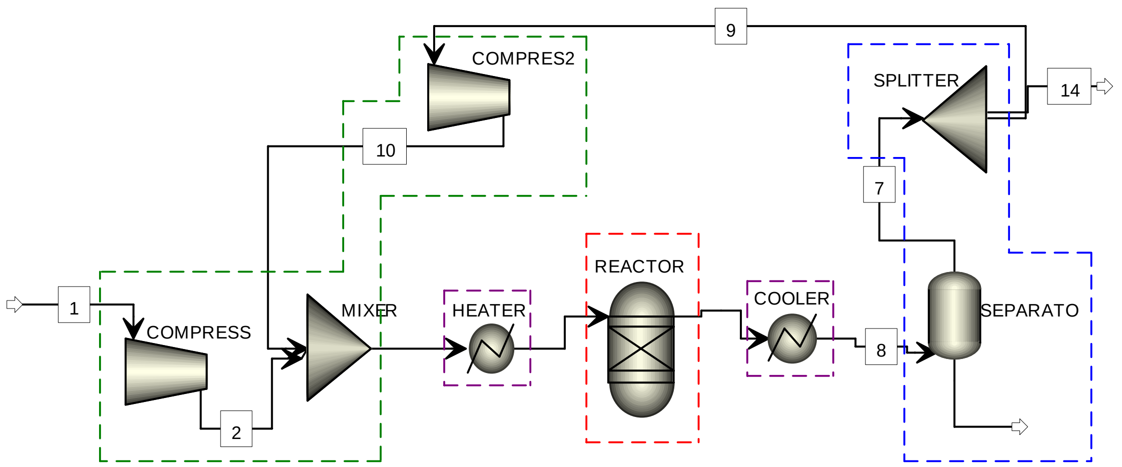

Fig. 1. The process flowsheet generated using the process simulator Aspen Plus for the second laboratory module on the steady-state simulation of the ammonia production process, with labels depicting unit operations that correspond to the different courses in a typical undergraduate chemical engineering curriculum.

Heat
Transfer

Fluid Mechanics/
Transport Phenomena

Rea

9. Current and Future Work

The current work in progress is to improve and refine the existing simulation modules with the following objectives that are in line with good teaching practices:

- to provide clearer learning or instructional objectives (whose importance is stressed by Felder and Brent [21]);
- to increase the variety of the delivery mode and feedback and assessment strategies, in tandem with the aim of catering to a wider spectrum of the learning styles of the students (in accordance with the momentous study on teaching and learning styles in engineering education by Felder and Silverman [22]).

Additionally, due to the possibility of the underpinning concepts on the workings of the simulators appearing to be overwhelming especially to the younger students in the first- or second-year of undergraduate studies, it has been highlighted of the need to match the level of the simulator use to the students' knowledge base [19, 20]

The future work on increasing the application of the systems approach in the chemical engineering curricula through the use of process simulation laboratory exercises as a part of traditional lecture-based courses, would naturally be to continue to develop more such modules that are rich in educational values. This is also in support of the move aligned towards producing more graduates that are industry-ready to face the tomorrow challenges of a highly-dynamic field such as chemical engineering.

10. Conclusions

The systems approach is unarguably a fundamental and critical concept in chemical engineering. Therefore, it needs to be explicitly addressed and integrated both horizontally and vertically in the chemical engineering curricula. To accomplish this goal, this article has proposed the development of laboratory exercises in the form of computer-assisted process simulation modules. These educational materials should be developed in increasing quantity and quality to augment the limited number of such resources at our disposal, in an effort to revamp, retool, and rejuvenate a curriculum that is in dire need of moving in concert with the wave of change in real-world chemical engineering practice.

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References

1. R. C. Armstrong, A vision of the curriculum of the future, Chem. Eng. Edu. 40 (2006) 104–109.
2. J. Enriquez, As the Future Catches You: How Genomics and Other Forces are Changing Your Life, Work, Health, and Wealth, Crown Business, New York, 2001.
3. A. Rugarcia, A., R. M. Felder, D. R. Woods, J. E. Stice, The future of engineering education—I: A vision for a new century, Chem. Eng. Edu. 34 (2000) 16–25.
4. Frontiers in Chemical Engineering Education, July 2003, 2003 July proposal to the National Science Foundation (NSF) [textfile], retrieved May 10, 2006 from the World Wide Web: http://mit.edu/che-curriculum/statements/NSF_proposal.pdf
5. Frontiers in Chemical Engineering Education, July 2003, New Directions and Opportunities—Creating the Future [online Microsoft PowerPoint file], retrieved May 10, 2006 from the World Wide Web: http://mit.edu/che-curriculum/statements/RCA_NSF_ChE_Frontiers_Overview.pdf
6. A. Kossiakoff, W. N. Sweet, Systems Engineering Principles and Practice, Wiley–Interscience, Hoboken, New Jersey, 2003.
7. T. F. Edgar, B. A. Ogunnaike, J. J. Downs, K. R. Muske, B. W. Bequette, Renovating the undergraduate process control course, Comp. Chem. Eng. 30 (2006) 1749–1762.
8. B. Thomé, Definition and scope of systems engineering, in B. Thomé, B. (ed), Systems Engineering: Principles and Practice of Computer-Based Systems Engineering, Wiley, Chichester, West Sussex, England, UK, 1993.
9. G. M. Jenkins, The systems approach, J. Syst. Eng. 1 (1969) 3–49.
10. C. W. Churchman, The Systems Approach, Laurel, New York, 1968.

11. P. B. Checkland, Systems Thinking. Systems Practice: Includes a 30-Year Retrospective, Wiley, Chichester, New York, Brisbane, Toronto, 1999.
12. R. W. H. Sargent, Forecasts and trends in systems engineering, Chem. Eng. 274 (1972) 226– 230.
13. E. L. Cussler, A different chemical industry, Chem. Eng. Edu. 40 (2006) 114–115.
14. W. D. Seider, J. D. Seader, D. R. Lewin, Product and Process Design Principles: Synthesis, Analysis, and Evaluation, Wiley, New York, 2004.
15. L. Dee Fink, Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses, Jossey-Bass Publishers, San Francisco, California , 2003.
16. Phillip C. Wankat, 2002, Integrating the use of commercial simulators into lecture courses [textfile], retrieved February 10, 2007 from the World Wide Web: http://www.che.utexas.edu/cache/newsletters/spring2002_integrating.pdf
17. Phillip C. Wankat, Reflective analysis of student learning in a sophomore engineering course, J Eng. Edu. 88 (1999) 195–203.
18. R. S. H. Mah, D. M. Himmelblau, Role and impact of computers in engineering education, in B. Carnahan, (ed), Computers in Chemical Engineering Education, CACHE, Austin, Texas, 1996.
19. CACHE (Computer Aids for Chemical Engineering Education) Corporation, 2004, Computing through the curriculum: an integrated approach for chemical engineering [textfile], retrieved July 11, 2006 from the World Wide Web: http://www.che.utexas.edu/cache/Edgar-computing%20through.html
20. T.F. Edgar, (corresponding author), Enhancing the undergraduate computing experience, Chem. Eng. Edu. 40 (2006) 231–238.
21. R. M. Felder, R. Brent. How to teach (almost) anybody (almost) anything, Chem. Eng. Edu. 40 (2006) 173–174.
22. R. M. Felder, L. K. Silverman, Learning and teaching styles in engineering education, J. Eng. Edu. 78 (1988) 674–681.

Student-Centred learning in UMP: e-Community as a helper

Abdullah Ibrahim[a], Aini Ahmad[b]

[a]Faculty of Electrical & Electronics Engineering, Universiti Malaysia Pahang
[b]Centre for Modern Languages & Human Sciences, Universiti Malaysia Pahang

Abstract

This paper is aimed at highlighting the importance of varying methods and techniques of teaching and learning, taking student-centred learning as a main approach in teaching engineering education in Universiti Malaysia Pahang (UMP). It highlights the importance of interactive learning in the development of generic skills among students and at the same time taking technology as a helper in educating students, using UMP as a key case study. The effort to embed technology in teaching and learning process has long been discussed and practiced in educational institution. From 'appropriate technology' until its modern application, it has proven its ability in enhancing teaching and learning effectiveness. This is due to the fact that technology plays important role in motivating students in their learning process. Currently, educational organisation pays much emphasis in the development of generic skills in students through their learning processes which can be realised through different approaches one of which is the student-centred learning approach. Computer-based education is apparently popular from primary to higher learning practices because of its ability to promote student-centred learning and at the same time to give multimedia and interactive presentation. More attractively, if teaching and learning is made *on-line* and *web-based*. These advantages have driven UMP to develop *student management system* via *e-community application* to compliment the teaching and learning strategy when it enables the community in UMP to communicate virtually. The system makes teaching management at ease and gives teaching and learning at a colouring pace.

Keywords: e-Community; Student Management System; Student-Centred Learning

1. Introduction

Student-centred learning has been used as a main approach in teaching engineering education in Universiti Malaysia Pahang (UMP). It is an approach that focuses more on the needs of the students rather than lecturers.

The concepts of Student Centered Teaching & Learning Strategies SCTLS are widely accepted and derived from research launched by American institutes of higher education since the 1970s, mainly to address the problem of gradually increasing loss of students in science-related disciplines.

In Student-Centred Learning (SCL) environment, students are required to be active and be responsible in their own learning. Students are given the opportunity to be active and participate in their own learning. They collaborate, demonstrate authentic learning and the most important is students monitor their own learning, understand how knowledge is acquired and develop their own strategies for learning.

In a technical university such as Universiti Malaysia Pahang where most of the students are engineering stream, Student-Centered Learning is popularly accepted and widely practiced. It is widely known also that intranet in campus has become a more important teaching resource. Students will get easy access to information, lecturers can use it as a useful teaching tool to deliver assignments, to assess students and most important to support students individually in real time. In such environment, students are also encouraged to do self access and self directed learning.

2. E-Community and SCL at UMP

The e-community (Fig.1) at UMP is a web-based application and it is part of e-Management System which is designed with combination of technology based system and characteristic of future organization. The e-Management System is an Integrated System where all information comes from the same database (Fig.2).

Computer-based education is apparently popular from primary to higher learning practices because of its ability to promote SCL and at the same time to give multimedia and interactive presentation. In this aspect, UMP has made compulsory to all lecturers using the e-learning application and student management system via e-community application. It is an online and web-based application where the community in UMP can communicate virtually.

In describing how these applications facilitate in SCL approach, it is important to understand the features of those applications. The e-Learning (Fig.3) is an application whereby student can access all information regarding the subject that they are registered with. It is a place where students can obtain lecture notes, additional readings provide by their lecturers, announcements from time to time, assignments, forums and so on. The Student Management System (Fig.4) is a system used by lecturers and administrators to manage timetable, section management, mark distribution, mark entries and so on.

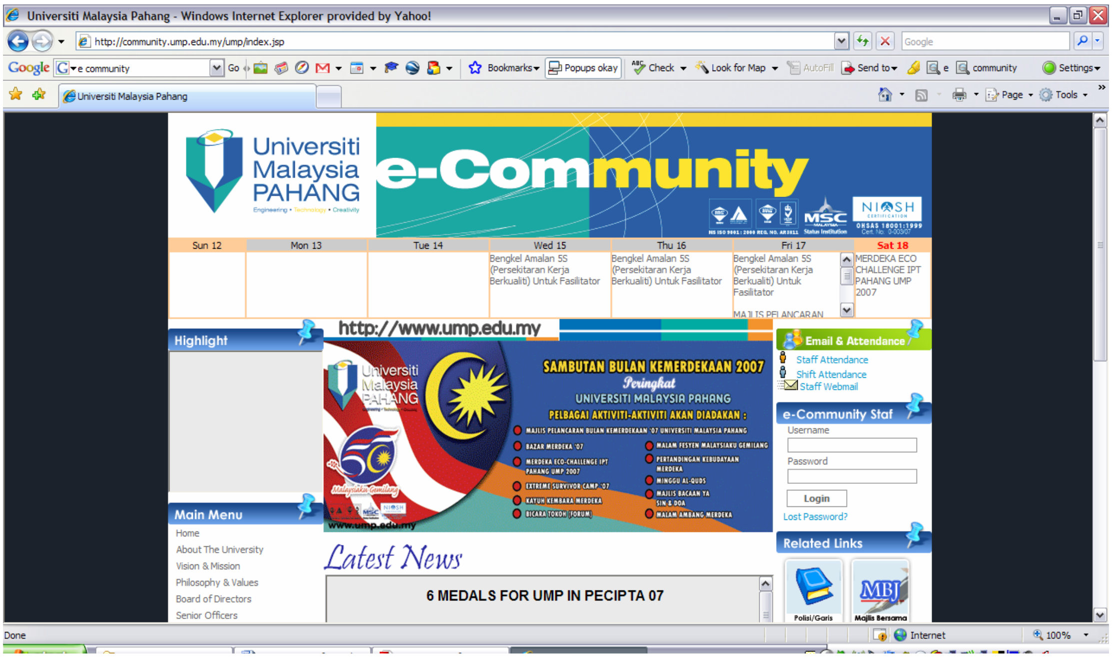

Fig. 1. Front page of web-based UMP e-Community

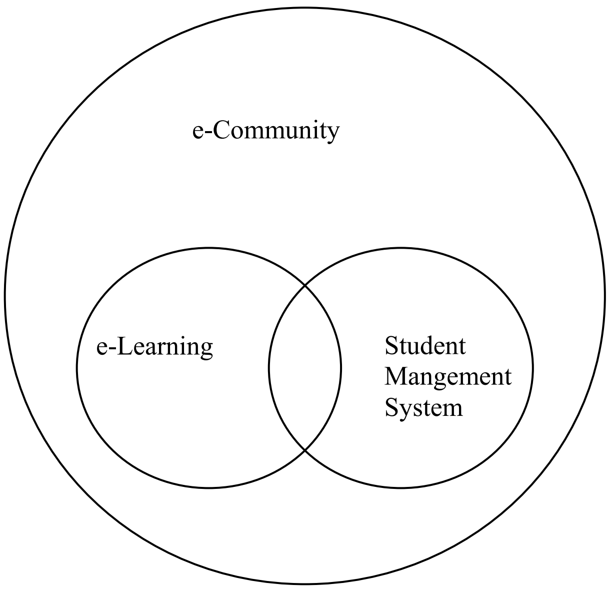

Fig. 2. e-Community, e-Learning and student management system

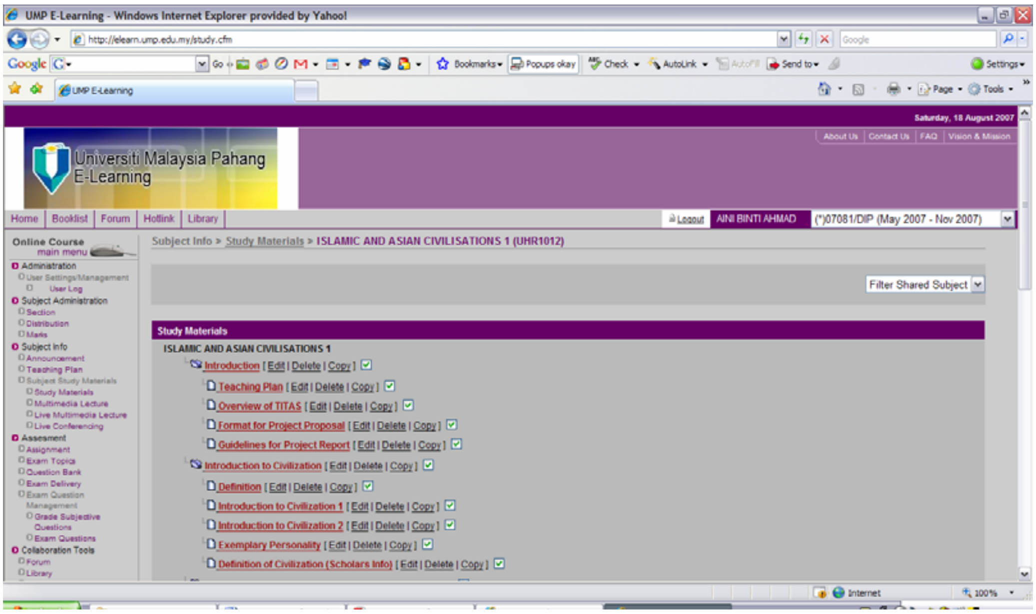

Fig. 3. e-Learning

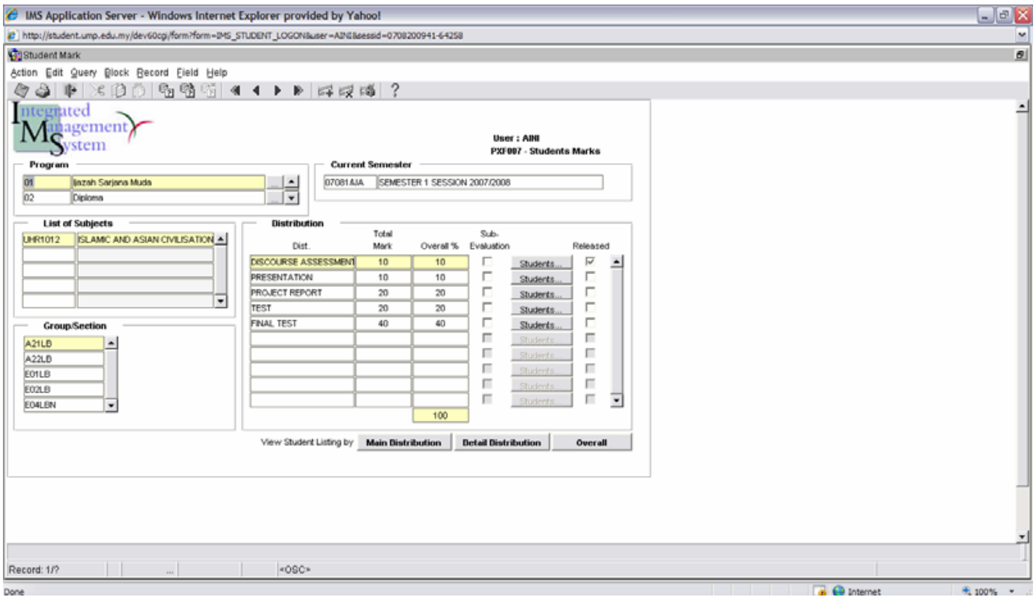

Fig. 4. Student Management System

3. How e-Community facilitates SCL approach

It is a fact that in SCL, students are the active participants in their learning. With e-Community application, every student at UMP has a unique ID to access any information related to his or her study. It is a must for a student to access e-Community in order to get assignments, announcements and even forums related to subject matter. Some lecturers use interactive multimedia presentation for self-access study and there are also other additional reading listed by the lecturers that can be accessed by the students. Different learning styles will also encourage interest and curiosity in student thus promotes creativity and innovativeness.

Another characteristics of SCL is students make decisions about what they will learn and how. Through e-Community, students can easily choose the time and space suitable for them. Students construct new knowledge and skills by building on their current knowledge and skills without spoon-fed element in it. They are free to browse any links that associated with the subjects. Furthermore, the e-Library which provides e-books, e-journals and other online databases are also there, again accessible through e-Community. In physical class, where SCL is also practiced, students will be asked about what they have learnt by themselves and there is where students understand expectations and are encouraged to use self-assessment measures.

In a forum that can be found in e-Learning application, students can discuss issues and they work in collaboration with other learners and their lecturers – another element of SCL. Students make their own journey in knowledge construction and make sense out of it. Teachers can recognize different learning styles by looking at report that can be generated from the system. In all, the e-Community application is undoubtedly assist and facilitate SCL approach at UMP. Table 1 illustrate the characteristics of SCL and its application in e-community.

Table 1. SCL characteristics and e-Community application

CHARACTERISTICS OF SCL	e-Community Application
Students are active participants in their learning	√
Students make decisions about what they will learn and how	√
Students construct new knowledge and skills by building on their current knowledge and skills	√
Students understand expectations and are encouraged to use self-assessment measures	√
Students work in collaboration with other learners	√
Students demonstrate authentic learning	√
Teachers recognize different learning styles	√
Teachers help students work through difficulties by asking open-ended questions to guide the student so that they arrive at a conclusion or solution that is satisfactory to them	√
Learning is an active search for meaning by the learner;-constructing knowledge rather than passively receiving it, shaping as well as being shaped by experiences	√
Students monitor their own learning, to understand how knowledge is acquired, and to develop strategies for learning	√
Students are intrinsically motivated to reach goals they have set for themselves	√
Students make decisions about group membership; who they will work with and how	√

4. Generic skills through SCL

The concept of generic skills or soft skills refers to the ability of the graduates to work independently and confidently in facing various uncertainties in the business and working environment. Soft Skills assessment is a must at UMP and every student will be evaluated on their competencies from certain aspects of Soft Skills elements namely leadership skills, team working skills, positive values, communication skills and learning capability. All UMP students will be evaluated every semester by various departments for their Soft Skills competencies (Fig.5). The evaluation will be done based on observation and student’s performance throughout the semester.

The e-Community provides excellent facility for lecturers to evaluate each student individually. Since students are aware that their performance, behavior, moral and ethics are to be assessed by every lecturer, they are at all time had to keep their generic skill at accepted level of competency. Evaluation of team working skills for example, will be evaluated based on student’s role and contribution and able to work in group in their group project. This aspect is very much in accordance with the SCL concept. Furthermore, students can always access their Soft Skills result from their e-Community which again promote self-access and students become active participant in their learning activity (Fig.6).

5. Conclusion

The application of technology using e-Community system makes learning in UMP more student-oriented. As such, student-centred learning approach can be implemented properly with the help of this technology when it always gives students the opportunity to participate actively in their learning process. The e-Community system in UMP can be a smart teaching tool when most of the time it gives a chance for students to promote their creativity and innovativeness. Students learning activities and performance can be monitored and assessed via e-Community system. The system also gives students the opportunity to communicate virtually with their lecturers as well as their colleagues.

Despite these advantages, technology may sometimes hinder the process due to faulty system. The university therefore, has to ensure continuous supervision is given to the e-Community system as to keep it at a maximum efficiency.

References

1. Aini Ahmad, Anita Abdul Rani, Haslinda Hashim, Muhammad Nubli Abd Wahab. ”Program Soft Skills Dan Klinik Soft Skills: Konsep Dan Kaedah Pelaksanaan Ke Arah Membentuk Sikap Graduan Berdaya Saing”. *Seminar Sains, Teknologi dan Sains Sosial,* Mei 2006, Kuantan.
2. Brush, T., Saye J. (2004). “Supporting learners in technology-enhanced student-centred learning environments”. *International Journal of Learning Technology,* Vol. 1, No.2 pp. 191-202
3. Carlile, S., Barnet, S., Sefton, Ann., Uther, James. (1998), “Medical problem based learning supported by intranet technology: a natural student centred approach”, *International Journal of Medical Informatics* 50 pp. 225–233
4. Charles Cheng (2003). “Introducing student-centred teaching strategies to improve Teaching and learning in Theory of Machines and Mechanism”. *The China Papers*, July 2003
5. D. Lont (1999), “Using an intranet to facilitate student-centered learning”, *Journal of Accounting Education* 17 pp. 293-320
6. Eric Y. Lu., Hongyan Ma, Sandra Turner, Wayne Huang. (2007). “Wireless Internet and student-centered learning: A Partial Least-Squares model”, *Computers & Education*, 49, pp. 530-544
7. *Student-centred learning.* (n.d). Retrieved August 1, 2007 from http://en.wikipedia.org/wiki/Student-centred_learning

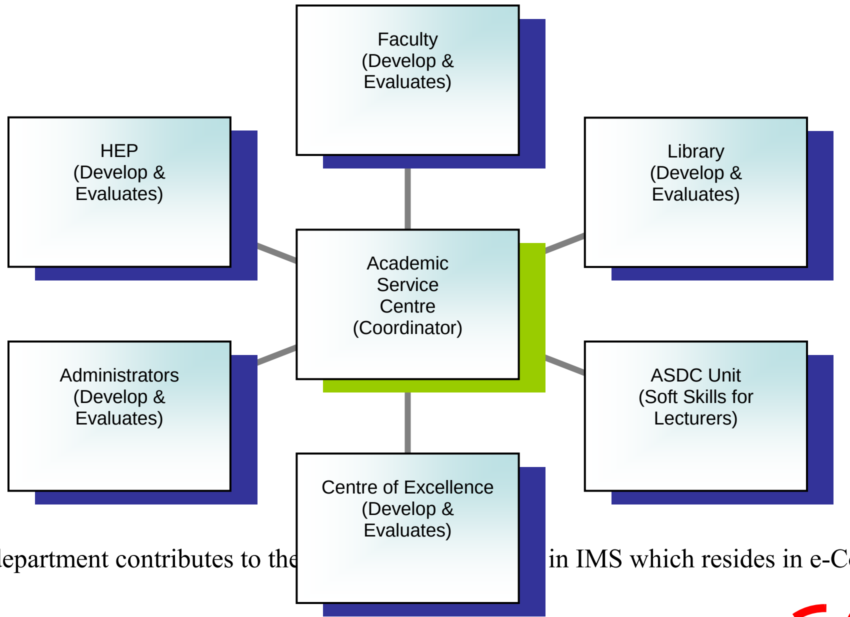

Fig. 5. Every department contributes to the in IMS which resides in e-Community

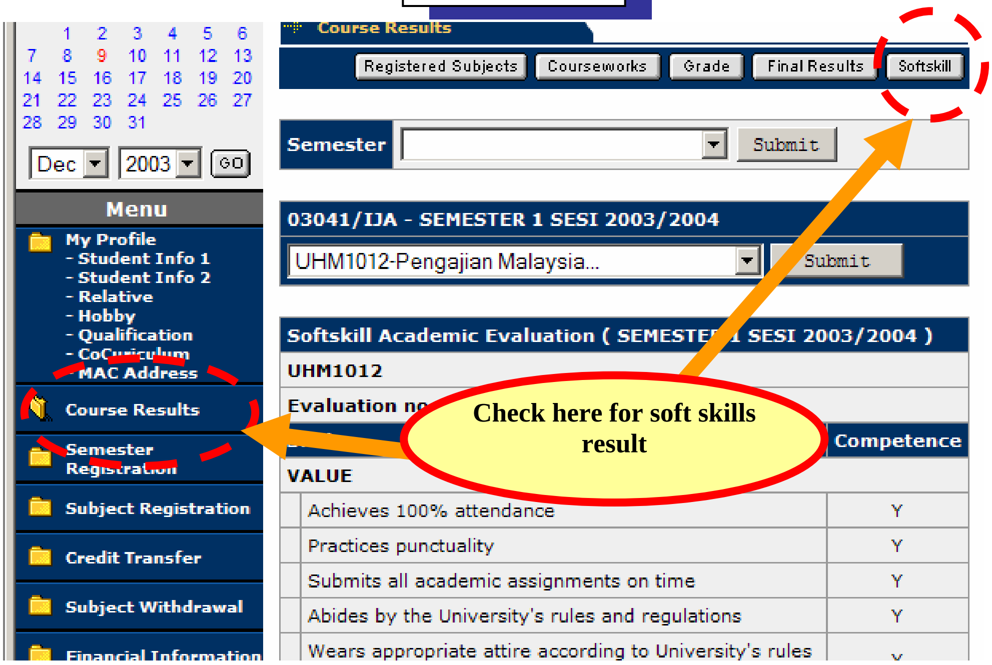

Fig. 6. Soft skill evaluation and result in e-Community

UTM's Experience in Industrial Engineering Education

M. Z. Mat Saman, M. Y. Noordin, M. S. Nabi Baksh

Department of Manufacturing and Industrial Engineering,
Faculty of Mechanical Engineering,
Universiti Teknologi Malaysia,
81310 UTM Skudai, Johor, Malaysia.

Abstract

Industrial Engineering (IE) is a profession that can be counted on for solving complex problems in this highly technological world of the future especially with the rapid advances in the use of automation and other forms of high technology in factories and production systems around the world. Designing a factory of the future is a challenging and complex task because it requires knowledge in fundamental sciences, economics and a broad area of topics concerning the basic principles of production systems. At Universiti Teknologi Malaysia (UTM), IE knowledge is incorporated into the Mechanical Engineering (ME) undergraduate curriculum. It is designed to prepare students to meet the challenges of the future. Many engineering graduates will indeed design modern manufacturing facilities. Besides that, they will also be capable of designing maintenance systems, transportation systems or other systems that provide services. The demand for graduates with IE knowledge is growing each year. In fact, the demand for them greatly exceeds the supply and this situation is expected to continue for many years in the future. This paper highlights the various related issues and how the Mechanical Engineering – Industrial Engineering curriculum being offered at UTM addresses them. Various subjects are designed and developed in such a way that they meet the current requirements and the changing needs of the manufacturing industry.

Keywords: mechanical engineering - industrial engineering curriculum, productivity and quality improvement

1. Introduction

The Institute of Industrial Engineers, the world's largest professional society dedicated solely to the support of the industrial engineering profession, defines IE as a field that is concerned with the design, improvement and installation of integrated systems of people, material, information, equipment and energy. It draws upon specialized knowledge and skills in the mathematical, physical and social sciences, together with the principles and methods of engineering analysis and design to specify, predict and evaluate the results to be obtained from such systems [1].

IE is basically an engineering discipline that designs, plans and implements processes effectively and efficiently. It is among the leading five engineering disciplines. Its graduates work in many areas such as manufacturing and also service industries.

Nowadays, IE is important for Malaysia as it has been voiced in many policy statements and action plans. The country is changing rapidly and engineers need to be prepared to deal with these changes. In relation to these, the Faculty of Mechanical Engineering (FME) at UTM has been offering courses and programs relating to IE since the early 1980s with regular updating being done to cater for the changing needs. Initially, IE is being offered as an option within the ME undergraduate course. Candidates wishing to opt for the IE option will do so at the end of their 3rd year of their 5-year undergraduate course. Subsequently the course was upgraded as a specialization within the ME course. With this upgrading more topics relating to IE was able to be accommodated. In 2004, the 5-year course was revamped into a 4-year course with the new entry requirement based on the STPM and Matriculation qualification. This provided further opportunities to upgrade and improve the course as it has now become necessary for engineers to be trained with greater depth and comprehensiveness in this field to meet the current and future needs of the country.

Hence, this paper highlights various related issues and how the IE specialization is being offered at UTM. Various subjects are designed and developed in such a way that they meet the current requirements and the changing needs of the manufacturing industry.

2. The role of industrial engineers in managing industries

As mentioned earlier, the manufacturing sector is important for Malaysia as proposed in many action plans such as The Ninth Malaysia Plan and IE has a major role in this context [2]. According to the Sloan Career Cornerstone Center [3], Industrial Engineers determine the most effective ways to use the basic factors of production (people, machines, materials, information and energy) to make a product or to provide a service. They are the bridge between management goals and operational performance. They are more concerned with increasing productivity through the management of people, methods of business organization and technology than are engineers in other specialties, who generally work more with products or processes.

Although most industrial engineers work in manufacturing industries, they may also work in consulting services, healthcare and communications. To solve organizational, production and related problems most efficiently, industrial engineers carefully study the product and its requirements, use mathematical methods such as operations research to meet those requirements and also design manufacturing and information systems. They develop management control systems to aid in financial planning and cost analysis and design production planning and control systems to coordinate activities and ensure the quality of products. They also design or improve systems for the physical distribution of goods and services. Industrial engineers determine which plant location has the best combination of raw materials availability, transportation facilities and costs. Industrial engineers use computers for simulations and to control various activities and devices, such as assembly lines and robots. They also develop wage and salary administration systems and job evaluation programs. Many industrial engineers move into management positions because their work is closely related.

Generally, manufacturing has undergone rapid changes in orientation and content. Briefly customers are becoming more discerning and demanding which led to the demand for quality products from quality manufacturers. In addition to the common definition dealing with fitness, reliability, etc., quality now also includes considerations of cost, customization, flexibility and timeliness. Competition is intense and to meet these demands require integrated approaches to both the technologies and the systems for designing, manufacturing, delivering, maintaining and disposing of products.

The technologies and application in manufacturing are evolving faster both in depth and breadth. An example of the problems faced by some of the industries in Malaysia is to improve productivity and quality of the whole plant by integrating advanced equipment from different manufacturers from different countries. This requires engineers that are able to think system-wide, be aware of productivity and quality issues, understand the manufacturing process, be able to extract information electronically from the equipment and be able to use Information Technology techniques to transfer, manipulate and analyze data and control the series of machines. These functions are carried out by Industrial Engineers.

As a country advances to become a more service-based economy, the need for modernizing and improving competitiveness of service organizations is going to become more challenging. Industrial Engineering has been very successful in helping service organizations including hospitals, transport and local governments to become more efficient and competitive.

As described above, IE discipline is one of the critical areas to the economic growth in Malaysia. Currently, the demand for Industrial Engineers is strong and growing each year. In fact, the demand for Industrial Engineers greatly exceeds the supply. This demand or supply imbalance is greater for IE than for any other engineering or science discipline and is projected to exist for many years in the future.

3. Curriculum development for IE education at UTM

IE is a profession that will be counted on for solving complex problems in the highly technological world of the future. Designing a factory of the future is a challenging and complex task; which requires knowledge of fundamental sciences, engineering sciences, behavioral sciences, computer and information sciences, economics and broad array of topics concerning the basic principles of production system [4].

At UTM, the IE specialization curriculum is designed to prepare students to meet the challenges of the future. They will design modern manufacturing facilities, design health care delivery systems, transportation systems or systems that provide service.

The Society of Manufacturing Engineers (SME) [5] suggests that the roles of manufacturing engineers can be called upon to play one of three roles, i.e. technology specialist, operations integrators and manufacturing strategies. Fig. 1 shows these three roles against the dimensions of breadth and depth. There are no clear boundaries and there is considerable overlap between the roles.

Technology specialists are required to address specific problems of manufacturing and engineering in great detail. Also, they are required to provide solutions to manufacturing problems that increasingly require integration of different technologies.

Meanwhile, Operation Integrators are required to ensure that the systems for manufacture operate efficiently and effectively to provide quality goods and services. They interact with many different functions and levels within the organization as shown in Fig. 2. Technology strategists exploit manufacturing systems and technology to gain competitive business advantage.

Based on that, the Mechanical Engineering – Industrial Engineering specialization curriculum has been developed to accommodate these requirements. This curriculum is combination between academic or knowledge skill with generic skill. The generic skills have been identified as necessary to ensure that Mechanical Engineering – Industrial Engineering specialized graduates will be relevant at the local and international level, both currently and in the future.

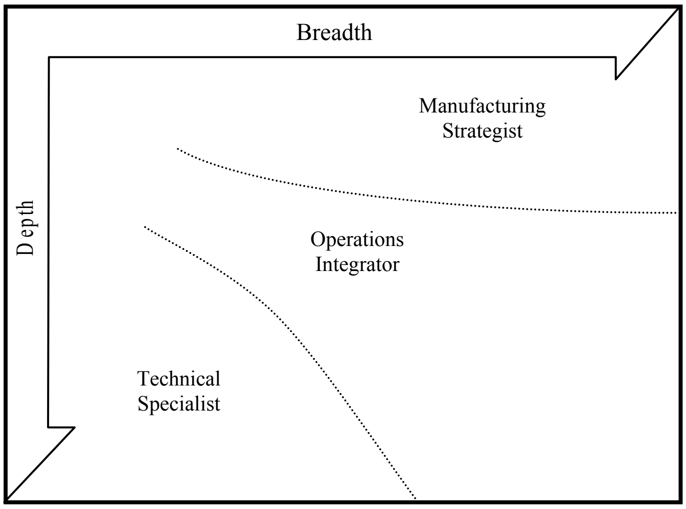

Fig. 1. Roles of Industrial Engineers

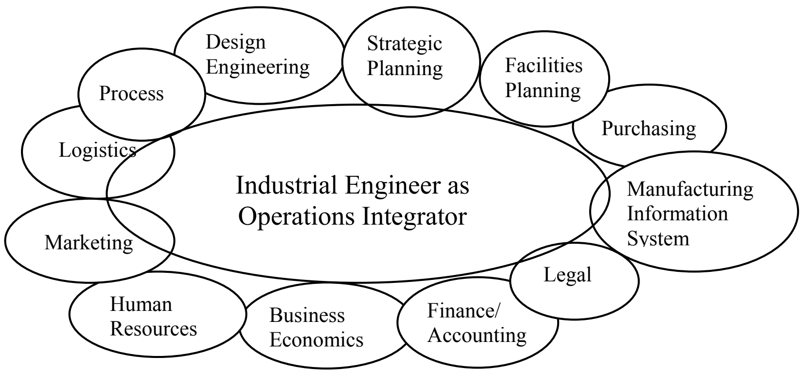

Fig. 2. Role of Operations Integrator

All the subjects were designed significantly to this through the use of proper delivery methods and experiences. These include problem based learning (PBL), Outcome Based Education (OBE), Cooperative Learning (CL), Active Learning (AL), group work and presentation.

Generally, the curriculum for this course can be categorized into various categories and these and their percentages are general university subjects (13%), mathematic and computing (10%), engineering foundation (subjects and laboratories - 38%), Production Engineering (4%), Industrial Engineering (subjects, laboratories and bachelor project – 29%), Engineering Workshop and Industrial Training (5%). The complete curriculum structure is shown in Table 1.

This curriculum structure provides candidates with a strong grounding of ME in the early years of their course. Subsequently subjects in the various areas of IE such as Operations Study, Ergonomics and Safety, Production Planning and Control, Work Study and Facility Planning and Quality Engineering are introduced in the later years in order to enable the students to function effectively in their selected area with minimum further training. The FME has also plans to develop a new course solely on IE in the near future.

4. Conclusion

The 9th Malaysia Plan forecasted a demand increase of 19500 and 15200 for Electrical/Electronic and Mechanical Engineers respectively over the five year plan period. The shortfall is expected to be 2920 and 2080 respectively. It is shows that the demand for such engineers is expected to grow at an even faster rate. Furthermore, the new government policy of shifting away from assembly type of operations to design of products and systems is also expected to fuel this growth. Thus, it can be expected that a large portion of this demand will be for Industrial Engineers.

Acknowledgement

The authors would like to thank everyone who has contributed to the development of the program, especially the faculty members from Department of Manufacturing and Industrial Engineering.

References

1. Institute of Industrial Engineers (website), http:// www.iienet2.org.
2. Ninth Malaysia Plan (website), http://www.utusan.com.my/utusan/SpecialCoverage/RMK9/html/english.htm.
3. Industrial Engineering Overview, Sloan Career Cornerstone Center (website), http://www.careercornerstone.org.
4. W. C. Turner, J. H. Mize, K. E. Case, J. W. Nazemetz, Introduction to Industrial and Systems Engineering, Prentice Hall International, USA, 1993.
5. Society of Manufacturing Engineers (website), http://www.sme.org.

Table 1. IE curriculum structure

Category	Subjects	Sub-credits	Percentage
General University Subjects	English for Academic Communication	18	13
	Advanced English for Academic Communication		
	English Elective		
	Islamic and Asian Civilization		
	Islam and Current Issues		
	Ethnic Relations		
	Humanities Elective		
	Entrepreneurship and Enterprise Development		
	Co-curriculum I		
	Co-curriculum II		
Mathematic and Computing	Calculus	14	10
	Engineering Mathematics		
	Differential Equation		
	Programming for Engineers		
	Data Analysis in Industrial Engineering		
Engineering Foundation	Static	51	38
	Engineering Drawing		
	Material Science		
	Dynamics		
	Fluid Mechanics I		
	Fluid Mechanics II		
	Thermodynamics I		
	Thermodynamics II		
	Solid Mechanics I		
	Solid Mechanics II		
	Vibration and Mechanics of Machine		
	Control Engineering		
	Instrumentation		
	Introduction to Design		
	Component Design		
	Engineering Professional Practice		
	Electrical Technology		
	Electronic		
	Engineering Laboratory I		
	Engineering Laboratory II		
Production Engineering	Manufacturing Processes	5	4
	Advanced Manufacturing Technology		
Industrial Engineering	Productivity and Quality Engineering	39	29
	Work Design		
	Advanced Quality Engineering		
	Deterministic Operations Research		
	Facility Design		
	Production Planning and Control		
	Non-Deterministic Operations Research		
	Ergonomics and Safety		
	Design for Manufacture and Assembly		
	Engineering Economics and Accounting		
	Project management and Maintenance		
	Engineering Laboratory III		
	Engineering Laboratory IV		
	Undergraduate Project I		
	Undergraduate Project II		
Practical	Engineering Workshop (4 weeks)	7	5
	Industrial Training (10 weeks)		
	Total	134	100