A STUDY OF THE EFFECTIVENESS OF THE PETROLEUM ENGINEERING SPECIALIZATION CURRICULUM OFFERED BY THE MECHANICAL ENGINEERING PROGRAM AT UNIVERSITY TECHNOLOGY PETRONAS

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PART A

ABSTRACT

Tertiary education in Malaysia has become a subject of great importance and concern to both its people and the government. *Universiti Teknologi PETRONAS*, or UTP, which is wholly owned by the national oil and gas corporation *PETRONAS*, is one such tertiary institution that has emerged in response to the growing demand for higher education in the country.

Under the mechanical and chemical engineering programs of UTP, undergraduate students are offered a petroleum specialization stream, for those interested in the study of petroleum or inclined to pursue a career in the oil and gas industry, which is undoubtedly one of the biggest sectors of the Malaysian economy.

The motivation for offering petroleum education at UTP and the effectiveness of UTP's petroleum program and courses are the principal areas of concern of this paper. A discourse will first be presented on the progress of Malaysia's tertiary education leading to the founding of UTP, on the university's education system and its overall undergraduate engineering programme. Then, the following three aspects to the rationale for having a petroleum specialization elective at UTP are deliberated.

The first aspect concerns UTP's main motivation for offering education on petroleum engineering– why petroleum engineering is taught at UTP, considering it is not a conventional field of study at the undergraduate level. The second relates to the advantages and effectiveness of offering petroleum education as a specialized stream under the mechanical engineering program*, as opposed to conferring a full petroleum engineering degree. The third aspect of the issue of UTP's petroleum education discussed in this paper is the apportioning of the study of petroleum under mechanical and chemical engineering programs.

The effectiveness of UTP's petroleum curriculum, in preparing its mechanical engineering graduates for the oil and gas industry, is investigated. For this, the

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* The scope of discussion of this paper centers on the mechanical engineering program's petroleum specialization stream. Thus, when a specific program evaluation is presented, the petroleum elective stream under chemical or civil engineering will not be discussed in this paper.

educational process flow within the mechanical engineering program is examined to determine the program's strength and weaknesses in preparing its students for the final-year petroleum specialization courses.

The suitability of UTP's petroleum elective courses are also discussed, along the lines of adequacy to impart maximum benefit to students who will be embarking on a career in the petroleum industry. Due to their relevancy, monologues on the Malaysian oil and gas industry and the significance of petroleum education for the local industry are presented, to reflect on the industry's current and future requirements for skills and knowledge of its workforce.

For comparison and for assessing the appropriateness of UTP's petroleum program, this paper briefly discusses similar programs offered by other universities. In the final evaluation, issues of quality assessment and academic accreditation are delved into, capped up by a review of the strengths of UTP's petroleum program and some recommendations for improving the program's courses.

1.0 INTRODUCTION

In an economically emerging country like Malaysia, tertiary education has become a subject of great importance and concern to both its people and the government. Growing population, increase in living standards and rising demand for highly-qualified manpower are among the factors that have made higher education a rapidly developing field, increasingly crucial for the country's progress.

Private institutions of higher learning, in addition to public universities, have emerged in response to this growing demand for higher education. One of such universities is *Universiti Teknologi PETRONAS* or *UTP*, an incorporated academic institution wholly owned by the national oil and gas giant *PETRONAS*.

With the petroleum industry prevailing as a significant contributor to the nation's economy, *Universiti Teknologi PETRONAS* offers its undergraduate students a petroleum elective, as a specialization stream under the programs of mechanical and chemical engineering.

The intent of this paper is to study the rationale for offering petroleum education at UTP and the effectiveness of the mechanical engineering program's petroleum stream as set forth by *UTP*, in preparing its students for the transition from academé into the oil and gas industry.

2.0 PROGRESS OF TERTIARY EDUCATION IN MALAYSIA

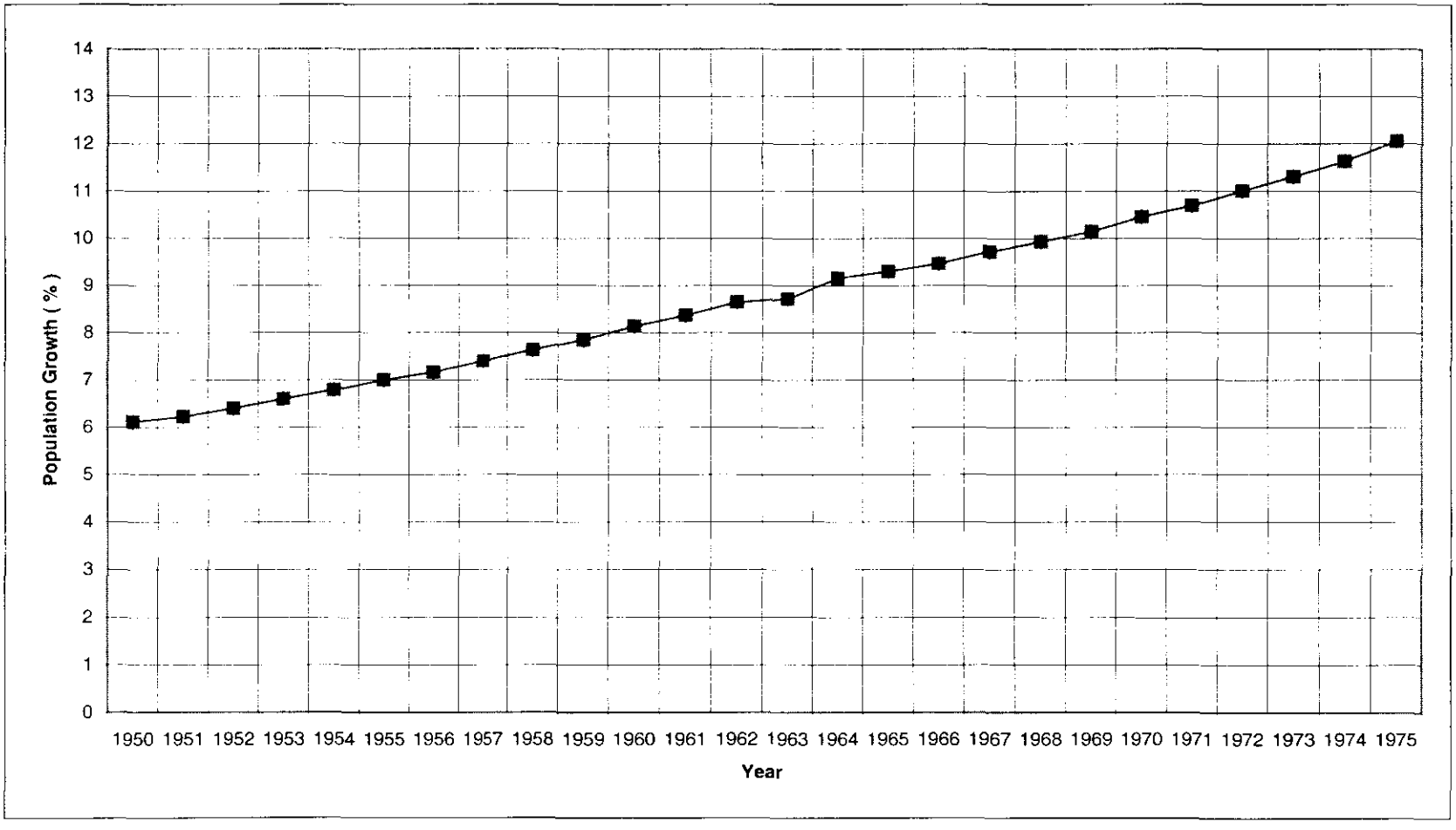
2.1 MALAYSIAN PUBLIC UNIVERSITIES

The first university to be established in Malaysia, *Universiti Malaya* opened its door to its first batch of undergraduates in October 1949[7]. At that time, there were only 46 students enrolled in courses such as medicine and *Malay studies*[7]. Being a commonwealth country, Malaysia implemented the British education system; thus, to qualify for university placement, a student must have completed 12 years of formal schooling culminating in a minimum grade of 1 Principal and 2 Subsidiary Passes in the *High School Certificate (H.S.C.)*, which is equivalent to the British A-Levels[7].

This was, at that time, a relatively difficult qualification requirement to meet; hence, during this era, the issue of insufficient university placement was non-existent as the number of qualified students applying for placement was comparable to the extent of spaces the university had to offer. As there was only a limited number of qualified students, it was not until 1969 that the Malaysian government established a second public university, Universiti Sains Malaysia, when it was deemed necessary to cater for the increasing demand for tertiary education[10].

The increase in the number of students applying for tertiary education in Malaysia was a reflection of the growing population; the population growth rate at that time was around 9 %[10]. Figure 2.1 below shows the trend of population growth in percentages in Malaysia during the years of 1950-1975. However, a more important factor for the rise in the level of applicants for university education was the gradual increase in the standard of living in Malaysia, which meant that more families were now able to manage the expense of higher education.

Figure 2.1: Malaysian Population Growth Rate



The Malaysian economy grew at a rapid rate of 5.8% between the years of 1957-1970, 7.8% during the years of 1971-1980 and oscillated in the range of 7.8% to 9.5% between 1992-1997[3]. Through these years – the first 40 years since the first public university was founded - more and more universities were established by the government to accommodate for the increase in demand for tertiary education; up until today, the number of public universities that confer a minimum of a Bachelor's degree has increased to 11[11]. Table 2.1 below details the date of institution for each individual public university in Malaysia[11].

Table 2.1 Malaysian Public Universities

University Name	Date of Institution
University Malaya (UM)	1962
University Sains Malaysia (USM)	1969
University Kebangsaan Malaysia (UKM)	1970
University Putra Malaysia (UPM)	1973
University Teknologi Malaysia (UTM)	1972
University Utara Malaysia (UUM)	1985
University Islam Antarabangsa Malaysia (UIAM)	1983
University Malaysia Sarawak (UNIMAS)	1992
University Malaysia Sabah (UMS)	1997
University Perguruan Sultan Idris (UPSI)	1997
University Inst. Teknologi MARA (UiTM)	2000

However, in recent years, the capacity for tertiary education offered by these 11 universities has been inadequate to accommodate for the proportionately higher rise in qualified applicants. In fact, by 1995, approximately 80% of all applicants to public universities were turned down for placement due to insufficient space [1]. This gap has since been made narrowed by the increasingly significant emergence of colleges owned by private organizations and companies.

2.2 PRIVATE COLLEGES

Alongside the continuously growing 'family' of public universities – to be found in both town and country - private colleges have sprung up in towns across Malaysia. Initially, these colleges offered post-high school programmes only, to prepare for university placement to the less-qualified students after their O-Levels-equivalent *Sijil Pelajaran Malaysia (S.P.M.).* There were also tutorial courses for the weaker students reseating the *S.P.M.* or the A-Levels-equivalent *S.T.P.M.*

In 1991, the Malaysian Government introduced to these private colleges twinning programs with foreign universities of countries such as Australia, the United States and the United Kingdom[1]. This measure boosted private colleges' enrolment, as students were able to obtain a degree from overseas universities at a fraction of the cost if they had lived and studied in foreign countries for the entire period of their degree program. Coursework undertaken at these local private colleges were transferable to the degree-granting foreign universities, allowing students to complete part of the degree program locally and the remainder portion overseas.

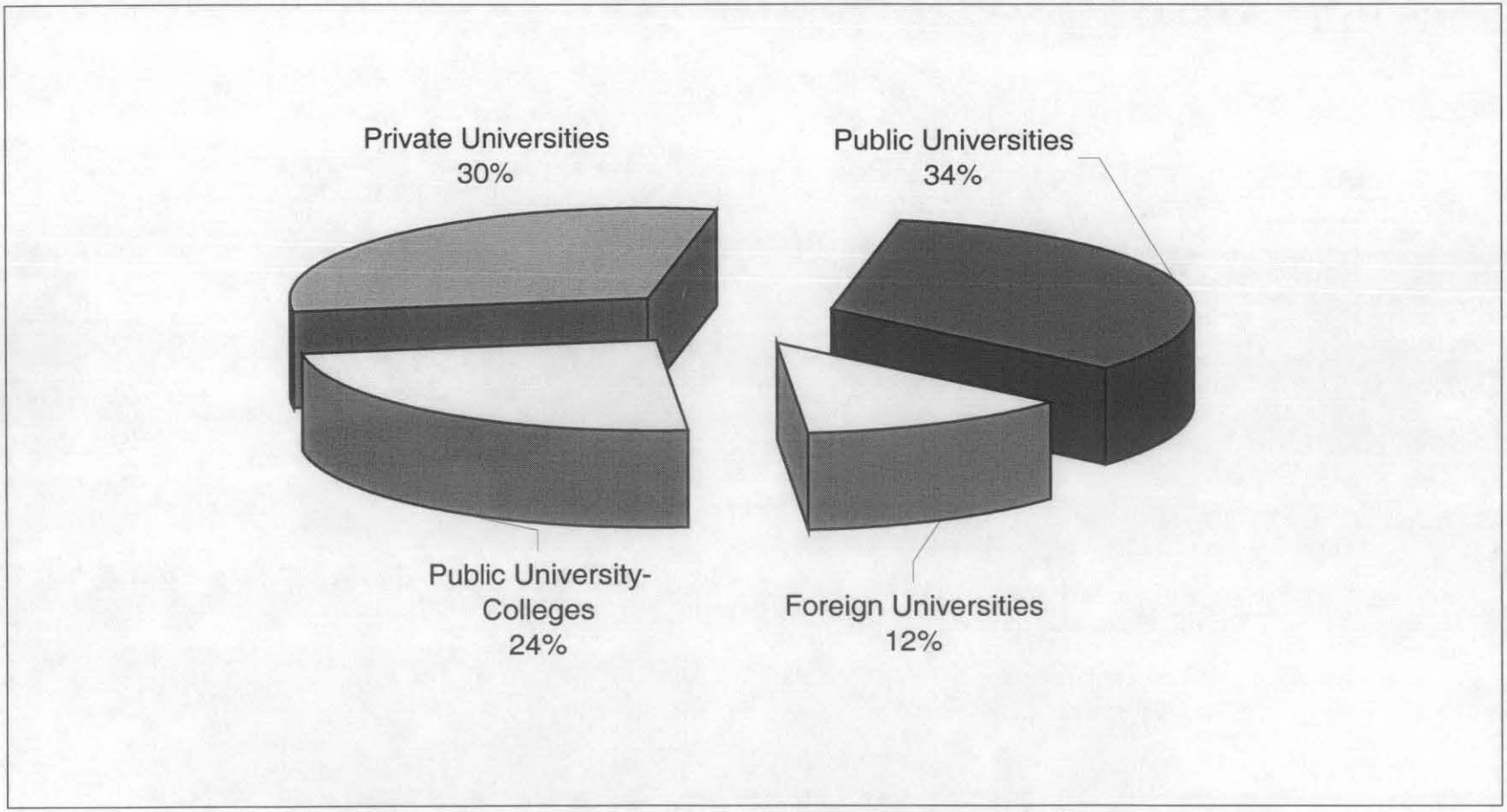
In more recent years, as government higher education policies continue to evolve, private colleges have developed programmes serving as alternative route for earning a first degree locally [8,9]. They have begun offering specific franchised university matriculation programmes and selected diploma degrees, making them attractive to students seeking higher education for their generally less-stringent admission requirements.

Thus, by the Malaysian public universities broadening their entrance requirements to accept not only students with *S.T.P.M* but also those with either a Matriculation or Diploma qualification from private colleges, a bigger range of students have had the opportunity to obtain placement into university - those students who would have been lacking in meeting the entrance requirements to public university after their *S.T.P.M.* now have a second chance at earning a university degree through the Matriculation or Diploma programmes offered at these private colleges.

From the aspect of increasing access to tertiary education for all socio-economic groups of the Malaysian population, private colleges have served a very crucial role. Ever since the 1970's, Malaysian public universities have imposed admissions quota of 45%-55% favouring the *bumiputras* (a legal, socio-political ethnic classification term for the Malay & indigenous population). Due to these affirmative-action quota restrictions, large percentages of otherwise qualified non-*bumiputras* (the Chinese, Indians and other ethnic groups) have been unable to obtain entry into local public universities[1,3].

Thus, private colleges serve an especially significant role for the non-*bumiputras,* as they become an avenue for them to pursue higher education: upon completion of the Diploma programs at these private colleges, they would have the option to further their studies by either re-applying to the local public universities or by using their diploma qualification as a stepping stone to obtain baccalaureates degree at an overseas institution. Figure 2.2 below shows a comparison of the growing number of private universities to the current number of public universities.

Table 2.1 Malaysian Universities



2.3 OVERSEAS EDUCATION

The movement of Malaysian students setting off to foreign land seeking tertiary education dates back decades ago to the era of British colonization, when higher education was predominantly for the elite or the upper class of society. Only extremely privileged and affluent families could afford to send their children abroad to further their studies. Most of them were relations to the Malaysian royalties and they privately funded their children's education – there were no organized sponsorship programs.

However, after the country's independence, students could pursue overseas education through a variety of channels. The Malaysian government, through a scholarship program created under the National Education Program of 1970 started to open the doors for overseas education to the general population, sending abroad the first batch of Malaysian students to study in the fields of engineering and science in the year 1970[24].

There were also private companies - plantation corporations and major multinationals – that were sponsoring students overseas; upon completion of their studies, these students would join the sponsoring companies' payroll[3]. Additionally, students were also sent overseas through funding from foreign entities such as the World Bank and through third-world development programs such as AUSAID and the Colombo Education Plan. Gradually, over the years, as the Malaysian economy strengthened, more and more families could afford private education for their children and were also sending students overseas for higher education by private financing arrangements.

Besides being a prestigious privilege for the qualified, the educationally motivated and the financially able factions of society, overseas tertiary education was also much desirable to the then young and just-developing country of Malaysia. Having its roots in agricultural society, the country has now shifted its focus to industrialization; with the manufacturing sector GDP contribution up from 14 % in 1970 to 27 % in 1990[20]. Technology is the key factor to push Malaysia to its goal of being an advanced, affluent and industrialized nation.

To avoid Malaysian lagging behind in industrial technology, which was much needed to fulfil the industrialization agenda of the country, Malaysia needs to "establish a scientific and progressive society, a society that is innovative and forward looking, one that is not only a consumer of technology but also a contributor to the scientific and technological civilisation of the future " [2].The truth of this statement holds even until today, as Malaysia undergoes rampant industrialization in heading towards the status of a fully developed nation.

The principal reason for the interest in overseas education is to acquire knowledge and expertise which is not available locally or which is more technically advanced and in-depth than what is available locally, to take advantage of the extensive material and academic resources and the vast experience of industrial application and - as one educationist puts it - to go after a "state-of-the-art education" [27].

Students studying overseas pursue a varied degree of programs in diverse fields such as medicine, business and engineering. The number of students seeking education overseas has always been substantial, with the total number over the course of 30 years amounting to tens of thousands. In 1995, of the 140,200 Malaysian students pursuing tertiary education, 36 % were doing it overseas[1].

Overseas education is capable of providing students with exposure to diversity in culture, way and philosophy of life, which is generally perceived as beneficial for character and personality development of the student. This has been a very important reason and motivation for sending students abroad and a crucial factor in justifying the considerable financial investment of their sponsors – be they their own parents or government agencies.

This is also why more students further their education in the U.S., Great Britain and Australia than in other equally technologically advanced countries like Germany, Japan and France for the medium of instruction and the language spoken in the former countries is English, which is the second most-commonly spoken language in Malaysia.

2.4 EDUCATION AND MANPOWER

Since independence, Malaysia has put great emphasis on the correlation between education and the manpower needs of the nation. The national education policy has primarily been developed to meet manpower needs of the present and future markets; producing creative and analytical graduates is one of the means of achieving this objective. Thus, knowledgeable human resource, being a most valuable commodity - some arguing it to be a more important source of production than the nation's land and capital – would need to be developed so that it can be utilized for the nation's economic growth[4].

Education and training has generally been geared to support and accelerate the industrialisation of Malaysia. Higher education was thus desired with this objective in mind: to provide not merely for the manpower needs of the nation but for building a pool of better-educated, highly-skilled work force especially in the field of science and technology, which is a key ingredient in the country's industrialization programme[17].

The period of 1990's saw Malaysian economy developing at an immense rate of 7.8 % to 9.5%[3]. The continued growth of the Malaysian economy brought about a labour shortage whereby employment growth was at 3.4% while labour force only grew up to 2.9% during the years of 1991 to 1995[1]. Recruitment of engineers during the economic peak period of 1991-1995 witnessed a supply of only 13,100 against a demand for 36,350[1].

Due to the increasing demand for highly skilled labour in health care, engineering and pure and applied sciences, there was an intensified urgency to meet market demand by increasing the output of labour. Thus, the objective leading to the higher education policies of 1996-2000 was to generally increase tertiary education capacity, to specifically meet the growing demand for engineering workforce in the short term and to generate export capacity for tertiary education in the long term[8,9].

To achieve its industrialisation objectives by the year 2020, the country needed 153,000 engineers and engineering assistants [20]. Although it managed to increase university enrolment in engineering programmes an almost threefold from the low figure of 4,050 in 1985 to 11,270 by the end of 1995, Malaysia's ratio of the number of engineers to the entire population is still 5-10 times less than other comparable developing nations[20]. Thus, to achieve developed nation status by 2020, Malaysia must increase its population of engineers and engineering assistants by a minimum of 500% [20].

Consequently, during this period, the Malaysian public saw the government expanding the capacity of existing public universities and tertiary institutions and establishing two new universities in East Malaysia - University Malaysia Sarawak and University Malaysia Sabah. Additionally, the creation of four new polytechnic institutes, the upgrading of technical institutes to degree-awarding universities and the incorporation of distance and on-line learning programmes were also implemented as means of providing for more opportunities for higher education. As of date, there are 25 institutions, both public and privately owned, that confer minimum of Bachelor's degree. Figure 2.2 shows the percentages of public versus private universities in Malaysia.

2.5 REGIONAL CENTRE FOR HIGHER EDUCATION

In 1996, the Malaysian Parliament passed the Private Higher Education Institutions Act. With this move, the government began emphasizing the role of the private sector - both local and foreign companies alike - in the nation's higher education[9]. Private firms already involved or interested in establishing institutions of higher learning should not only complement the provision of tertiary placement by government universities but should also present educational diversity and choice[1]. The private sector's response to the government's mandate to set up full degree-granting universities has been encouraging.

Six private corporations have since then established wholly- or partially-owned universities while 4 overseas universities have opened up branch campuses in Malaysia. Meanwhile, more than 600 private higher learning institutions have flourished in towns across Malaysia. Additionally, the ratification of the Private Higher Education Act reflects the nation's intent to attract students from regional Asian countries to study in Malaysia and the aspiration to make Malaysia as the region's country of choice for higher education[3,5].

A major turning point for the higher education scene was the Asian economic crisis that struck Malaysia in July of 1997, when student enrolment in both public and private institutions went through the roof due to inflated costs of overseas education. In a relatively short span of time, the Malaysian Ringgit plunged from an initial value of RM2.5 to the US Dollar to an astounding RM4.2 to the greenback. However, through the government's strict fiscal control, Malaysian currency was finally pegged at a value of RM3.8 to the US Dollar, which has remained until today.

Under this economic condition, the allocation for sending Malaysian students overseas was stretched to the limit. The government was now faced with the prospect of a huge exchange rate loss from overseas education expenditures of both sponsored and privately funded students. With more than 50,000 students studying in foreign shores, Malaysians spent more than RM 2 billion in 1997 for tuition and living expenses[6]. The government strongly felt that tighter budget controls should be implemented and transfer of currency to foreign lands brought to a minimum in order to prevent the country from falling into recession.

Thus, in a rather drastic move, roughly 2,000 government-sponsored students who had been studying abroad were called back and had to complete their studies locally[5]. Students in local colleges who had just completed their pre-university courses and were ready to be sent overseas were also rerouted to local tertiary institutions. As a result, both public and private universities had to increase their enrolment capacity to accommodate for the sudden and overwhelming increase in student population.

Malaysians who were privately funding their children's tertiary education overseas also felt the strain of the higher exchange rate. Due to the depreciation of the Ringgit compared to western currencies, the Malaysian public as a whole could now afford less internationally as their buying power had diminished significantly. Thus, irrespective of changes in government policy on overseas education, Malaysians on their own began to favour less overseas universities compared to local institutions.

Consequently, not long after the economic crisis struck the nation, enrolment in private colleges, which were most accessible to the general public, flourished with figures up to 100,000 students[1]. Initially, those colleges offering twinning programs with overseas universities reported a 20-30 percent decline in enrolment since students would still need to complete their education overseas and thus would have had to bear the higher costs[5]. British-linked programs were therefore the worst affected since the ringgit had weakened to less than half of its pre-crisis value compared to Pound Sterling[5].

Many private colleges reacted promptly, by introducing, in lieu of the '2+1' study plan, an alternative program of '3+0' in which students could carry out the entire undergraduate course locally, while they continued to benefit from the higher quality and standards of education typically expected of fine overseas institutions, maintained by the local colleges offering such programs. Most importantly, by opting for such programs, students and their parents were able to save, in tuition fees alone, a staggering RM10,000 to RM50,000 per year of instruction [5].

Simultaneously, while Malaysia is now sending fewer students abroad, more students from neighbouring Asian countries are coming to Malaysia for their tertiary education, as a result of the economic crisis spreading across most of Asia. Thus, Malaysia's intent of becoming a regional education hub begins to materialize. The number of foreign students studying in Malaysia increased from pre-crisis figure of 5,635 in 1996 to 11,733 in 1998[5]. Students are pouring in from countries such as Indonesia, China, Thailand and Korea. Compared to the currencies of these countries, the Malaysian Ringgit has devalued due to the crisis at roughly the same rate or even a little less, rendering studying in Malaysia inexpensive compared to studying in Western countries.

As most private colleges in Malaysia conduct their courses in English, foreign students do not experience problems related to language barrier. Additionally, the similarity along socio-cultural lines between Malaysia and other regional Asian countries can make incoming students feel at home, providing them with an easier transition moving from their home land to a foreign country. This could contrast greatly with studying in Western countries, where students would need to cope with assimilating themselves into a foreign culture and could face difficulties in dealing with 'cultural shock.'

In addition, since private colleges in Malaysia continue to offer twinning programs with foreign universities, students would be able to obtain an overseas degree at a 'Malaysian cost.' Foreign universities have also been setting up campuses in Malaysia, such as Curtin University in Sarawak, Monash University and Nottingham University in Kuala Lumpur. Hence, students from Asian countries have in front of them a variety of options when they decide to come to Malaysia to further their education.

As an incentive to promote Malaysia as a country of choice among students, the Malaysian government has allowed for double tax deduction for all expenses related to such promotion activities in foreign countries. In fact, in the recent past, the government itself has organized educational road shows in neighbouring *ASEAN* countries to encourage students to choose Malaysian universities for their tertiary education[5].

3.0 UNIVERSITI TEKNOLOGI PETRONAS (UTP) EDUCATION SYSTEM

3.1 BRIEF INTRODUCTION TO PETRONAS

With the ratification of the Petroleum Development Act of 1974, the Malaysian government established Petroliam Nasional Berhad, better known as *PETRONAS*, on the 17th of August 1974[17]. It is the country's very own petroleum corporation - fully owned by the Malaysian government – and thus has full ownership and exclusive rights over all petroleum-exploiting activities across all of its territories. The company has been entrusted with the responsibility of developing and adding value to Malaysia's non-renewable resources of oil and gas, in line with the needs and aspirations of the nation.

To date, *PETRONAS* has grown to be an integrated international oil and gas corporation with business interests in more than 20 countries. As at the end of March 2001, the *PETRONAS* group of companies comprises 62 wholly-owned subsidiaries, 19 partly-owned outfits and 47 associated companies and is involved in diverse economic fields ranging from upstream and downstream petroleum development activities to shipping and car manufacturing[17].

Recognizing its commitment to the improvement of life for the Malaysian public, *PETRONAS* has long invested much of its resource in the field of education. The company has been a key sponsor in providing qualified students with the financial means to seek tertiary education in reputable universities, both locally and overseas. *PETRONAS* spends RM100 million annually on the *PETRONAS* Scholarship and Loan Fund. Approximately 1,474 students are sponsored through this fund and 1,121 of these students are sent overseas for their education. Almost 60% of *PETRONAS* scholars are studying engineering[14]. As product of the *PETRONAS* sponsorship programmes, the student-turned-graduates will not only fulfil the company's own manpower requirements but will also furnish the nation's needs for a highly-educated workforce.

In a recent development, the company proves its commitment and takes on a more important and active role in the provision of education services to the nation.

Realizing that knowledge and education are important tools to spur the nation's growth and for achieving its vision for a fully-developed nation by the year 2020, *PETRONAS* has thus taken upon itself the role of an education provider, with the establishment of its wholly-owned university, Universiti Teknologi Petronas.

3.2 HISTORICAL AND STRUCTURAL BACKGROUND OF UTP

On the 26th of April 1995, *Institut Teknologi PETRONAS* (ITP) was established with the initial objective of providing ongoing education and training programmes to *PETRONAS* employees and scholars. However, when the Malaysian government - intent on transforming Malaysia into a regional education hub – called on *PETRONAS* to set up a private university, the company was more than obliged to upgrade the existing ITP, then regulated under the *Essential Higher Education Institute Regulation* of 1996, to a degree-granting institution consequently named *Universiti Teknologi PETRONAS* (UTP). The university was formally established on the 10th of January 1997[16].

Edge-of-technology companies such as *PETRONAS*, with multitudes of ongoing projects overlapping various industries, has the added advantage of access to the latest R&D activities, applied industrial expertise and an up-to-date knowledge base of the diverse industries. These factors would prove invaluable to the development of academic and instructional resources for a technological university like UTP. Furthermore, its graduates will have developed skills in engineering and technology and be equipped with not only theoretical knowledge in their respective fields but also indispensable hands-on field experience which can reinforce their entry into the working world.

The establishment of UTP proves PETRONAS' commitment to the Malaysian public to take on the role of a tertiary education provider and signifies its intent of becoming "a leader in technology education and centre for creativity and innovation"[16]. The creation of the university is a major investment on the corporation's part to enhance the nation's competitiveness in the field of engineering, science and technology. The university aims to produce well-rounded graduates, taking on the challenge put forth by Prime Minister Mahathir Mohamad in his vision

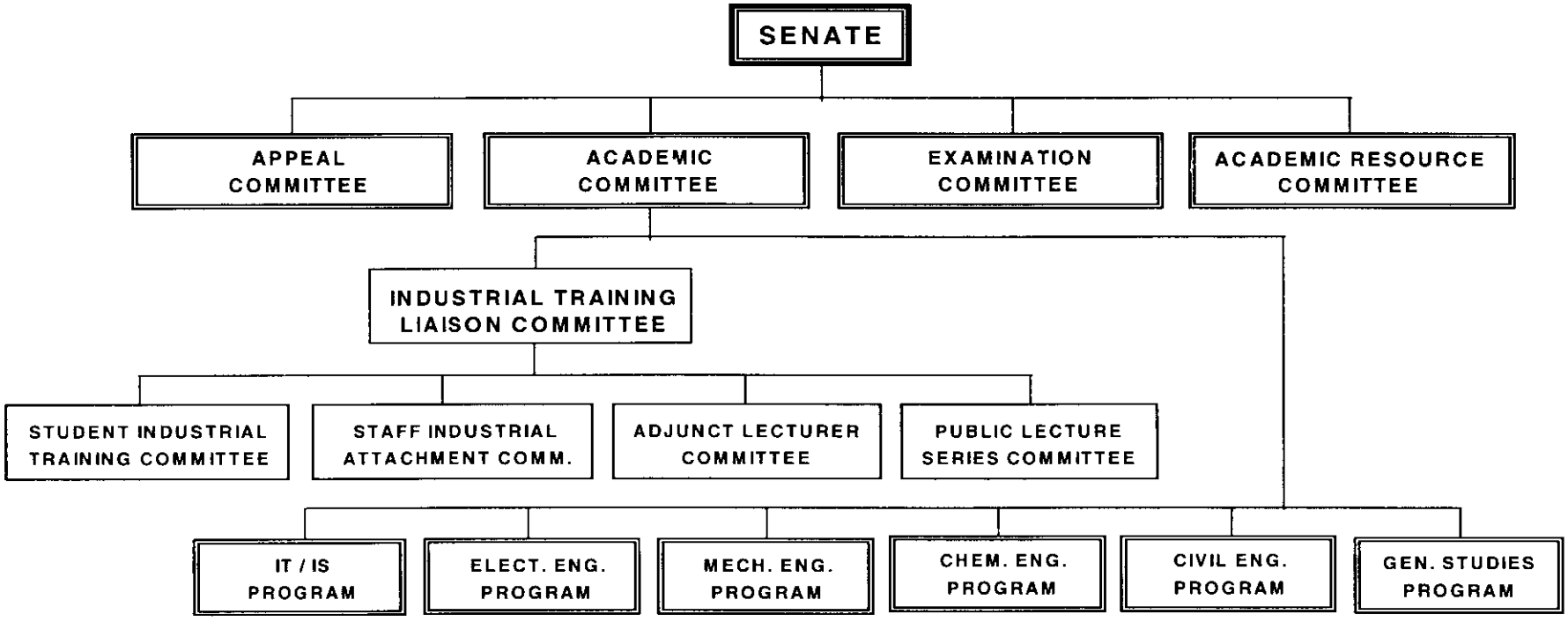
for a generation of not only users but also creators of technology, thus pioneering the effort to cultivate indigenous technology, in line with Malaysia's Vision 2020[2].

Being a private university, UTP's administrative structure is similar to that of a corporate firm. A 5-member board of directors heads UTP, alongside a Rector who serves as president of the university. In keeping with academic tradition, UTP appoints a chancellor as a symbolic representor of the university in official ceremonies and occasions.

The academic section of the university falls under the jurisdiction of a senate, which oversees not only matters of academic policy and affairs but also such services as the management of the institution, the registrar, finance, consultancy and research and development (R&D) activities. The academic section is further divided into these individual committees: academic, appeal, examination and resources.

Figure 3.2 on the following page shows a graphical view of UTP's senate organization and management structure[13,16].

Figure 3.2: UTP Organization Structure



Universiti Teknologi Petronas is a specifically focused technology-based university offering broad-based engineering degrees in the following programmes: chemical, electrical, mechanical and civil engineering. Additionally, UTP also grants the Bachelor of Technology degree for the Information Technology and Information System programmes. Enrolment currently stands at around 3,900 students with 2,700 in engineering and 1,200 in information technology. At its peak, enrolment at UTP is expected to reach a maximum of 5,400 students with 70% of them enrolled in engineering[13].

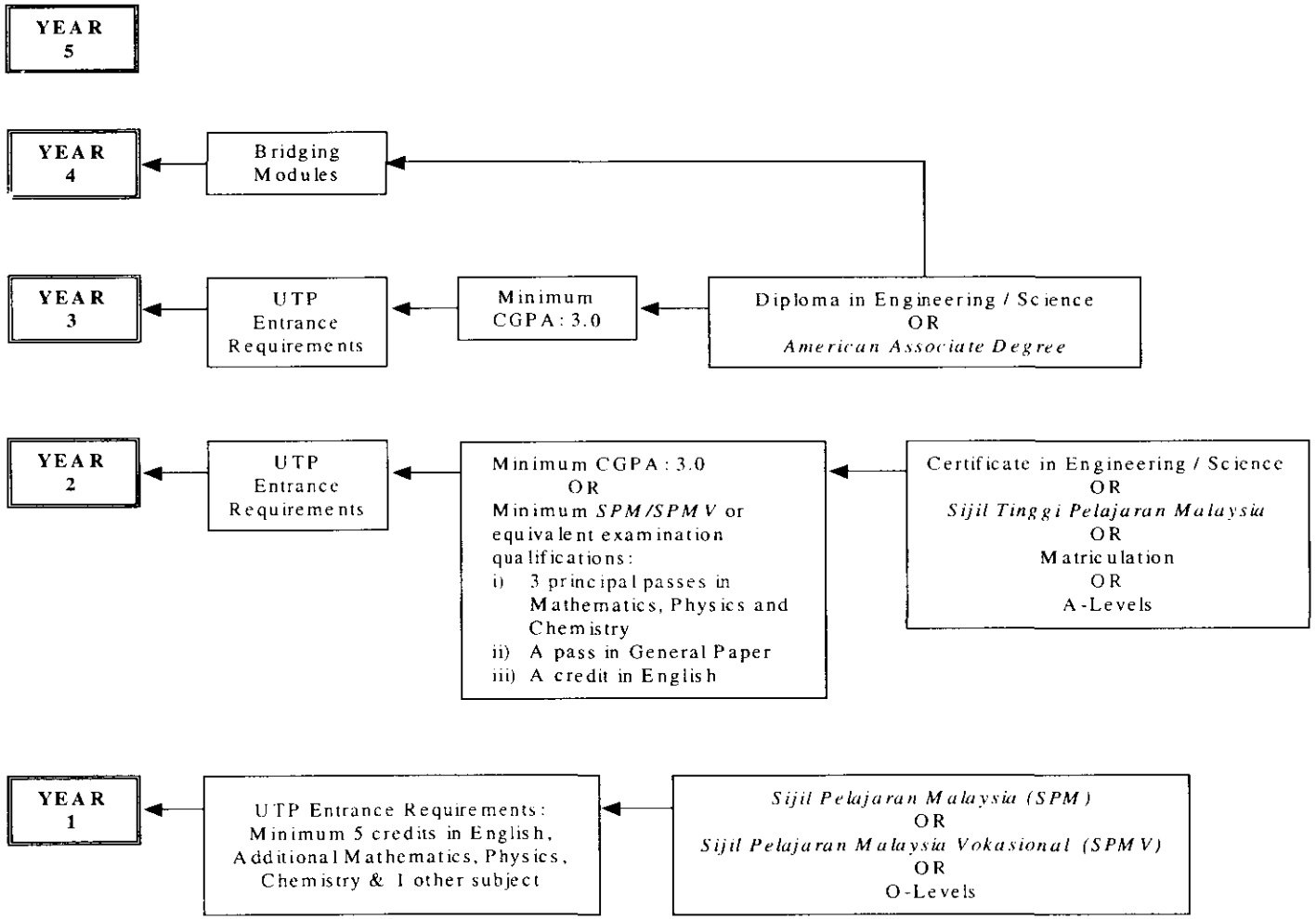
To add value to its graduate standing, UTP offers specialised elective streams within its broad-based engineering programmes. Students under the chemical engineering programme shall choose between petrochemical, process or environment streams for their final year elective courses. As for electrical engineering, students shall specialize in one of the following two elective streams: controls and instrumentation or computer systems. Specialized streams in the civil engineering discipline include offshore structures and building technology for its final year elective courses. The mechanical engineering programme offers students the most options for specialization: mechatronic, materials, manufacturing, automotive and lastly petroleum.

3.3 ENTRANCE REQUIREMENTS - SKILLS AND QUALIFICATIONS

UTP practices a flexible entrance requirement policy for its prospective applicants: it does not restrict entrance to students with the O-Levels-equivalent *Sijil Pelajaran Malaysia* (S.P.M.) only and thus students with higher qualifications are welcome to apply for enrolment at the university. Entry level into the academic system shall be decided according to the student's highest qualification achieved and based on the concepts of transfer of credit and equivalent course exemption.

Therefore, there are various routes that a prospective student may take to enter the UTP academic system. This flexibility in accepting students into the institution from various academic backgrounds is not at all a compromise on standards but - as discussed earlier on in this paper - a means of widening the access to tertiary education, which is characteristic of private universities. In actual fact, UTP has one of the most rigorous entrance qualification requirements. The chart on the following page shows admission requirements for any of the engineering programmes offered at UTP[13].

Figure 3.3: UTP Entrance Requirements



4.0 UTP PROGRAMME OF STUDIES

THE FOUNDATION YEAR

Fundamental Math & Science & Vital Skills

The first year of study at Universiti Teknologi Petronas is vital to the academic wellbeing of students as it is their transitional year from high school to tertiary institution. It is a crucial period for students to develop constructive attitude and perception towards academics and to acquire expedient academic skills to cope successfully with the later years at UTP.

Should they not manage well in integrating themselves into the university system during this initial period, they are more likely to perform poorly in the advanced years compared to those who cope effectively with their first year at university. Surely, to drop out altogether from university due to poor transition would be a great loss to both the student and the university.

Thus, UTP's curriculum for the first year has been developed not only to provide students with a strong foundation in mathematics, science and engineering but also to cultivate in them skills which are vital for the rest of their academic life at UTP and throughout their entire forthcoming life as engineers in the real world.

This objective is achieved through courses in the first year which educate students in the following areas: English and communication proficiency, computing aptitude, engineering communication practices and analytical and critical thinking skills. The table on the following page elucidates the academic programme for students in their first year at UTP:

Figure 4.1: Foundation Year Course Requirements at UTP

Semester 1		
	Course Title	**Credit Hours**
1	Engineering Math I: (Calculus I)	3
2	Physics I	3
3	Chemistry I	3
4	Computers and The Information Age	3
5	English I	3
6	Engineering Profession and Communication	2
7	Co-curriculum	1
	Total	**18**

Semester 2		
	Course Title	**Credit Hours**
1	Engineering Math II: (Calculus II)	3
2	Physics II	3
3	Chemistry II	3
4	Analytical Skills and Critical Thinking	2
5	English II	3
6	National Language A	3
7	National Language B	3
8	Co-curriculum	1
	Total	**21**

Interest, Appreciation & Attitude Towards Education

According to Besterfield, students' perceptions of their own capabilities in mathematics and the sciences, together with their attitude towards engineering as their future profession are key factor for failure or success as engineering students in university[31]. It is thus a critical task for UTP to not only maintain but also cultivate the students' interest in these fields during their first year, in preparation for the more advanced courses of the later years at UTP.

Students should be able to integrate knowledge attained from the compulsory 2-semester math, physics and chemistry course series, so as to appreciate the interdependence between these fundamental subjects and the significance of a strong command of these subjects in order to perform throughout their engineering programme at UTP and in their future engineering career. As the students progress through their courses, they will apply concepts acquired in one course to solve

problems in another and they should be exposed to this learning process early on, during their foundation year at UTP.

Backbone of Upper Level Courses: Math & Science, English Competency & Communication Skills

The fundamental math and science courses of the foundation year are the backbone of the upper engineering courses. To develop a strong command of these subjects among the first-year students may not be the greatest challenge for UTP as the majority of the incoming students already have a sound math and science background.

Almost all of the students are from the science stream at high school and have recently sat for the O-Levels-equivalent S.P.M. Since a minimum of a credit in mathematics and the sciences and a strong Aggregate points in the S.P.M. are pre-requisite for entrance into UTP, the incoming students can be perceived to be on equal academic footing in terms of math and science aptitude.

In this respect, a more critical task for UTP is to build language competency among the first-year students, as English is the medium of instruction at UTP while language command of majority of the students is of the Malay national language and other languages they were brought up with. UTP's practice is also in contrast with the government schooling system, which uses Malay as the medium of instruction.

Therefore, it is crucial for UTP to ensure that its English language courses offered in the first year of university help students build a strong command of the language, not necessarily of aesthetic literary prowess but specifically of technical English rhetoric, which is critical for effective comprehension of lectures and technical literature. The students also need to strengthen their writing skills for reports and technical writing and their oral skills for presentation of ideas within discussion groups and for delivering effective engineering presentations.

At UTP, these objectives are achieved not only through formal classroom instruction – through the two compulsory English courses offered in the first year - but also through informal activities such as teamwork induction and orientation programmes during the students' initial entry and other compulsory and optional extracurricular activities throughout the students' academic life at UTP.

Basic Computer Knowledge & Engineering Communication

In the first-year computing course aptly titled *Computers and the Information Age*, computer knowledge is imparted as an essential tool for students living in today's world of information technology. The course is structured to expose students to the various elements, aspects and applications of the computer: operating systems, hardware such as microprocessors, input, output and storage devices, software including word-processors, databases and programming languages, networking, data communications and many more. Students will also learn the various functions of a computer that will serve as useful tools throughout their academic and professional career.

Students will be introduced to the various disciplines and functions that are part of the engineering profession, to the means of becoming a professional engineer and to the ethics and professionalism expected of an engineer, in the course *Engineering Profession and Communication*. Through hands-on, technical design team assignments, the course exposes students to problem-solving skills, interpersonal qualities and leadership skills that are vital for working in teams.

Working in small teams of 5 or 6, each student will learn to build self-confidence, overcome apprehensiveness and participate interactively with other members of the group, which could also serve as basis for building a 'professional' relationship with fellow classmates, with whom they will be sharing forthcoming years of academic and professional life.

The course requires students to produce project progress journals, submit technical reports and deliver technical presentations; through these activities, they

will be exposed to effective engineering communication skills. By applying knowledge acquired in their English courses and integrating it with communication skills taught in this class, students will not only absorb taught material of these courses better through the practical activities but also learn to put theory into practice. All of this will reinforce the students' understanding of an engineer's work practices, in preparing them for the real working world.

Paradigm Shift in Thinking

Malaysia's *Vision 2020* represents the nation's strategic move into the *information age*, which would almost completely alter the traditionally agricultural and manufacturing-based character of its society. In line with the aspiration to engender generations of Malaysians who are not merely users but creators of technology, UTP sees the pressing need to cultivate innovative thinking in its students. This, according to the founders of UTP, is in fact one of the challenges of today's educational institutions, which is "to prepare the minds of the people for the future"[14].

In this respect, the first-year *Analytical Skills and Critical Thinking* course offered at UTP targets to shift the paradigm of conformity thinking present in most Malaysian students to analytical and critical thinking, as part of UTP's attempt to mould the minds of its graduates. The course offers students a multitude of powerful self-development tools that will enhance the quality and effectiveness of the students' thinking and thought processes, in order to make them "work and think for themselves" and "function independently as learners "[21].

Preliminarily, students will learn to distinguish between the concepts of intelligence, thinking and knowledge. In addition to learning the principles and tools for thinking, the students will also discover how the human mind works and how perception and attitude influences and affects their own thinking.

It is the objective of the course that students will be able to approach future research and design challenges throughout their academic and professional career by

being systematic, applying creative and lateral thinking and employing the various problem-solving techniques taught in the course. Last but not least, the course aims to inculcate in the students effective and appropriate learning skills and explain to them the significance and benefits of a conducive learning environment by, among others, expounding on the concept of motivation and how strong self-motivation can greatly improve their learning curve specifically and other aspects of their life generally.

4.2 THE SECOND AND THIRD YEARS: ENGINEERING CORE STUDIES

Advanced Math & Introduction to Engineering Science

The second and third years of UTP's academic programme present students with more advanced mathematical concepts and introduce them to engineering science. For the second year's curriculum, students begin to enrol in engineering-related courses. Most of the engineering courses are at introductory level in order to gradually expose students to engineering perspective and analysis.

These introductory courses are: *Introduction to Material Science, Introduction to Thermodynamics, Static & Dynamic Mechanics* and *Electrical Technology*. Since these subjects are considered core engineering courses and form the foundation for future engineering courses, they are all pre-requisites to the higher-level engineering courses.

To ensure that students have a good grasp of these foundation subjects before they move on to the advanced years, these introductory engineering courses include tutorial sessions catering to students grouped in relatively smaller sizes compared to main course lectures, which would allow better student-instructor rapport. Attendance in tutorial groups is made compulsory and students are encouraged to participate actively in the discussions in which sample problems are worked out, difficult concepts further elaborated and student queries can be more effectively attended to.

As part of the requirement for mathematics, students continue in the second year with *Differential Equations* and *Vector Calculus*. Both these courses present students with mathematical tools that are essential in engineering applications and for problem solving in future engineering and math courses. For example, the fourth-year *Control Systems* course encompasses analysis and description of systems using *Laplace* transform, which is one of the areas covered in the *Differential Equations* course. Students also need to be familiar with vector calculations for solving and analysing arrays in control pairing problems.

The second-year mathematics courses are structured not only to ensure students' grasp of advanced mathematical concepts but also to show the significance of mathematical aptitude in engineering analysis so that students become more motivated to master the concepts and skills taught in the math courses in order to perform well in their respective engineering streams.

The diagram below shows the courses students need to take in their second year at UTP.

Figure 4.2-1: Second-Year Course Requirements at UTP

Semester 3		
	Course Title	**Credit Hours**
1	Engineering Math III: (Differential Equations)	3
2	Intro. to Material Science	3
3	Electrical Technology	3
4	Workshop Practices & Design Project	3
5	Mechanics: Statics	2
6	Malaysian Studies	3
7	Co-curriculum	1
	Total	**18**

Semester 4		
	Course Title	**Credit Hours**
1	Engineering Math IV: (Vector Calculus)	3
2	Intro. to C++ Programming	3
3	Intro. to Thermodynamics	3
4	Engineering Graphics	3
5	Mechanics: Dynamics	3
6	Islamic Studies	3
7	Moral Studies	3
	Total	**21**

Computer Programming & Engineering Graphics

In the second year, students also get in-depth exposure to drafting and programming through *Engineering Graphics* and *Introduction to C++ Programming* courses. Engineering drafting and computer programming have become critical and universally-required skills for today's engineers. In *Engineering Graphics*, students are taught the fundamentals of computer-aided drafting using softwares such as *CAD 2D, Auto 3D, Mechanical Desktop, Microstation, ProE* and various other graphics packages.

Students are also introduced to the principles and concepts of programming using the *C++* language, along with multitudes of hands-on coding assignments to build their computer programming aptitude, which is indispensable in this digital age of engineering. Programming offers a means to perform engineering analysis, calculations and problem-solving in a logical and systematic manner.

Students are exposed to the fundamental principles and applications of engineering drafting and computer programming relatively early on in their academic programme to allow for more time for them to develop a strong command of these essential skills for use in advanced courses of the later years.

Practical Workshop & Design Skills

Invaluable hands-on design-and-build experience can be gained through the introductory course *Workshop Practices & Design Project*, which provides students with an opportunity to develop practical workshop skills. Students are introduced to workshop equipments and processes and are taught basic fabrication skills such as metal cutting, milling, grinding and welding. This practical exposure helps to stimulate students' interest in the field application aspects of mechanical engineering, to motivate them to understand the underlying principles and theories and to instil a sense of appreciation and awareness of the knowledge already gained and that which is yet to be acquired.

Furthermore, since students take up the workshop course relatively early on in their curriculum, those with little practical exposure to and experience with mechanical equipments will greatly benefit from the course as it can improve their comprehension of technical concepts while reinforcing their "engineering sense, (which can be) garnered from 'tinkering' with electrical or mechanical equipment"[32].

In addition to the hands-on workshop experience, the design portion of the course introduces students to engineering design and grants them the first opportunity to put knowledge into practice, by integrating various aspects of what they have learned throughout the course to produce functional mechanical components in an innovative and rewarding manner. Thus, this course serves as a precursor to the more advanced and challenging project design assignments of the senior years' courses.

3rd Year: Engineering Math & Statistics

Students' mathematical aptitude is fortified through the continuation mathematics courses *Numerical Methods* and *Probability & Statistics* as they progress to their third year at UTP, as shown in the following diagram which illuminates the academic curriculum for third-year students. This mathematics curriculum is above and beyond what is recommended in the *Malaysian Engineering Education Model*, an ongoing study commissioned by the Institution of Engineers, Malaysia and the Malaysian Council of Engineering Deans and conducted by a team of academics from local universities.

UTP is thus among the very few institutions in Malaysia that require extensive mathematics preparation of its graduate engineers. Even in the United States, a relatively small percentage of the universities there require such advanced mathematics for their engineering programme[29]. This enforced groundwork in mathematics is aimed to prepare UTP's engineering graduates for a prospective career in research and development, in accordance with UTP's aspiration to produce graduates who are not merely static users of technology but also dynamic contributors in their respective engineering fields.

Figure 4.2-2: Third-Year Course Requirements at UTP

Semester 5		
	Course Title	**Credit Hours**
1	Engineering Math V: (Numerical Methods)	3
2	Fluid Mechanics	3
3	Mechanics of Materials	3
4	Heat & Mass Transfer	3
5	Mechanics Laboratory	2
6	Health, Safety & Environment	3
	Total	**17**

Semester 6		
	Course Title	**Credit Hours**
1	Probability & Statistics	3
2	M.E. Thermodynamics	3
3	Thermofluids Laboratory	2
4	Heat Transfer Design	3
5	Engineering Team Project	2
6	Manufacturing Technology	2
7	Technology, Society & Development	2
	Total	**17**

Foundation Mechanical Engineering

The third-year curriculum carries on with in-depth investigation into the fundamental areas of study and application of mechanical engineering. This is achieved through the following 'core' courses: *Fluid Mechanics, Mechanics of Materials, Heat & Mass Transfer, Heat transfer design, Thermodynamics and Manufacturing Technology*. These courses contribute to the scientific requirement of an engineering curriculum, as recommended in the *Malaysian Engineering Education Model* that advocates a range of 30-50 required units to fulfil scientific skills competency[26].

Table 4.2-1 on the following two pages demonstrates that UTP's curriculum requires its mechanical engineering students to complete a total of 67 units of engineering science courses, which is again over and above MEEM's recommendations. This strong emphasis on engineering science affirms the commitment of the institution to produce graduates who are not only users but more importantly creators of technology, cultivating indigenous technology through efforts

of home-grown research and development. This sentiment and aspiration is echoed in MEEM's statement that,

> "substantial professional skills and a strong scientific background would make R&D an important agenda in the engineering fraternity (which) would propel a greater thrust into innovative technologies and ensure that the country becomes technologically sufficient"[26].

Furthermore, as claimed by Prusak in his paper, in a world where the breadth and depth of engineering knowledge is constantly evolving at a rapid rate, "continued strong accentuation of traditionally emphasized engineering knowledge base" becomes increasingly important in preparing engineering graduates to face future challenges in their profession[30]. This justifies UTP's extensive syllabus of core engineering courses, in the effort to ensure students' robust foundation in engineering, so that they are intellectually well-prepared for the future engineering profession which is characterized by continual progress in its knowledge base.

Table 4.2: Categorization of UTP Mechanical Engineering Courses (As Per MEEM Guidelines)

Skills & Competencies	Course Title	Credit Unit
Global & Strategic	English I & II Computers & The Information Age Analytical Skills & Critical Thinking Engineering Profession & Communication	13
Practical	Workshop Practices & Design Project Mechanics Laboratory Thermofluids Laboratory Materials Lab Control Lab Engineering Team Project Final Year Design Project Industrial Training I & II	37
Industrial	Engineering Economics & Entrepreneurship Engineers in Society Health Safety & Environment Management Elective I	10
Humanistic & Social Sciences	Malaysian Studies Islamic Studies Moral Studies National Language I & II Co-Curriculum I &II Social Science Elective I	19

Table 4.2-1: Categorization of UTP Mechanical Engineering Courses (As Per MEEM Guidelines)

(Continued)

Skills & Competencies	Course Title	Credit Unit
Scientific	Calculus I & II Physics I & II Chemistry I & II Differential Equations Intro. to Material Science Electrical Technology Statics Vector Calculus Intro. to Thermodynamics Intro. to C++ Programming Engineering Graphics Dynamics Numerical Methods Fluid Mechanics Mechanics of Materials Heat & Mass Transfer Probability & Statistics M.E. Thermodynamics Heat Transfer Design Manufacturing Technology	67
Professional	Machine Component Design Mechanical Design Technology Control Systems Kinematics & Dynamics of Machines Industrial Electronics Engineering Materials Technology Manufacturing Systems Specialization Elective I, II, III & IV	31

Mechanical Engineering Laboratory and Design Project

During their third year at UTP, mechanical engineering students gain the opportunity to apply knowledge learned in engineering mechanics courses on statics and dynamics of the second year and on fluid mechanics and heat transfers of the third year, in practical laboratory experiments. In the *Mechanics Laboratory* course, students are able to enhance their comprehension of concepts of static and dynamic mechanics through experimenting with beam bending and deflections under various load conditions, performing tensile tests on a variety of materials and other experimental activities.

Meanwhile, the *Thermofluids Laboratory* aims to assist students to better understand in a practical hands-on environment the principles of conductive, convective and radiant heat transfers. The properties of gases and liquids and various other fluid mechanics concepts are investigated through experiments on drag and lift, viscosity, pressure and flow rate.

Through both these laboratory courses, students gain beneficial experience in data collection and property measurement, in systematic and scientific analysis and in forming logical conclusions. In addition, students also learn the art and science of collating and presenting technical results on paper, as they are required to submit their experimental analyses and conclusions in academically- and professionally-written reports.

In his paper *Factors for Change in Mechanical Engineering Education,* Hodge, et al state that "design is what distinguishes an engineering education from a science education" and thus is a significant part of an engineering educations curriculum[22]. In the course *Engineering Team Project*, students are again given the opportunity to undertake design exercise and put into practical implementation design concepts that they have learned on the theoretical level, in the form of an engineering project. This time, projects are designed and implemented in a smaller group setting and after more technical knowledge is gained from preceding classes to effectively carry out the more technically-challenging design assignments.

Students have the flexibility to investigate and research potential technical project areas of interest to them. Under the guidance of the course instructor, they will delve into the feasibility of their project choice and the technical challenges it would pose, to produce a system model, process simulation or conceptual design. The course requires students to generate project proposals, implement the projects to completion, submit technical reports and deliver technical presentations at the conclusion of their projects.

Social Science for Engineers

Each semester of the third year of study requires students to enrol in a social-science related engineering and technology course. These courses are: *Health, Safety & Environment* in the first semester and *Technology, Society & Development* in the second semester, both of which aim to broaden the intellectual horizon of an otherwise technically specific engineering education.

Students are exposed to - on paper and within classroom setting – the responsibilities of the engineering profession to their own selves at first and more importantly to the society at large, which are as diverse and complex as the engineering discipline itself. They are taught to be personally conscious of and professionally sensitive to the effects and contributions of their actions and decisions, to the progress and well-being of the society, the environment and the cultural and political dimensions in which they work and make their living.

Health and safety knowledge is increasingly important in today's engineering practice. This knowledge consists of not just the awareness and identification of hazards or the ability to draw up safety procedures to minimize accidents in the workplace but more significantly - for the design engineer - is the diverse health and safety issues and factors that the engineer needs to bear in mind in conceiving engineering processes, structures, systems, components or whatever the subject matter may be. In the United States, it is stated as a design mission of the *National Security Council's Institute for Safety* that all stages of the design process must

incorporate decisions affecting the reduction of risk to safety, health and the environment[33].

The Vice President and General Manager of *General Motors Corporation* acknowledged that new engineers entering the workforce must already have in hand the knowledge of health and safety and that the *National Safety Council*'s initiative to implement safety in design is absolutely critical to America's future[33]. In accordance with the call for increased awareness among engineering professionals to health, safety and environmental concerns, UTP has incorporated into the third-year curriculum a course that imparts basic HSE knowledge to its students. In the course, students are educated on, among others, making environmental impact assessments, work hazards & their impacts and consequences, HAZAN and hazard prevention and the various issues concerning pollution and global changes.

Additionally, UTP's third-year mechanical engineering students are taught the dynamics of technology and its interaction and impact on society and its development, in the course *Technology, Society & Development.* It is the objective of the course to enable students to better understand the vibrant and positive relationships between technology and society.

The class begins with a retrospective look on pre-colonial, colonial, and post-colonial societies of Malaysia, from the perspective of technological development. It then focuses on the past, present and future modernizing efforts and the impact of technology on people's lifestyles. It also discusses the role of liberating force that technology has played in the past and can present in the future and how technology should achieve its purpose of serving humanity and not contribute to its degradation - due to unbecoming socio-psychological consequences or to the abuse and exploitation of natural resources.

4.3 THE FOURTH YEAR AND THE INDUSTRIAL INTERNSHIP PROGRAMME

Figure 4.3: Fourth-Year Course Requirements at UTP

Semester 7		
	Course Title	**Credit Hours**
1	Machine Component Design	3
2	Mechanical Design Technology	2
3	Control Systems	3
4	Kinematics & Dynamics of Machines	3
5	Industrial Electronics	2
6	Engineering Materials Technology	2
7	Materials Lab	2
	Total	**17**

Semester 8		
	Course Title	**Credit Hours**
	Industrial Training I & II	16
	Total	**16**

Professional & Industrial Engineering & Emphasis on Core Engineering Courses

As can be gathered from the above diagram on UTP's fourth-year academic programme, the first semester in the fourth year of studies sees the introduction of mechanical engineering students to professional industrial courses such as Machine Component Design, Kinematics & Dynamics of Machines, Industrial Electronics and Control Systems. The *Malaysian Engineering Education Model* recommends a minimum of 30 credit hours to a maximum of 50 credit hours of subjects in the professional engineering criteria.

From Table 4.2-1 of the previous section, it can be seen that UTP's mechanical engineering curriculum requires its students to enrol in only 30 credit hours' worth of professional engineering courses and this corresponds to the lower end of the MEEM's recommended range. This reflects the institution's greater

emphasis on the core subjects under each engineering science, rather than on the more specialized fields of study within each discipline.

This philosophy parallels the sentiments of the MEEM's researchers - on how to prepare engineers of the new millennium for future challenges - that there should be less emphasis on specific specialization skills within an engineering discipline and more on "the knowledge of engineering science, so that engineers are flexible and able to move across several engineering disciplines"[26]. This opinion is further supported by Prusak in his statement that

> "...the progress of technology and the rapid change in business practices transform the practice of engineering..." such that "...new jobs which demands interdisciplinary knowledge and skills that were previously considered unrelated to engineering, are being created"[30].

On a similar note, the authors of the paper *Engineering Education in the Era of Global Markets* believe that it is the mission of today's educators to cultivate students' ability to bridge the boundaries between disciplines and make the connections that produce deeper insights[21].

The *Malaysian Engineering Education Model* identifies being multi-skilled and having scientific strength as two criteria expected or required of a graduate engineer. UTP's strong mathematics curriculum and the greater focus on core engineering subjects as opposed to specialization courses help to ensure a firm scientific background and better mobility and broader function of its graduate engineers across the various specialization areas within mechanical engineering.

Thus, it can be said that the two criteria of the MEEM - to produce graduate engineers who are multi-skilled and scientifically sound – can be accomplished under UTP's current mathematics and engineering curriculum. The remaining three out of the five criteria of the MEEM as to what engineering education should inculcate in a graduate engineer, which form part of the MEEM's 'design intent' are: to possess professional competencies, to be well-respected and a potential industry leader and to be morally and ethically sound. These remaining criteria advocated by the MEEM

can be realized by UTP through its *Industrial Internship Programme* scheduled in the second semester of the fourth year and the introduction of the professional courses in the first semester would help to prepare students for that upcoming industrial training programme.

Industrial Internship: Practical Work Experience in the Real World

Industrial internship offers university students the opportunity to observe field work at an up close and personal level, where they will be able to apply theoretical knowledge that they have learned in a class setting to real-world engineering problems. Whether the experience is gained directly as part of their job assignments or indirectly through observation of co-workers and existing processes, the opportunity to see engineering solutions applied first hand can definitely help to increase their comprehension and appreciation of the subject matter.

It is thus the purpose of the *Industrial Internship Programme* to expose students to the working world in order for them to be able to relate theoretical knowledge to applications in industry.

UTP requires all its students to undergo a 32-week internship programme for which they will work with an engineering-related commercial company under the supervision of a company personnel[16]. In this respect, UTP has the unique advantage over the public and unaffiliated universities and even other private universities since UTP is part of the *PETRONAS* group of companies which has the support of 62 wholly-owned subsidiaries - 19 partly-owned outfits and 47 associated companies - involved in diverse economic fields, ranging from upstream to downstream petroleum development activities. Thus, under the guidance and supervision of the *Industrial Internship Unit* of UTP that oversees the programme, students have a wide range of choice as potential industry placement to meet their internship requirement.

Development of Soft Skills & Exposure to Potential Employers

It is also the aim of the programme that students shall develop during the duration of their industrial training, soft skills - those relating to work ethics, interpersonal communications, team management and other people-related proficiencies, the significance of which are difficult for students to appreciate and acknowledge in a classroom setting. UTP also hopes that the *Industrial Internship Programme* will help to foster a close relationship between the university and the industry, a continuous UTP-wide effort overseen also by the *Industrial Internship Unit*, or IIU for short.

In addition, besides being a platform for students to integrate theory with practice and to develop essential soft skills, students will gain through the practical setting of internships, the invaluable opportunity to expose themselves to industrial practitioners and thus to potential employers.

The exposure students obtain from working in the industry allows them to evaluate their personal level of knowledge, while giving them an indication of what the industry shall expect of them when they graduate, in terms of both theoretical and practical knowledge. Thus, during the 32 weeks of exposure to the various engineering, commercial and industrial aspects of the host company, students will gain the experience that would be of great influence to them in determining their field of specialty, not only for the final year of studies at UTP but for their career after graduation.

For example, a fourth-year mechanical engineering student completing his or her internship program at the *Petronas Malacca Refinery* would have had the opportunity to be exposed to a multitude of experiences including, but not limited to, the refinery process, plant management, the various process and support equipments, control measures, work procedures and safety systems and practices, all of which would be helpful to the student in deciding his academic and career path.

Benefit for All: Students, Industry & University

Upon completion of the program, the students will submit reports from which the university will benefit in the long run by utilising the students' experiences to further develop or refine its curriculum to meet industry's demands. Industry employers also have thus the opportunity to play an active role in developing the expertise required by industry by moulding the incoming interns to their expectation, according to the respective job specifications, so that in the long run, industry employers will also benefit as the program will help to generate graduate engineers who are able to serve and meet the rigorous expectations, demands and requirements of the industry in terms of human resource and intellectual capital[23].

Thus, in addition to being a platform for students to relate theory to practice, other important benefits of the program include serving as both an industrial feedback for the university in which the university gains in curriculum development and refinement and a feed forward for the students in which they gain in their personal academic and career planning. At the same time, the industry has much to benefit by making sure that the progress of academics is in harmony with developments in industry.

Internship Program Structure

When the host company receives an intern from UTP, personnel from the university's IIU will be present at the host company's place of business. During this initial visit, the host company's management is briefed by the UTP staff on the internship program structure, assessment procedures and the responsibilities of all sides involved in the programme: UTP, the host company and the interning student[19].

To ensure effectiveness of the internship program, the host company will provide support by appointing a training coordinator who will help to plan and schedule the student's overall program according to the student's field of study, for optimum benefit to both parties. The host company will also select for the student an

experienced employee to act as plant supervisor for the entire duration of the program.

Apart from the responsibility to guide and manage the interns, the plant supervisor has the authority and privilege to assess the student's performance. To ensure maximum benefit is derived from the internship programme, both UTP and the host company will carry out the intern's assessment: the intern is jointly evaluated by his or her supervisor at UTP and by the plant supervisor of the host company.

Assessment Procedure & Guidelines

Assessment is performed through evaluation of the student's logbook, oral presentation and final report and through performance review, with the assessment by the host company weighted more than that by UTP: 55 % compared to 45 %, which reflects the important role and commitment conferred by the university to the host company. Students are assessed not only on their ability to undertake technical assignments but also on their receptivity and general attitude within a working environment[19].

UTP has set up guidelines to ensure that the various host companies across the industry perform assessment of their interns on an equal basis and against a common standard. This is partly achieved by listing nineteen desired attributes that the students must strive to achieve while discharging their responsibilities at the host company's premises. Additionally, plant supervisors are provided with standard assessment forms. Students must keep a logbook, for which UTP has provided guidelines on the standard format of entry and other requirements. In the logbook, the students shall record detailed reports of their activities at the host company on both daily and weekly basis and the logbook is endorsed by the student's plant supervisor[19].

The overall system of evaluation would be generally similar to the form of assessment employed by the industry on a new employee, before confirming his or her position in a company. It would normally take a company a period of between 3 to 12 months to assess new staff before they can be confirmed. Thus, the 32-week or

eight-month long UTP internship program gives ample time for the host company to reasonably form an evaluation of the interning students' performance.

Much of the above information has been derived from UTP's document entitled *Industrial Internship Guidelines for Supervisors*, a publication of the university's *Industrial Internship Unit*. Thus, detailed information of the assessment procedures or other related issues can be obtained from that booklet.

4.4 THE FINAL YEAR: SPECIALIZED STREAM & ELECTIVES

Specializing Within Mechanical Engineering: Gaining Exposure or Depth

For UTP students, the final year of study is a critical juncture of their academic life, as they need to decide on a very important issue that will presumably have a large impact and influence on their future academic and professional life. As shown in the diagram on the following page on UTP's fifth-year course requirements, there are four specialized elective courses that set apart the final year of study at UTP from the other academic years as it is during this final year that students embark on their specialization fields. Mechanical engineering students shall have to decide to concentrate on a specific area of study within the discipline, for which *Universiti Teknologi Petronas* offers 5 options as follows:

i) Mechatronics
ii) Materials
iii) Manufacturing
iv) Automotive
v) Petroleum

Each specialized elective stream is made up of four specialized courses that aim to give students exposure to and relative depth on that specific field of study. This ability to concentrate on a particular area of mechanical engineering illustrates UTP's investment on producing graduates with an edge over those from competitor universities. In an era of mass production of university graduates, UTP endeavours to ensure that its graduate engineers are non-generic; instead, they should be distinctive by acquiring an added dimension of knowledge.

This added dimension will involve either delving deeper into one specialised field within mechanical engineering such as automotive engineering or, broadening the mechanical engineering perspective – as in the case of petroleum elective - to absorb new extraneous and cross-disciplinary knowledge and synergise these new skills with those of classical mechanical engineering education to cultivate an

understanding of the multidisciplinary workings of, for example, the upstream oil & gas industry.

Figure 4.4: Fifth-Year Course Requirements at UTP

Semester 9		
	Course Title	**Credit Hours**
1	Manufacturing Systems	3
2	Engineering Economics and Entrepreneurship	3
3	Engineers in Society	2
4	Controls Lab	2
5	Final Year Design Project	4
6	Specialized Elective I	3
	Total	**17**

Semester 10		
	Course Title	**Credit Hours**
1	Final Year Design Project	4
2	Management Elective: Organizational Behaviour	3
3	Specialized Elective II	3
4	Specialized Elective III	3
5	Specialized Elective IV	3
	Total	**16**

Benefits of Specializing for Career in Industry or Advanced Studies

It is a fact that students may or may not end up with a career in their specialized field of study, as knowledge and skills from the sub-fields within mechanical engineering are inter-related, compatible and applicable with each other. Thus, a student specializing in materials would possibly secure a job in the automotive industry or, as is very common today, a student of mechatronics may end up working in manufacturing.

It is also a certainty that, as is strongly the case for the petroleum industry, only the best and highly-qualified graduate engineers - generally irrespective of their degree specializations - are recruited by the exceedingly selective oil and gas companies, service consultants or contractor companies. Thus, even though a student's overall academic performance is in general a more important factor of consideration compared to his or her specialization field, concentrating on a certain field within mechanical engineering can still serve as a distinguishing aspect working

to the advantage of the student. This is due to the fact that a student's particular specialization field is often a subject of great interest and concern to the employers of today and to the academic professionals.

As for employers of the industry, the student's specialization field can be a crucial factor in the filtering or selection process for potential engineering recruits, as it can assist them in identifying the best or most suitable graduate engineers from a pool of equally-qualified and indistinguishable pool of applicants. Many employers look for a specific area of expertise within mechanical engineering and thus the student's specialization area becomes an important distinguishing factor in the recruitment process.

In addition, if the engineering student intends to further his or her studies to the Master's or PhD. programmes, the student's particular specialization area within mechanical engineering is also an important consideration in the decision process for acceptance into graduate school, along with the student's overall academic achievements.

Final-Year Design Project: A Distinguishing Factor for Students

Besides the four specialization courses, final-year UTP students shall contend with a 2-semester long design project course. This *Final Year Design Project* course is considered a capstone of the engineering student's academic programme and training at UTP as this final project or research, in addition to his or her field of specialization, also serves as a distinguishing mark for the student when he or she joins the working world.

The design courses of the preceding years aim to stimulate students' interest in engineering design, introduce them to design concepts, grant them their first opportunities at putting theory into practice and familiarize them with project implementation procedures - all the while in a team environment. In contrast, the entire project for the *Final Year Design Project* course - from literature research, project proposal, design and analysis through to project implementation and report

presentation - is performed individually, albeit under the supervision of a faculty member. Backed up by the two previous project design courses - one each in the first and third years - and various laboratory and computer courses throughout their academic programme at UTP, students are expected to be well prepared for this final year design or research project.

For this course, students will need to pull together knowledge gained from preceding engineering courses and the various skills learned from previous design courses to produce a technically rigorous and well-researched analysis of a recent engineering problem or speciality topic, a well-developed computer simulation of a process or an innovative prototype of a component or device. The final approved topic for the student's project or research would usually depend on and influenced by the student's specialization field, on which he or she must decide in the final year at UTP.

At the completion of their research work or design project, students are expected to produce a technical report and must be prepared to convey their findings and results in an oral presentation, before a panel of faculty members. By maintaining a professional- and research-oriented structure for this final-year course, it is the university's aim that this course will stimulate students' interest in the area of research and development - or R&D for short - which has become increasingly crucial to the progress and competitive strength of various industries.

Through this course, the university also intends to encourage the more academically-motivated and research-inclined students to take up post-graduate education, to undertake more in-depth research work or more advanced study of a particular area in engineering science.

Design-Oriented Thinking for Problem Solving & Analysis

A mind trained to think from the point of view of design will be anticipative and thus more prone to consider future uncertainties and more responsive to variations in expected outcomes, compared to one trained merely to analyse. Therefore, all of UTP's design and research courses - especially this final-year design course - are also expected to cultivate in the engineering students, research- and design-oriented qualities that will positively influence their approach in engineering analysis and problem solving and even in dealing with non-technical matters such as financial and commercial aspects of a project.

Thus, these design courses will also benefit those students who have little interest in a research career – be it academic research or industrial R&D - even if their future engineering career is in production-oriented, output-driven industry, as these graduate engineers will have developed strong design-oriented problem-solving and analytical skills, received through these rigorous design and research courses.

Therefore, the objectives of this final-year project course along with the other design project courses of the previous years - which comprise a total of 13 credit units, or 35% of the total units offered by courses under the MEEM's *Practical* category - are in line with the aspirations of the university to produce not only distinctive graduate engineers with a certain specialization expertise but also innovative, results-orientated and dare-to-be-different engineers capable of contributing towards the creation of indigenous Malaysian technology.

More Social Science Studies: Economics, Organization & Society

In addition to the final project course and the four specialized elective courses, a series of 3 courses on economics, organizational behaviour and engineer's ethics are also offered in the final year at UTP. The first, titled *Engineering Economics and Entrepreneurship* deals with the significance of economics in the viability of any engineering investments or decisions. Students learn to evaluate a project's worth through the various measures such as economic indicators, cash flow balance and public financial reports.

Students will also learn to assess the impact on project viability, of capital expenditures, operating expenditures and various taxation regimes, not only in the short term but also throughout the project life cycle. Measures of Net Present Value, Rate of Return, Return on Investment, salvage value, inflation and depreciation are among some of the topics that will be explored at length in the duration of this course.

In this course, students are also introduced to the challenges involved in the start-up and the operation of small businesses. Ideally however, theories covered in a course such as this will be better digested and retained if delivered through a "simulated business development" sessions or workshop[25]. Looney and Kleppe's novel approach to teaching entrepreneurship to electrical engineering students at the University of Nevada can be applied to UTP's scenario albeit with some modification.

In this *Engineering Economics and Entrepreneurship* course, UTP students get together in small groups to discuss the establishment of a desired company structure. Within the imaginary model company, the students then move through a full cycle of business development to expose, train and familiarize them on implementing business economics, practices and decisions. Potential product or design ideas are explored and evaluated and product or project feasibility studies are performed, which include economic evaluation of the product or project, market research and financial funding and deliverability.

The second course *Organizational Behaviour* aims to educate students on how to be successful and effective in an organizational environment, when they set their foot on the corporate world. Students are introduced to the concepts of the firm, the structure and design of an organization system and the rationale, philosophy and theories behind a corporation's formation and structure.

Teamwork, interpersonal communication, leadership, power & politics are discussed and explored within the context of group dynamics and group behaviour. Issues related to an individual's behaviour within an organization including an individual's decision-making, personality, ability, values and perceptions are studied, especially with respect to the impact, influence and risk these factors pose on the functionality and efficiency of the organization as a whole.

Human resource policies, work cultures, stress management and other relevant corporate administration issues are further topics into which students of the course *Organizational Behaviour* will delve. Additionally, students will also explore the functions, challenges and benefits of being in a managerial position as it is an objective of this course that by bringing the various organization leadership concepts on a personal level, the course will help students to become effective and successful organization leaders and managers of the future.

Last but not least, the course *Engineers in Society*, which is a continuation of the earlier third-year course *Technology, Society & Development*, carries on with the effort to instil personal consciousness and professional sensitivity into these future engineers and managers. The students must realize the importance of being conscious and sensitive towards both the positive and negative impacts that may result from their actions and decisions in the future capacity as engineering professionals, to the progress and well-being of society, the environment and the cultural and political dimensions in which they work and earn their living.

While the previous course would have introduced students to the effects and impact of technology on society, this upper-level course attempts to specifically explore the engineer's roles and relations to society, from the local and global perspective. Students are taught in this course to define, develop and recognize the

social responsibility of engineers and how to cope with the ensuing moral, environmental and socio-political dilemmas. Ethical issues are brought to life with case studies on common practices of today such as gift-giving, occurrences such as unions and strikes and matters related to effluence emission, sub-standard product quality and product defects, all of which are important issues affecting the engineer.

In this course, students are also encouraged to engage in open discourses on the so-called 'grey area' of responsibility - its moral and ethical boundaries, on priorities and expectations of stakeholders in project design and development and on other responsibilities that an engineer must uphold in practicing their trade. Additionally, safety and environmental concerns are discussed in the course within the context of protecting society's welfare, which include preventive engineering and using resources in a sustainable manner.

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PART B

5.0 PETROLEUM ENGINEERING EDUCATION

5.1 PETROLEUM ENGINEERING SPECIALIZED STREAM AT UTP

5.1.1 Philosophy and Objectives of UTP's Petroleum Education

As stated in the previous section, petroleum is one of the five specialization streams offered to UTP's mechanical engineering students. There are three aspects to the rationale for having a petroleum specialization elective at UTP:

The first and foremost concerns UTP's main objective of offering petroleum education – why petroleum engineering is taught at UTP. The second aspect to the matter relates to the advantages and effectiveness of offering petroleum education as a specialized stream under the mechanical engineering program, as opposed to conferring a full petroleum engineering degree. This subject will be discussed at length and in great detail in section 5.3 of this paper, along with the third aspect of the issue of petroleum education at UTP, which pertains to the rationale for offering petroleum electives under both mechanical engineering and chemical engineering programs.

The current section shall attempt to address the first aspect of the rationale for offering petroleum specialized stream at UTP: what is the primary motivation for UTP to provide education on petroleum engineering?

Rationale for Offering Petroleum Engineering

Petroleum activities, ranging from upstream exploration and production to downstream refining and processing, represent the core business of the *PETRONAS* group of companies. Thus, the demand and supply for specific technical expertise in the various disciplines within the petroleum sector is a major and direct concern of the company, not to mention a critical factor for the company's business growth and development. Therefore, one essential reason that UTP offers petroleum education is to provide for the current and future manpower needs in petroleum engineering, of its parent company *PETRONAS*.

The *PETRONAS* group has established an Education Division that oversees the implementation of education and training programs to meet the company's corporate needs. The Education Division is responsible for, among others, the establishment of education institutions, ranging from early kindergarten facilities to tertiary-level university – the *Universiti Teknologi Petronas*.

Thus, UTP, being one of *PETRONAS'* major investments in the field of education, plays a key role in providing companies within the *PETRONAS* group with a pool of prospective engineering professionals and the petroleum sector is indeed one of the crucial areas that require the human capital.

PETRONAS is not only a major contributor to the national economy but also a company which aspires to be a key participant in tertiary education and training in Malaysia, as discussed earlier on in this paper. Thus, being the company's subsidiary, UTP would be able to help *PETRONAS* realize this role by, among others, generating petroleum professionals not only for the manpower needs of *PETRONAS* but also for the entire national job market.

Nevertheless, being the parent company of UTP, *PETRONAS* has the advantage of having the first picks of graduates of the university to work for any of its subsidiaries, since those students who excel in their first 2 semesters of study at UTP will be offered a sponsorship program from *PETRONAS* for the remaining duration of their studies and under the terms of that scholarship, sponsored students will be contracted to work for

PETRONAS for a minimum number of years upon completion of their undergraduate program. Being able to absorb the cream of UTP's graduate engineers into *PETRONAS'* workforce can no doubt provide a momentum for continued progress of the company within the oil and gas industry, in the region and around the world.

Universiti Teknologi Petronas is committed to establishing itself as a leader in technology education and a centre for creativity and innovation through, among others, a distinctive academic curriculum, distinguished faculty members, small classes and cutting-edge technology research. At present, the petroleum specialization stream at UTP is aimed at exposing its mechanical engineering students to knowledge of the upstream oil and gas industry and thus, the program is aimed to produce engineers who are trained and capable to work in this field.

In the future however, the petroleum programme is expected to grow and evolve to eventually assume the role of a centre for the exchange of ideas, knowledge and experience and a centre for research and development in the area of oil and gas engineering, for the country in particular and the Asian region at large. The university currently confers a Bachelor of Engineering degree in mechanical engineering with specialization in petroleum. However, it is an aspiration of and a challenge for the university to extend its capabilities to become an institution that confers degrees in specialist petroleum-related subjects on both the master's and doctorate levels.

Monologue 1: Introduction to Malaysian Oil & Gas Industry

The global petroleum industry has grown tremendously since Edwin Drake discovered the first commercial well in Pennsylvania, in 1859[45]. Initially used as lighting oil, petroleum has since been an important catalyst fuelling the development of our industrialized civilization. As reported in a publication of the *Australian Institute of Petroleum*, petroleum fossil fuels currently meet 80 % of the world's transportation fuel demand and nearly half of the world's primary energy demand[44].

The following paragraphs describe the current scenario of the upstream Malaysian oil & gas industry and its trend for the future, which are both important considerations in discussing the subject of petroleum engineering education. This "background" information should be insightful and beneficial in understanding the rationale behind UTP's petroleum specialization curriculum.

In Malaysia, petroleum was first discovered as early as July 1882 in the Baram district of Sarawak - of the Borneo subcontinent, now one of the two states of East Malaysia - by the then British Resident of the state. Initially, the discovered oil was used for medicinal purposes before locals started to use it as lighting oil and waterproofing of boats. Only in 1910, did a company call the *Anglo-Saxon Petroleum Company* - precursor to the present *Shell* of Sarawak, begin to commercially explore for petroleum in the state of Sarawak. Although oil was successfully found in the town of Miri, further attempts to explore economically-sized fields onshore met with failure[15].

Yet, with new improvements in offshore petroleum technology during the 1950's, attention for petroleum exploration activities in Malaysia shifted seawards, so that by 1962, offshore exploration activities began showing results with the discovery of oil in two areas off the shores of Sarawak. Following this, a rapid succession of other discoveries emerged in East Malaysia, in the waters of the Borneo subcontinent[15].

industry to thrive. Consequently, a multitude of opportunities exists for engineering students and professionals intending to pursue a career in this sector in Malaysia.

At present, for the purpose of drilling developmental wells in proven oil or gas fields in Malaysia, all facets of recovery mechanisms are employed, from the established conventional drilling techniques to those that involve more cutting-edge technology processes such as slim-hole drilling and coiled tubing drilling. In the more recent crude oil development projects such as the in-field drilling of the *Tiong* and *Bekok* fields offshore Terengganu, methods such as extended reach wells, horizontal wells and horizontal-multilateral wells were successfully employed. A senior executive of the *PETRONAS* Petroleum Management Unit testifies that these technologies are expected to continue to serve as standard options for drilling development wells in Malaysia.

Meanwhile, there is extensive work in the area of reservoir advancement. As Malaysia endeavours to improve its capability to produce in-house technology specific to the Malaysian petroleum reservoir characteristics, *PETRONAS'* research arm, *Petronas Research Science & Services* is working hard to develop packages for the modelling and simulation of the region's reservoir and basin, to facilitate work in current and future enhanced oil recovery projects.

Oil & gas produced in Malaysia originates from three major sedimentary basins, namely the Malay basin, the Sarawak basin and the Sabah basin. As of date, most of the major discoveries within these three basins are at the end of their production stage. The next challenge for the engineers responsible for these fields is to undertake comprehensive, albeit time-consuming reviews of field data and reservoir characteristics in order to rejuvenate these fields for enhanced oil recovery programs. In the near future, enhanced oil recovery (EOR) pilot projects and in-fill drillings would be the main scope of interest for these mature fields.

However, there exist three other major basins within Malaysian territorial boundaries that have yet to be developed and produced. These are the *Penyu* basin, *Northeast Sabah* basin and the *Southeast Sabah* basin. Presumably, these basins have not been developed due to their deepwater characteristics. A diverse range of

issues need to be considered in developing deepwater fields including, but not limited to, the particular drilling fluids and cement design requirements, the specialist equipments required for drilling in deepwater such as the marine riser, the rig system, wellhead and subsea equipments.

All the above considerations need to be carefully studied and coordinated by knowledgeable and experienced personnel to achieve a cost-effective development and an effective reservoir management program so as not to jeopardize the reservoir for future field production. Furthermore, the risks - which include among others, the safety of personnel - involved in the development of deepwater fields need to be offset by the economic returns and overall field performance of these fields.

On the periphery of the future of the region's oil & gas industry is the ASEAN member countries' plan for a *Trans-ASEAN Gas Pipeline and Power Grid* infrastructure, which is an ambitious gas pipeline network project that aims to connect major cities across the borders of the ASEAN countries in an effort to ensure long term security, availability and reliability of energy supply.

Currently, cross-border pipelines between Singapore and Malaysia and those between Thailand and Myanmar have been completed and have come on-stream. The next phase of the venture shall be seven separate pipeline networks connecting Malaysia, Indonesia, Thailand, Singapore, Vietnam and the Philippines, as described in Table 5.1.1 below[43]. These infrastructures are expected to be available before the year 2020.

Table 5.1-1: Trans ASEAN Gas Pipeline Interconnections

	PIPELINE INTERCONNECTIONS	DIAMETER (inches)	DISTANCE (km)	LIKELY YEARS OF OPERATIONS
1	Duri, Indonesia - Melaka, Malaysia	20	200	2005
2	W. Natuna, Indonesia - Duyong, Malaysia	18	100	2002/03
3	E. Natuna, Indonesia - JDA-Erawan, Thailand	42	975	2012
4a+4b	East Natuna - West Natuna, Indonesia - Kerteh, Malaysia	42/28	280	2010
4a+4c	East Natuna - West natuna, Indonesia - Singapore	42/28	720	2010
5	East Natuna, Indonesia - Sabah, Malaysia - Palawan - Luzon Philippines	42	1540	2015
6	Malaysia - Thailand JDA - Block B	20	140	2016
7	Pauh, Malaysia - Arun, Sumatera, Indonesia	36	365	2010

Most of the ASEAN countries are presently importing natural gas to meet their country's energy demand. After the completion of the *Trans-ASEAN Gas Pipeline* network, stranded and marginal gas fields will be more attractive for development. ASEAN countries should then be able to develop their gas fields and be assured of a market for their natural gas production. In the meantime, construction of the approximately 4,000-km long transmission pipelines (in total) between the various ASEAN countries is expected to generate numerous job opportunities for the various engineering companies servicing the region's oil & gas industry[43].

Additionally, Malaysian oil & gas operators need to face in the near future the task of decommissioning and abandoning of offshore structures that have come to the end of their design life. As of Jan 2001, Malaysia has 232 platforms built within its territorial boundaries. The distribution of these structures in Malaysian territorial water is illustrated in Figure 5.4.4. Unfortunately, Malaysia has not had any experience whatsoever in the process of platform decommission and

abandonment, as explained by Abdul Wahab in his paper on E&P co-operation among ASEAN countries[42].

In summary, it is projected that in the not-so-distant future, the Malaysian oil & gas industry would require manpower in the following areas of petroleum activity:

1) Enhanced oil recovery
2) Subsea development and deepwater technology
3) Pipeline design, construction and management
4) Abandoning and decommissioning of offshore structures

5.1.2 *The Four Petroleum Engineering Elective Courses*

Representing Main Subdivisions of Upstream Oil & Gas Industry

Universiti Teknologi Petronas offers the following four courses as the line-up for the petroleum specialization stream under the mechanical engineering curriculum:

i) Reservoir Engineering
ii) Drilling and Well Completion
iii) Petroleum Production
iv) Offshore Structures

These four courses have been selected from among the many subjects within petroleum engineering discipline, for they represent the main sub-divisions involved in the upstream petroleum industry[40]. As stated earlier, the motivation for offering a petroleum specialization stream under the mechanical engineering program at UTP is to expose mechanical engineering students to the essential skills of the upstream petroleum industry.

Since the above four subjects correspond to the primary areas of upstream petroleum activities, these courses would deliver the best coverage of the main subdivisions involved in the upstream oil & gas industry, as elaborated in the paragraphs below. Following that will be an explanation of course syllabus and contents for each of the four courses, along with a discussion on how these courses fit into UTP's mechanical engineering curriculum.

During the initial years of petroleum discovery, only rudimentary knowledge was available to extract oil from the ground to the surface. Petroleum was exploited in an inefficient and wasteful manner. Many oil fields had to be abandoned prior to full exploitation of its recoverable reserves due to poor understanding of reservoir characteristics or unintentional damage done to the formation. Throughout the years,

ongoing research and improvements in techniques materialized and environmental awareness heightened in the various activities of exploration, drilling and production of petroleum.

These developments have led to the discovery of potential new reserves, enhancement of productivity in the producing fields, extraction of the most recoverable reserve from the mature fields and production from previously inhospitable or technically challenging – thus uneconomical - reserves. Improved techniques in the areas of exploration, hydrocarbon recovery, drilling and production, to name a few, are part of the factors that have effectively broadened the scope of activity of the petroleum industry and have created more and more specialization areas within the industry, so that the petroleum sector has kept expanding over the years, both horizontally - as in the discovery of new reserves - and vertically - as in the increased diversity of the fields of expertise within the industry.

Considering the vast sector of the petroleum industry, with activities ranging from the initial geological studies to the final processing of crude petroleum to produce end products, the industry has long been regarded as consisting of two separate sections: the upstream and downstream sections. The upstream petroleum industry deals with the exploration, extraction, production and transmission of petroleum from the reservoir to the surface facilities, while the downstream section deals with the processing of petroleum as it arrives at the surface facilities until it is marketed and distributed to end users.

The upstream section is further divided into subsections that are characterized by the particular dominant activity involved in that subdivision; essentially thus, it is divided according to the sequence of stages involved in the cause of extracting petroleum from the reservoir: geological studies and formation evaluation, reservoir analysis, drilling and completion of production wells and finally, petroleum production.

This is in accordance with the conventions of the Society of Petroleum Engineers - internationally regarded as an authority in petroleum engineering practices and education and commonly referred to by its abbreviation SPE - which

has distinguished the various disciplines within petroleum engineering as "drilling, completion/ production/ facilities, formation evaluation and reservoir," as stated in an SPE paper on the establishment of professional competency guidelines for petroleum engineering[40].

Boundaries between these sub-disciplines are nevertheless not distinct; there exists overlap between the sub-sections as there is considerable knowledge that is inter-related and common to the different areas, not to mention intersecting scope of work and activities between the sub-disciplines, so that acquiring a sound foundation in any one sub-field would necessitate a strong understanding of the other sub-fields.

This is supported by a statement in the above-mentioned SPE paper that "all sub-disciplines share common knowledge and related tasks...and each sub-discipline requires specialized knowledge, understanding and ability (Bobo, et al.)"[40]. Consequently, an engineer expected to have the knowledge and skills of the upstream petroleum industry would be expected to be well-versed in all the relevant sub-fields of upstream activities, namely reservoir, drilling, completion and production.

Thus, in view of the practice of the petroleum industry in general and conventions of the SPE in particular, UTP's choice of subjects for three of the four specialized electives is most reasonable as these courses represent the main subdivisions in the upstream oil and gas industry, in line with UTP's intent of generating mechanical engineers skilled in upstream petroleum activities. As for justification for the inclusion of the course on offshore structures into UTP's program, the final paragraphs of this section on petroleum electives will present a discussion of this issue.

In the paragraphs that follow, a brief description is given on each of the four Petroleum elective courses offered under the mechanical engineering program at UTP, following which is a discourse on how these courses fit into the mechanical engineering curriculum. More specifically, it will address the issue of incorporating the study of upstream petroleum industry - as represented by the four elective courses - into a mechanical engineering program. The competence of final-year mechanical

engineering students to undertake these courses and the rationale for the sequence of the courses as they are offered at UTP will also be discussed.

i)

Reservoir Engineering

Although petroleum derivative products are used in all aspects of everyday life, for most Malaysians, the internal machinery of the petroleum industry is relatively and largely obscure. Indeed, UTP students coming into the petroleum elective stream have relatively limited knowledge of the upstream, or downstream, petroleum industry. Thus, R*eservoir Engineering*, which is designed to be the first course in the series of petroleum elective specialization courses, aims to give an overview of the upstream petroleum industry.

In this course, students will be given a historical perspective of oil & gas exploration activities around the world in general and in Malaysia and the Asian region in particular. Students will learn the developmental sequence involved in extracting hydrocarbon: from geological studies and surveys of the formation through to the time when the 'hydrocarbons' arrive at the consumers in ready-to-use end products. Career prospects for mechanical engineers intending to develop their career path within these various petroleum development stages will also be explored.

Students will be introduced to the principles and practices of reservoir engineering through a multitude of fundamental knowledge and concepts such as petroleum geology and petrophysics, formation of natural hydrocarbons and the distribution of hydrocarbon reservoirs. In addition, formation damage and evaluation, reservoir rock and fluid properties, volumetric and material balances for gas and oil reservoirs and multiphase flow of fluids in porous media are also dealt with in reasonable detail. The course will also educate students on reservoir optimisation and management, which includes determining optimum well siting and number of wells for optimum reservoir production and development.

It is an objective of this course that upon completion, UTP students will be able to propose an oil or gas field development by making basic formation evaluation, estimating the amount of hydrocarbon reserves in place and proposing the optimum well siting and spacing and number of wells required to optimise reservoir production.

ii)

Drilling and Well Completion

The next course scheduled under UTP's petroleum elective stream is *Drilling and Well Completion*, in which students will explore the different types of drilling methods and drilling systems available. Students will be exposed to the diverse components of a drilling rig, the equipments required for drilling a well, well hydraulics and well control, the selection of drilling fluids and well-bore stability and casing design and cementing. The course will also introduce students to the various concepts of and systems for drilling, which include conventional, horizontal, directional and multi-lateral.

Students will also develop an understanding of well construction and completion to maximize well productivity and are also familiarized with the various engineering parameters involved in determining the completion profile of a well: either a simple open-hole completion or a complex configuration of tubings to enable production of preferential pay zones. In addition, issues of smart wells will also be introduced and explored.

Upon completion of the course, students are expected to be able to design a rudimentary drilling sequence of a hypothetical field development, similar to a drill-on paper exercise performed by a working engineer in the field. Finally, students will be required to propose a well completion program that would optimise well productivity.

iii)

Petroleum Production

The third course in the petroleum engineering sequence is *Petroleum Production*, which gives an overview of the principles involved in the production of an oil and gas well. UTP students will be introduced to the concepts of reservoir fluid flow rates, pressure drops through production networks and static and flowing bottom-hole pressures. Determination of well deliverability through inflow and outflow performance will also be investigated, along with the artificial lift for maintenance and improvement of productivity.

Students will learn the factors for obtaining an optimum completion program, in terms of workover and intervention management, by studying the concepts of tubing design, well stimulation through hydraulic fracturing and matrix acidizing and water and sand control. In this course, students will also be introduced to the main concepts available for retrieving damaged or faulty equipment downhole.

Upon completion of the course, students should be able to identify suitable techniques and equipments for optimum well production and to implement good reservoir management.

iv)

Offshore Structures

In Malaysia, almost all of the petroleum exploration and development activities are done offshore; thus, the course *Offshore Structures*, which is the final course offered in the petroleum engineering series at UTP, plays a crucial role in making students understand the behaviour of structures in ocean environment. Students will be introduced to the concept of energy spectrum of the sea, plus topics on waves and wind forces such as linear wave theory and wave properties, wave spectrum models, wave force spectra and wind and

current effects, all of which are critical factors in the design of offshore structures.

Studies of fundamental naval architecture and metocean seas and of probability distributions are also included in this course. The course also presents to students the various types of offshore structures: fixed or floating, drilling or producing. Students will also attempt to comprehend engineering parameters considered in designing offshore topside and jacket or gravity-based structures. All facets in the design, fabrication, transportation and installation of these offshore structures will also be delivered in the course. Finally, students of the course will be taught the concepts of seismic and dynamic analysis of offshore platforms, of fatigue analysis and of mooring design.

Incorporating P.E. Courses into UTP's M.E. Curriculum: Competence of Final-Year M.E. Students and Rationale for Sequence of Courses

How would the first four years of education at UTP prepare mechanical engineering students for the Petroleum elective courses outlined above? It is reasonable to claim that the majority of petroleum engineering subjects share a common foundation in fundamental concepts of engineering science as contained in the study of mechanical engineering.

For example, for the course *Reservoir Engineering*, mechanical engineering students would be able to utilise knowledge gained from the earlier exposure to fluid dynamics, to study phenomenon such as fluid flow through porous media - multiphase or single phase - preferential flow, residual saturation and wetting of surfaces due to capillary pressure and to handle applications of Darcy's and Bernoulli's Laws, - all of which being important concepts dealt with in this course on petroleum reservoirs.

Also in this course, students will be able to understand the structures and phase behaviours of hydrocarbons when they recall pertinent concepts learnt in their chemistry and thermodynamic courses of the preceding years. Obviously, there is

bound to be technically foreign material delivered in the course, such as petroleum geology and petrophysics, formation evaluation and reservoir management but in general, the level of depth and rigor on which the new concepts are taught is not at all difficult to digest.

The course involves only broad applications of the concepts explored and thus, students will find the new knowledge interesting as they are introduced to the upstream petroleum industry in this first course scheduled for the petroleum specialization stream. For mechanical engineering students to be able to technically handle the concepts taught in this course on reservoir engineering, they would need to have a good passing grade from the thermodynamics and fluid mechanics courses.

To construct an oil or gas well, rotary drilling methods are involved, along with the various mechanical systems and equipments required to drill the well. Within the oil or gas well, a complex system of pipes, valves, packers and mandrels is used to enable isolated or simultaneous flow of hydrocarbons from the various layers of the pay-zone.

Thus, for UTP's course *Drilling and Well Completion* – second in the series of Petroleum elective courses - mechanical engineering students should be able to cope well with the materials taught in the course as they are expected to have gained the necessary theoretical groundwork from the previous courses on thermodynamics, kinematics and dynamics of machines and control systems, to name a few. They should thus be technically comfortable with the application of equipments such as pumps, diesel engines, compressors, rotary gears, valve and pipe manifold systems and the various types of control systems covered in this course.

Furthermore, through previously gained knowledge on temperature and pressure effects that lead to stress, collapse and buckling effects on tubular sections - gathered from preceding thermodynamics courses - mechanical engineering students would not have difficulty comprehending concepts employed within the drilling and completion processes, such as well stability, pressure profile within wells and reservoir systems, pressure surges and swabs in well control applications and pore pressure fundamentals. Thus, students with a sound knowledge of hydraulics and

pressure can presumably grasp with relative ease material delivered in this course on drilling and well completion.

As for the third course in the series of Petroleum electives at UTP, *Petroleum Production*, mechanical engineering students will again find as familiar concepts introduced in this course: reservoir fluid flow rates, static and flowing bottom-hole pressures and pressure drops in production networks, for instance, due to their exposure to these topics in the previous *Fluid Dynamics* course. Likewise, various pumping and compressing methods and equipments used for the maintenance of deliverability and improvement of productivity, such as the use of artificial lift, will just be an application of concepts learnt in preceding courses on thermodynamics.

There are a variety of equipments and tools that are available as options in a well completion program, a workover schedule and a maintenance program employed for the well, which incidentally reflects an overlapping scope of knowledge with the previous course on drilling and well completion. Coming from a mechanical background, students will be able to appreciate the design and functions of these various tools and equipments.

New petroleum-related material covered in this course includes tubing design, well stimulation through hydraulic fracturing and matrix acidizing, water and sand control and determination of optimum balance in terms of workover and intervention management. Students with a sound foundation in the physical and chemical sciences and a strong grasp of thermodynamic and fluid mechanic concepts will be able to utilize fundamental concepts learned from previous coursework in these new applications that are specific to the petroleum industry. Thus, students will find this course as another instance of applying concepts and knowledge gained from previous classes into an industry-specific environment, specifically the upstream petroleum industry.

The final course in UTP's petroleum specialization series is *Offshore Structures*. Although the subject of offshore structures is not regarded by the Society of Petroleum Engineers as one of the sub-disciplines of petroleum education, UTP

has included it in its petroleum syllabus for it is nonetheless one of the main ancillary disciplines strongly tied to the upstream petroleum industry.

This is especially the case in Malaysia where indeed, as mentioned in the section on course syllabus above, almost all of the petroleum exploration and production activities are carried out offshore. It is therefore wise for mechanical engineering students to not only have a strong understanding of the various types of offshore structures employed in the industry and the behaviour of these structures in ocean environment - as has already been mentioned - but also to comprehend the engineering parameters considered in designing these offshore structures, which include the topside facility, the steel jacket and the gravity-based structure.

A multitude of topics, ranging from the design and fabrication to the transportation and installation of these offshore structures are delivered within the course. Mechanical engineering students will find that the various facets of the design process of these offshore structures are rooted in familiar engineering design principles on which they were trained in the previous years' design courses.

Basic concepts of static mechanics, dynamic mechanics and strength of materials learned earlier in the fundamental engineering science classes are applied together with new concepts learned in this course such as those on waves and wind forces, in seismic and dynamic analysis of offshore platforms, in fatigue analysis and in mooring design to provide a complete understanding of the workings of offshore structures.

Since the objective of the Petroleum specialization program at UTP is to produce engineers mainly for the local job market, characteristics of the local petroleum industry present an important factor in the design of such program's curriculum, justifying the inclusion of the course on offshore structures into UTP's syllabus.

With regards to the skills and knowledge on offshore structures, mechanical engineers specializing in petroleum are presented with a broad range of engineering positions; they can secure a career in not only the design and fabrication of offshore

structures but also in the operation of offshore facilities and equipments - an area of the industry with a diverse array of professions and offering substantial career prospects.

5.2 PETROLEUM ENGINEERING PROGRAMMES AT OTHER UNIVERSITIES

Since one of the main topics of discussion for this paper is the subject of UTP's petroleum specialization stream offered under its mechanical engineering program, it would be beneficial to view other similar programs on petroleum engineering education delivered at other universities. This brief overview is provided solely for the purpose of comparison of programs and gaining a better perspective on the motivation for UTP's petroleum engineering curriculum and for determining the effectiveness of the existing curriculum in light of the Malaysian oil & gas industry. Thus, this section serves to provide background information for these important issues, which shall be discussed in the sections that follow.

There exists a multitude of academic models across the world for the teaching of petroleum engineering. These academic models can be classified into two main curriculum structures: a pure petroleum engineering degree curriculum and a specialized petroleum stream incorporated under a more general engineering discipline of, for example, mechanical or chemical engineering.

In this paper, the programs of two universities, *Texas A&M University* in the U.S. and *Universiti Teknologi Malaysia,* shall be briefly described as examples of the former model of petroleum education and that of the *University of Southern California* as illustration of the latter type of curriculum, which is essentially similar to that of UTP.

5.2.1 Pure Petroleum Engineering Degree

As explained previously, petroleum engineering is the study of economically extracting hydrocarbon products from the earth. This involves exploration for and study of potential oil-bearing rock formation, design, drilling and operation of wells and well systems and sensible management of underground reservoirs to achieve maximum extraction of hydrocarbons from the reservoir.

A pure petroleum engineering curriculum would typically deliver an extensive, in-depth coverage of the subjects of geo-sciences and petroleum engineering. Thus, in this structure of curriculum, petroleum engineering and geo-science courses become the main disciplines of study – apart from the foundation science and engineering courses - representing at least 30 % of the total undergraduate credit hours required for graduation.

As mentioned above, two such models of this curriculum – that of Texas A&M University and Universiti Teknologi Malaysia - are outlined below, describing briefly the required courses and the corresponding credit loading for each university's program.

Petroleum Engineering Curriculum at Texas A&M University

Texas A&M University, of the U.S.A., has made a name for itself as one of the world's leading and most prestigious institutions in the field of petroleum engineering education. Its petroleum engineering program has consistently maintained its rank in the top-ten list of American institutions that offer P.E. The department was recognized as the best undergraduate petroleum engineering education provider in the United States for the year 2000 by the *US News and World Report*, and by the *Gourman Report* in 1996 by the National Education Standards[35].

The undergraduate engineering curriculum at Texas A&M requires a minimum of 131 credit hours to graduate. For students of petroleum engineering, at least 51 out of the 131 credit hours are dedicated to geo-science and petroleum

engineering courses, a staggering percentage of almost 40% of the total credit hours required for graduation[35]. The university confers a Bachelor of Science degree with major in petroleum engineering; thus, it offers a full B.Sc. degree in petroleum engineering, as opposed to a specialized petroleum stream within a major engineering program.

Table 5.2-1 on the following page shows a breakdown, by subject matter, of the required credit hours and courses offered under Texas A&M 's petroleum engineering undergraduate program. For effective comparison, the table categorizes the courses into the following subject areas: Petroleum Engineering courses broken down to Reservoir Sub-field, Drilling Sub-field, Production Sub-field and Broad-based Petroleum-Related Subjects; Geo-science courses and finally, Engineering Core Studies, to be in accordance with previous discussions on UTP's program of studies.

Table 5.2-1: Petroleum Engineering Degree Program Course Breakdown at Texas A&M University

Petroleum Engineering Courses	Credit Loading
Reservoir Sub-Field:	20
Reservoir Petrophysics (4)	
Reservoir Fluids (4)	
Formation Evaluation (4)	
Reservoir Models (3)	
Reservoir Development (2)	
Reservoir Description (3)	
Drilling Sub-Field:	9
Drilling and Production Systems (3)	
Well Drilling (3)	
Technical Elective (3)	
Production Sub-Field:	6
Well Completion and Stimulation (3)	
Well Performance (3)	
Broad-based	18
Petroleum-Related Subjects:	
Introduction to Petroleum Engineering (1) OR	
Petroleum Engineering Systems (1)	
Petroleum Project Evaluation (3)	
Petroleum Engineering Numerical Methods (3)	
Directed Study (1)	
Geostatistics (3)	
Technical Presentations (1)	
Systems Safety Engineering (3)	
Summer Internship (NA)	

Geo-science Courses	Credit Loading
Physical Geology (4)	7
Petroleum Geology (3)	

Engineering Core Studies	Credit Loading
Conservation Principles in Engineering Mechanics (3)	21
Conservation Principles in Thermal Science (3)	
Conservation Principles of Control Mechanics (3)	
Principles of Materials Engineering (3)	
Principles of Electrical Engineering (3)	
Engineering Ethics (3)	
Comm. for Technical Professions (3)	

It is evident from Table 5.2-1 that the curriculum emphasizes the sub-field knowledge of reservoir studies, for which it has allocated an amount of 20 credit hours, while the other sub-fields of drilling and production have courses worth 9 and 6 credit hours respectively. This implies the program's emphasis on reservoir studies.

The university also endeavours to provide a broad-based petroleum education by apportioning 18 credit hours to broadly-designed engineering courses that impart skills relating to project management and communication, technical presentation and writing skills, safety awareness and many more, all within the context of the oil & gas industry's perspective and practices. Texas A&M University ensures the balance between theoretical knowledge and practical skills by incorporating laboratory practices, software and simulation package familiarization and a compulsory internship program of a six-week minimum duration.

Petroleum Engineering Curriculum at Universiti Teknologi Malaysia

The second model of an undergraduate pure petroleum engineering program is taken from a Malaysian setting: the Universiti Teknologi Malaysia located south of the peninsular. Universiti Teknologi Malaysia has been generating petroleum engineers for the local oil & gas industry since 1975. The inception of the program has its roots in the 1970's oil crisis which led oil-producing countries including Malaysia to realize the importance of controlling and managing their petroleum reserves to ensure the supply of precious fuel energy for the continued development of their country.

The university offers petroleum engineering at both the Diploma and Bachelor of Science levels. Throughout the years 1990 to 1998, the university produced on average, 24 B.Sc. graduates and another 24 Dip.Sc. graduates annually in petroleum engineering[36].

The petroleum engineering degree program at Universiti Teknologi Malaysia has a typical pure petroleum engineering structure: the curriculum requires a minimum of 128 credit hours for graduation, with a minimum of 50 credit hours out

of these allocated to the study of geo-sciences and petroleum engineering, which amounts to almost 40 % of the total credit hours, identical to the curriculum of Texas A&M University[36]. Table 5.2-2 on the following page illustrates a breakdown of Universiti Teknologi Malaysia's courses and their corresponding loading, retaining the same categories and course grouping as before.

From the table, it is clear that Universiti Teknologi Malaysia, as is the case for Texas A&M University, also concentrates its teaching on the sub-field of reservoirs, dedicating a total of 14 credit hours to these courses. Courses on the topic of drilling make 4 credit hours while courses in the sub-field knowledge of production represent 9 credit hours out of the total credit loading required for petroleum engineering students.

Additionally, there exist similar types of courses offered under the category of Broad-based Petroleum-Related Subjects, for which 15 credit hours' worth of courses have been allocated. These include the standard courses on petroleum engineering fundamentals and economics, field development project course and a final-year undergraduate project.

As for engineering science, typical courses on mechanics and thermodynamics are offered, along with a course each on electrical technology, material engineering and computer programming. A discernible difference between this program and that of Texas A&M University lies in the former's lack of courses on "soft-skills", which can otherwise help develop in the students effective communication and presentation skills, educate them on engineer-society relation, engineer's work ethics and people management and organizational skills.

The above may be due to a lack of teaching resource or to an engineering education philosophy of only to produce standard engineers able to join the workforce, with the emphasis placed mostly on technical competencies and little on personal skills and qualities. This philosophy in turn, may have risen from the feeling of urgency to respond to the rising human resource demands of the industry, leaving less concern on the soft skills and other apparently less important characteristics and qualities of an engineer.

Table 5.2-2: Petroleum Engineering Degree Program Course Breakdown at Universiti Teknologi Malaysia

Petroleum Engineering Courses	Credit Loading
Reservoir Sub Field:	14
Formation Evaluation (3)	
Reservoir Rock & Fluid Properties (3)	
Reservoir Engineering (3)	
Reservoir Engineering Lab (1)	
Petroleum Testing Lab (1)	
Reservoir Simulation (3)	
Drilling Sub Field:	4
Drilling Engineering (3)	
Drilling Engineering Lab (1)	
Production Sub Field:	9
Petroleum Production Engineering (3)	
Well Completion (3)	
Well Testing (3)	
Broad-based Petroleum Related Subjects:	15
Fundamental of Petroleum Engineering (2)	
Petroleum Economy (3)	
Field Development Project (3)	
Undergraduate Project I & II (4)	
Industrial Training (0)	
Technical Elective (3)	

Geo-science Courses	Credit Loading
Basic Geoscience &	8
Geoscience Lab (4)	
Geology Field Work (1)	
Petroleum Geology (3)	

Engineering Core Studies	Credit Loading
Engineering Mechanics (3)	24
Electrical Technology (3)	
Fluid Mechanics (3)	
Material Engineering (3)	
Numerical Analysis (3)	
FORTRAN Programming (3)	
Thermodynamics (3)	
Project Economy (3)	

At UTP however, development of these soft skills are far from being disregarded. From the very first year, students are exposed to the importance of effective communication skills and analytical thinking in the courses *Engineering Profession and Communication* and *Analytical Skills and Critical Thinking.*

Throughout the subsequent years, at least 5 other courses, culminating in the final year's *Engineering Economics and Entrepreneurship, Engineers in Society,* and *Organizational Behaviour,* which introduce students to vital skills and qualities that would enrich UTP's engineering graduates and make them stand out against those from other local universities.

5.2.2 *Specialized Stream of Petroleum or Oil & Gas Engineering*

More often than not, the curriculum model of specialized stream of petroleum education is opted to produce graduates who have relative breadth in the knowledge and skills of oil & gas engineering, to allow for the understanding of new concepts within the context and framework of a more traditional engineering discipline.

Such curriculum is developed to produce an interdisciplinary exposure between two individual fields of study: a major discipline with a specialization field. Under such philosophy for engineering education, students at the undergraduate level need not delve deep into or be focused on any particular sub-field of, in the present case, the petroleum industry.

However, should a student develop an interest to gain further command of the knowledge of a certain field, he or she should be given the necessary support and encouragement to do postgraduate work and pursue a Masters of Science or a Masters of Engineering degree in that petroleum sub-field topic. Of course, this does not apply only to university students but also to working professionals, who can go for postgraduate work at a much later time after they have left university.

This is common in the oil & gas industry, whereby engineers acquire an advanced degree or a graduate diploma or even just a specialist certificate after being

in the workforce for some time and they may enrol in such programs as full-time or part-time students. In fact, some industry or academic professionals would have the opinion that a specific petroleum engineering curriculum may not be entirely necessary, especially if one considers the Malaysian oil & gas industry, as specialization into a particular field of work within the oil & gas industry can and does normally take place under post-graduate or industry specialization programs at tertiary institutions or specialized training centres.

The above issue will be discussed at length in the later sections of this paper, on the advantages and effectiveness of specialized petroleum stream curriculum, as opposed to pure petroleum curriculum.

Petroleum Engineering Curriculum at the University of Southern California

At the University of Southern California (USC), specialization studies into petroleum engineering are available for interested mechanical or chemical engineering students. This petroleum engineering specialization delivers broad-based knowledge for a career in the petroleum industry or other industry where there is a need for "the exploration, recovery and production of subterranean resources, and the underground disposal of hazardous waste, " as stated in the university's on-line catalogue[37]. The program also helps to prepare motivated students for graduate work in the field.

Table 5.2-3 on the following page shows the university's curriculum for Bachelor of Science degree in Mechanical Engineering with specialization in Petroleum Engineering. The courses are again broken down according to the categories and sub-fields used above, listed with each course's credit hours.

Table 5.2-3: Petroleum Engineering Specialization Program Course Breakdown at the University of Southern California

Petroleum Engineering Courses	Credit Loading
Reservoir Sub Field: Introduction to Transport Processes in Porous Media (3) Petroleum Reservoir Engineering (3)	6
Drilling Sub Field: Drilling Technology and Subsurface Methods (3)	3
Production Sub Field:	0
Broad-based Petroleum Related Subjects: Senior Design Project (4) Senior Seminar (1) Technical Elective (3) ME Core Elective: Upper-level ME Course (3)	0

Geo-science Courses	Credit Loading
Formation Evaluation (3)	3

Engineering Core Studies	Credit Loading
Intro to Mechanical Engineering & Graphics (3) Intro to Computational Methods in Mechanical Engineering (4) Mechanics I (5) Mechanics II (5) Engineering Thermodynamics I (3) Fluid Dynamics (4) Materials Science (4) Linear Control System I (3) Computer Aided Design of Mechanical Systems (3) Computer Aided Analysis for Aero-Mechanical Design (3) Experimental Engineering (3) Experimental Engineering Laboratory (3) Mechoptronics Laboratory I (3) Mechanical Laboratory II (3) Mechanical Engineering Problems (3)	52

As shown by the petroleum specialization program course breakdown in Table 5.2-3, the program at University of Southern California is essentially a classic mechanical engineering program curriculum with an added value of four courses i.e.

1. Introduction to transport processes in porous media
2. Petroleum reservoir engineering.
3. Formation evaluation
4. Drilling Technology and subsurface methods.

These courses contribute to 12 units of the total 131 units students required to graduate from the Mechanical Engineering department. These four courses are aimed to provide students with exposure on understanding single and multiphase flows in porous media, insight on the properties and characteristics of reservoir fluids and rocks through knowledge of petroleum geology, interpretations of well logs and processes and equipments utilized in drilling and completions operations.

The first three courses offered at USC in the petroleum specialization options predominantly deals with the subfield knowledge of reservoir and subsurface characteristics. Although the university has allocated one course which imparts knowledge on the subfield of drilling and completions, the university fails to address the issue of petroleum production. The author believes that this will not provide students with balanced knowledge on the upstream petroleum industry. After all, production of the petroleum products from the field is the main portion of the field life cycle.

In contrast, UTP has distributed its petroleum specialization courses evenly to cover the full spectrum of the upstream petroleum subfields. Courses at UTP impart balanced knowledge on all 3 of the main petroleum engineering subfield as defined by the Society of Petroleum Engineers. These defined subfields are :

1. Formation Evaluation/Reservoir Engineering
2. Drilling and Completion
3. Production

Additionally, realising the significant upstream activities present in the Malaysian Exploration and Production scenario, UTP has included a course on offshore structures within its petroleum specialization curriculum. The rationale for UTP in offering a wide range of courses covering the full spectrum of the upstream petroleum industry is to ensure that graduates from UTP have a broad range of knowledge and exposure to the industry and thus will not be unfavourably locked into any particular niche. The university believes that this will allow UTP graduates to move across the Oil and Gas industry with relative ease and confidence.

5.3 ISSUES CONCERNING PETROLEUM ENGINEERING EDUCATION

5.3.1 Advantages of Specialized P.E. Stream over Pure P.E. Curriculum

A Broad-based Curriculum Exposing M.E. Students to Upstream Petroleum Industry

It is a mission of *Universiti Teknologi Petronas* to produce engineering graduates who are well-rounded, ready to diversify into any specific industry or specialization field within their disciplines and capable to technically adapt to the field's knowledge and skills requirements.

As mentioned earlier on in this paper, this objective will help ensure that these future engineering professionals do not set their mind to only one particular industry of interest; instead, they should be well-prepared for today's continually evolving and rapidly progressing world of engineering. It will help to safeguard them from being undesirably locked in to any specific industry and ensure that they are not vulnerable towards the vagaries and uncertainties of the characteristically precarious job market.

In accordance with this philosophy, the university has designed its petroleum specialization stream to include a broad-based curriculum that is able to expose its mechanical engineering students to the various facets of the upstream petroleum industry. In contrast to universities that offer pure petroleum curriculum, the objective of UTP's petroleum stream, as stated in the previous sections, is not to produce

petroleum engineering graduates who are specialists in the areas of reservoir, drilling or any of the sub-fields within the discipline, with in-depth knowledge in all these fields.

Instead, it is the aim of the program to engender engineers who upon graduation do not only possess the fundamental expertise in the field of mechanical engineering but also have the added value of breadth of study, skills and working knowledge of petroleum engineering and the upstream oil & gas activities.

The above paragraphs explain UTP's underlying objective for providing a specialized petroleum stream under the mechanical - and chemical – engineering programmes, as opposed to offering a pure petroleum engineering degree. In the following paragraphs, the advantages of a specialized petroleum stream over a pure petroleum curriculum are discussed, within the context of Malaysian industry especially.

Avoiding "Over-Specialized" P.E. Graduates Disinclined to Work In Other Industries

Petroleum education is unique in the sense that it is tightly bound to the oil & gas industry. In the paper "*Overcoming Declining Enrollments in Petroleum Engineering*," Rogers and Carley believe that the declining interest in the mid-1980's among students to take up petroleum engineering for their degree has its roots in the fact that petroleum graduates are closely bound to the oil & gas industry - ups and downs of the industry have direct and severe impact on the employment status and recruitment process of its engineers[41].

What this close relationship entails is that support and acceptance from this highly specialized industry, of university graduates, are instrumental in ensuring that these entry-level engineers can set their foot into the industry. They claim that this relationship is in turn due to these two factors: petroleum companies stereotyping them as being "too specialized" and the graduates' high interest in the field and thus their disinclination to change to a different industry.

Petroleum engineering graduates may feel disinclined to work in a different industry considering the extent of education and training they have received in this specialized field and obviously the amount of labour they put into their studies. Intrigue and strong disposition for the field are thus some reasons that could make it difficult for pure petroleum graduates to voluntarily switch to a different industry.

At the same time, industries may stereotype and consider graduates of pure petroleum engineering as being too specialized in their engineering education. In conclusion, according to Rogers and Carley, an employment downturn in the oil & gas industry is seldom offset by recruitment of entry-level petroleum engineers into other industries.

Cyclic Nature of Petroleum Industry Affecting Recruitment Trend of New Graduate Engineers

The cyclic recruitment trend of the industry have led to the cyclic nature of tertiary enrolments in petroleum engineering programs to the extent that in the U.S., at certain times "enrolments soared to unmanageable levels" but at others, "there were not enough students graduating to replace the natural attrition of engineers in the industry" [41]. At present, the subject of declining interest or enrolment in petroleum engineering programs may not be an immediate or critical concern in Malaysia; yet, considering the global position of the industry and its significance to the Malaysian economy, this issue should not be overlooked.

A direct consequence of the industry's apparent failure to attract talented students to this field is the shortage of young professionals in the industry and its lack of a "suitably skilled" engineering workforce, both being major concerns facing today's oil & gas industry[38]. This has been reflected by Ronalds in her paper that discusses the new undergraduate oil & gas engineering program at the University of Western Australia.

A crucial consideration for the purpose of discussing the advantages of specialized petroleum stream over pure petroleum curriculum is the impact of the cyclic nature of the industry on the recruitment of new graduate engineers into the industry. Since not much can be done about the inherently cyclic nature of the oil & gas industry, it has to be regarded as a definitive and absolute characteristic of the industry. Strategies and methods to improve recruitment trends within the industry fall beyond the scope of the present discussion.

Instead, the immediate concern is focused on how to ensure that tertiary education offered on petroleum engineering in Malaysia not only meets industry expectations but also serves the future career and professional interest of students in this field, bearing in mind the inherent cyclic nature of the industry and its recruitment patterns, thus explaining the benefit of specialized petroleum stream over pure petroleum curriculum for an undergraduate degree in oil & gas.

Avoiding Reliance on One-Industry Economy & Improving Future Job Security

Engineering graduates, as opposed to graduates from other fields such as the pure sciences or the liberal arts, are relatively more career-focused in the sense that they usually have very high expectations of the industry in which they intend to set their career path. Most graduates of engineering are quite demanding and particular of the nature and specifications of the job they are seeking and have a relatively definite idea of what they want for their career - many of them have very specific targets and expectations of the profession they intend to secure.

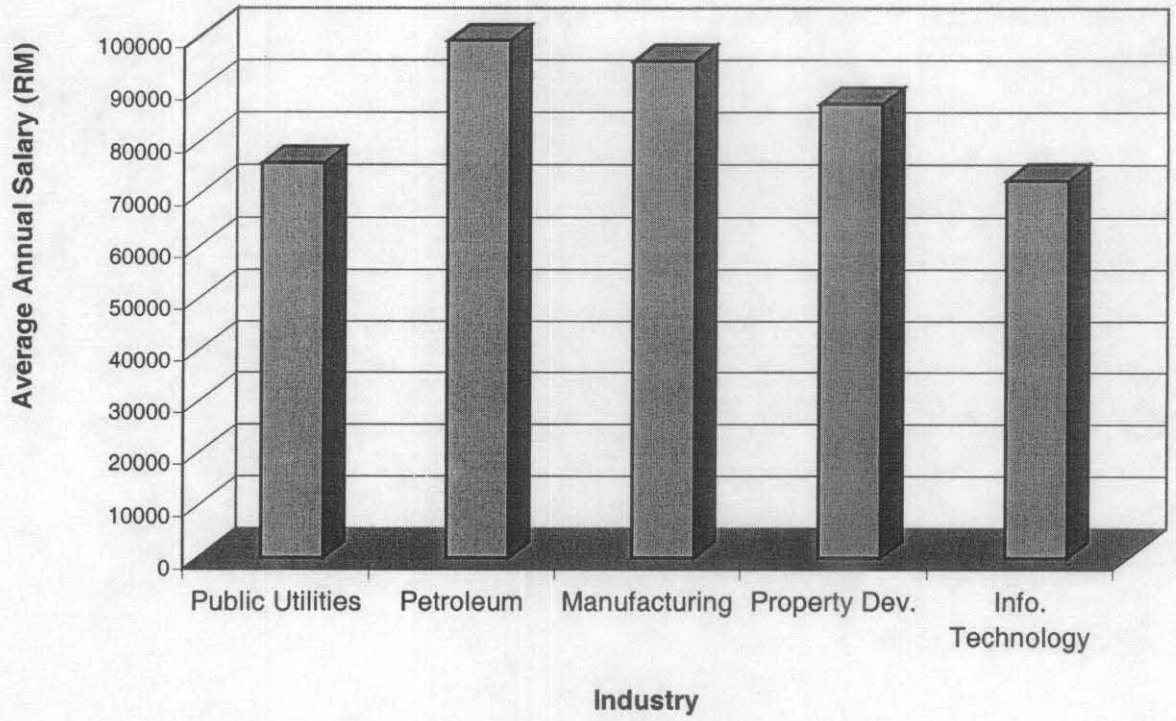
Students initially planning to enrol in a petroleum engineering program may be attracted to the field due to interest in the oil & gas industry, apart from academic interest to study petroleum. Superior remuneration in terms of high salary and allowances - as demonstrated in Figure 5.3-1 on the following page - satisfaction from a technically challenging job, the chance for frequent international travels, the opportunity to work in cutting-edge, technologically-innovative environment and the globally important position of the oil & gas industry may be some of the factors attracting students to study this field.

At the same time, interested students need to understand that to a considerable extent, petroleum engineering is a highly-specialized and narrowly-focused field - it is reasonable to claim that a large portion of knowledge and skills taught in the petroleum core courses has relatively limited applications beyond the oil & gas industry.

The consequence of this is that job security for engineers trained in petroleum relies considerably on the health of a one-industry economy so that - as discussed earlier - in times of a downturn in the industry, graduate entrants with a pure petroleum engineering degree will face some difficulty to move on to another industry, compared to those with the more general degrees of mechanical, electrical, civil or chemical engineering.

Thus, for an undergraduate petroleum education that is able to serve the future professional interest of the students, the difficulty for pure petroleum graduates to switch fields would favour a specialized petroleum stream under a generic engineering discipline over pure petroleum engineering education.

Figure 5.3-1: Average Annual Salary of Engineers in Malaysia (Year 2000)



Source : Survey Result done by Institute of Engineers Malaysia[46]

Vast Oil & Gas Industry Demands Diverse Skills of Graduate Engineers

Additionally, as pointed out by Ronalds in her paper, the broad nature of the oil & gas industry requires graduate entrants into the industry to have a wider range of skills than that which is commonly delivered in a pure petroleum engineering program. She pointed out to the diversity that existed in the employment of the oil & gas industry. Since oil & gas companies range in size and nature or scope of work, each company would require a specific set of qualifications and skills relevant and unique to the company's operations.

For example, engineers working in a giant multinational oil operating company would need the skills for managing the various service companies. Consultancy firms and service contractors would require engineers with specialist technical aptitude while engineers working on site would require considerable hands-on knowledge and "on-the-spot problem solving skills" [38].

Thus, many oil & gas employers do not take specific technical content and aptitude as a major consideration in recruitment and many generally assume students who graduated with good results to have the necessary technical skills, so that in the end, "natural talent, a good understanding of fundamental engineering concepts and softer skills are considered more important in recruitment than the discipline in which the graduate trained" [38].

Most Oil & Gas Employers Provide Training for New Recruits

Therefore, instead of looking for specific competencies in prospective applicants' resume, a lot of companies in the petroleum industry, especially the big multinationals, provide structured and on-the-job training programs to incoming engineers in the effort to ensure that the new recruits have the necessary and specific skills and technical aptitude required for their respective duties, which as explained above, are as varied as the types of companies there are in the oil & gas industry. There is also ongoing training for specific skills development for the senior and

existing engineers, as explained by a *PETRONAS* executive in response to whether specific petroleum engineering knowledge is required of the new entrants.

Indeed, the fact that many oil & gas companies provide in-house specialist training for new engineering recruits and the fact that many employers do not regard specific technical skills as a major consideration for recruitment are more factors that work towards the disadvantage of those with pure petroleum engineering degrees: evidence in industry shows that only a minimal percentage of such companies' incoming engineers have a petroleum engineering degree; many in fact were trained in the more generic engineering disciplines of for example, mechanical and chemical engineering.

Thus, as stated by Ronalds, "to be overlooked for employment in the industry that the students have originally set their hopes on in favour of graduates from other disciplines is demoralizing" to the students and graduates of petroleum engineering[38]. Recruitment aside, the above factors also discourage undergraduate students to take up graduate work in the field, which could lead to a shortage of academicians in the field, as pointed out by Rogers and Carley in their paper[41].

Principally, an undergraduate degree program serves to provide foundation education for engineering students, regardless of their specific discipline. More so in the oil & gas industry, "the first degree is ... regarded essentially as a foundation," states Ronalds in her paper[38].

Generic engineering graduates or science graduates with good results, strong technical aptitude and an ability to apply science and engineering fundamentals to a particular field and industry are more valuable to oil & gas recruiters than petroleum engineering graduates with mediocre results and a specialization field that could appear more extraneous than it is immediately applicable.

Producing Mechanical Engineers with Added Value of Knowledge & Skills in Petroleum Engineering - not Specialist Petroleum Engineers

The examples and factors discussed above suggest how a specialized petroleum stream is more appropriate than a pure petroleum curriculum, considering especially the job market and employment trends of the petroleum industry. At present, petroleum education at *Universiti Teknologi Petronas* is delivered via a specialization stream under the mechanical and chemical engineering programmes.

Without doubt a mechanical or chemical engineering degree is more versatile as it is applicable and relevant across diverse industries and to a multitude of engineering positions. Graduates of mechanical or chemical engineering do not have to limit his or her entry into the professional world to a specific industry, as is commonly the case for pure petroleum engineering graduates.

Instead, with the "added value" of petroleum specialization, these mechanical or chemical graduates open the door to the job market in the oil & gas industry, giving them an advantage over generic engineering graduates without that specialization field. All other factors being equal, mechanical or chemical engineers with petroleum specialization would stand out against generic engineering graduates in competing for a vacant position in the industry, due to the former group's oil & gas competency and the orientation of their undergraduate education to the oil & gas industry.

Employers would feel inclined to hire petroleum-specialized mechanical engineering graduates when they realize during interview sessions that besides classical mechanical knowledge, these graduates possess working knowledge of the upstream petroleum industry, which includes a minimum of basic geological science, fluid and reservoir properties, petroleum extraction equipments and processes and petroleum economy and management.

As a proof to this point, in a discussion on petroleum education, a PETRONAS senior executive concedes that mechanical engineering graduates with an oil & gas exposure tend to pick up training faster than those without such

specialization, as these graduates appreciate the technical relevance of the given tasks and could relate it to their undergraduate training, are able to work with minimum supervision and could generate faster results[47].

At present, both industry and academics believe that pure petroleum engineering programs are not able to attract bright and talented students "in sufficient numbers" due to the factors discussed above, as stated earlier[39]. According to Pinczewski and Abdul Wahab in their summary of the discussions that transpired in a regional colloquium on petroleum education, "attracting high calibre students into PE programs...will continue to be a major problem in the region," due to the critical issue of job security in this cyclic industry[39].

By providing education on petroleum within the programmes of mechanical or chemical engineering, as opposed to offering a pure petroleum engineering programme, it is hoped that more bright and talented students will be interested to study this very important field.

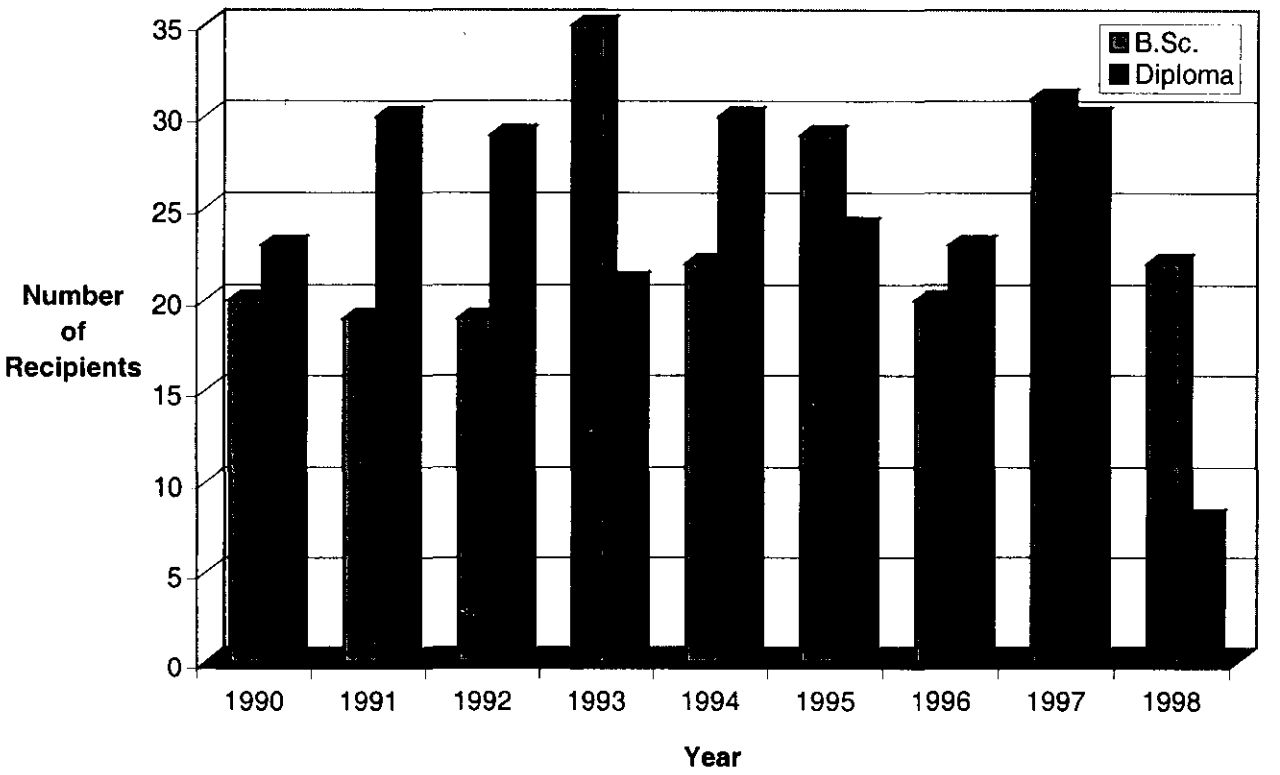
Such a programme should be able to not only overcome the issue of job security but also remove negative perceptions students may have regarding the oil & gas industry, such as the unfavourable image of an industry that will fade away some time in the near future or one that is socially and environmentally unfriendly in its activities and operations, in addition to the industry's discouraging cyclic nature and recruitment patterns[38].

Avoiding Excess Pure P.E. Graduates for Relatively Small Local Job Market

Last but not least, as described in the previous section, a traditional 4-year pure petroleum engineering program already exists in Malaysia, offered by *Universiti Teknologi Malaysia*. Figure 5.3-2 on the following page shows the number of petroleum engineering graduates produced by the university each year from 1990 to 1998. From this chart, it can be seen that an average of 48 students graduate from UTM annually with either a degree or a diploma in petroleum engineering.

The relatively small job market of the Malaysian oil & gas industry would not be an encouraging factor for duplication of such programs. This sentiment is echoed by practitioners in the industry[48,49]. UTP's adaptation of oil & gas exposure for its mechanical and chemical engineering students adds a new breed of engineers into the Malaysian job market. These petroleum-specialized graduate engineers have the advantage over the pure petroleum engineering graduates, as discussed in the paragraphs above.

Figure 5.3-2: Universiti Teknologi Malaysia (UTM) Graduates in Petroleum Engineering



5.3.2 *Incorporation of Petroleum Education into Engineering Curricula*

The oil & gas industry has long been accepting technical entrants into the industry from non-petroleum engineering fields, a fact already stressed in the preceding section. It was also claimed that a strong foundation in engineering science and a firm grasp of the generic technical competencies are criteria of graduate engineers that are sought after by the oil & gas employers when recruiting new staff, factors that are weighted more than the actual discipline in which they graduated. In her paper, Ronalds cited the example of Schlumberger's Asia Pacific whose two-year technical graduate intake consisted of a meager 1 % of graduates from petroleum engineering[38].

UTP's P.E. Education Across Mechanical, Chemical& Civil Engineering Programmes

At UTP, a broad-based oil & gas engineering curriculum has been designed across two separate undergraduate programs: mechanical engineering and chemical engineering. The discipline of oil & gas is both conventionally and customarily regarded to be divided into an upstream and a downstream section. The upstream section involves the processes of extracting and producing of hydrocarbons, which at UTP is covered by the petroleum specialization stream under mechanical engineering. Meanwhile, a petrochemical specialization stream is offered by UTP under its chemical engineering program, which studies the downstream side of the oil & gas industry - activities that include the treatment and processing of hydrocarbons.

In the near future, UTP's civil engineering program will also offer a specialization stream on a subject matter very much a part of the petroleum industry: offshore structures. This civil engineering specialization field shall incorporate studies on the design and construction of offshore foundations, structures and platforms. In the meantime, since this specialization curriculum is still in the design stage, the petroleum specialization stream under the mechanical engineering program at UTP shall temporarily fill this void, to expose students to this very important area of the petroleum industry, as explained in an earlier section of this paper.

Therefore, UTP's master plan for petroleum engineering education shall consist of a comprehensive, albeit not in-depth, coverage of the oil & gas industry, implemented within the three otherwise distinct disciplines of mechanical, chemical and civil engineering.

Realising the boom and bust nature of the oil & gas industry and the Malaysian industry's relatively small size on the global scale and thus its correspondingly small job market, UTP curriculum designers have consciously made the decision to append a petroleum specialization to a main discipline of study instead of structuring a pure petroleum engineering, petrochemical engineering or offshore engineering program for its undergraduate studies on oil & gas.

These three overlapping fields are identifiable with and adaptable within the generic education of mechanical, chemical and civil engineering respectively. A degree in mechanical or chemical engineering with a corresponding specialization in petroleum or petrochemical helps to ensure that students do not unnecessarily narrow their employment options, considering the relatively small job market of the Malaysian oil & gas industry.

5.4 EVALUATION OF UTP'S PROGRAMME

5.4.1 Overall Discussion of UTP's Engineering Programme

At UTP, petroleum engineering will be offered as a specialization stream to students of mechanical and chemical engineering. Thus, in evaluating UTP's petroleum education, it would be appropriate and beneficial to review UTP's overall engineering program, as issues of quality assessment and academic accreditation would encompass all specialization streams within an engineering program and not specific to the petroleum or any other stream.

In the following sub-sections, several issues are discussed with regards to the overall engineering program at UTP, from a university-wide perspective. They are: significance of quality education, UTP's program objectives and quality philosophy, academic accreditation, quality assessment and international recognition.

Significance of Ensuring Quality in UTP's Engineering Education

Establishing and operating Universiti Teknologi Petronas is a major financial investment on *PETRONAS'* part. It was estimated during the initial development studies of the university that with a projected total student population of 6,000 in the year 2015, UTP's operating cost will exceed RM250 million a year[14]. Yet, as an academic institution, in contrast to a commercial enterprise, making substantial monetary returns is not the primary expectation of its parent company, as the university is indeed a service to the community, in return for the wealth and value that the company gains through exploitation of the nation's resources.

Thus, for UTP to be established merely as a "mediocre" university can be a waste of resources for *PETRONAS* - and the country - for in the long run, a mediocre university could experience difficulty in attracting funding from student sponsoring organizations, private or federal government's, for the university's scholarship programs, research work and consultation services.

Although currently the nationwide problem of insufficient university placement is a more critical issue to address than the problem of student retention or satisfaction, if UTP's quality of education is to be just average and meeting minimum education standards, the time would come when the university would find it difficult to attract new students or even to retain existing fee-paying students, while operating expenses remain effectively unchanged regardless of student population.

The university's founders' philosophy for UTP was to establish a tertiary institution different from the others, one that is in a league of its own - similar in the level of excellence and stature to the American "ivy league." To be extremely competitive and achieve such distinguished reputation in both the local and international academic community, UTP must make a name for itself and set itself apart by ensuring that it's programs and services are of exceptional quality and standards and work towards the goal of making itself the university of choice for students intending to study engineering, in line with the goal of the parent company *PETRONAS* to be the leading oil and gas multinational company of choice. Only when UTP is regarded as an institution capable of providing superior educational services will it prosper in the growingly competitive business of higher education.

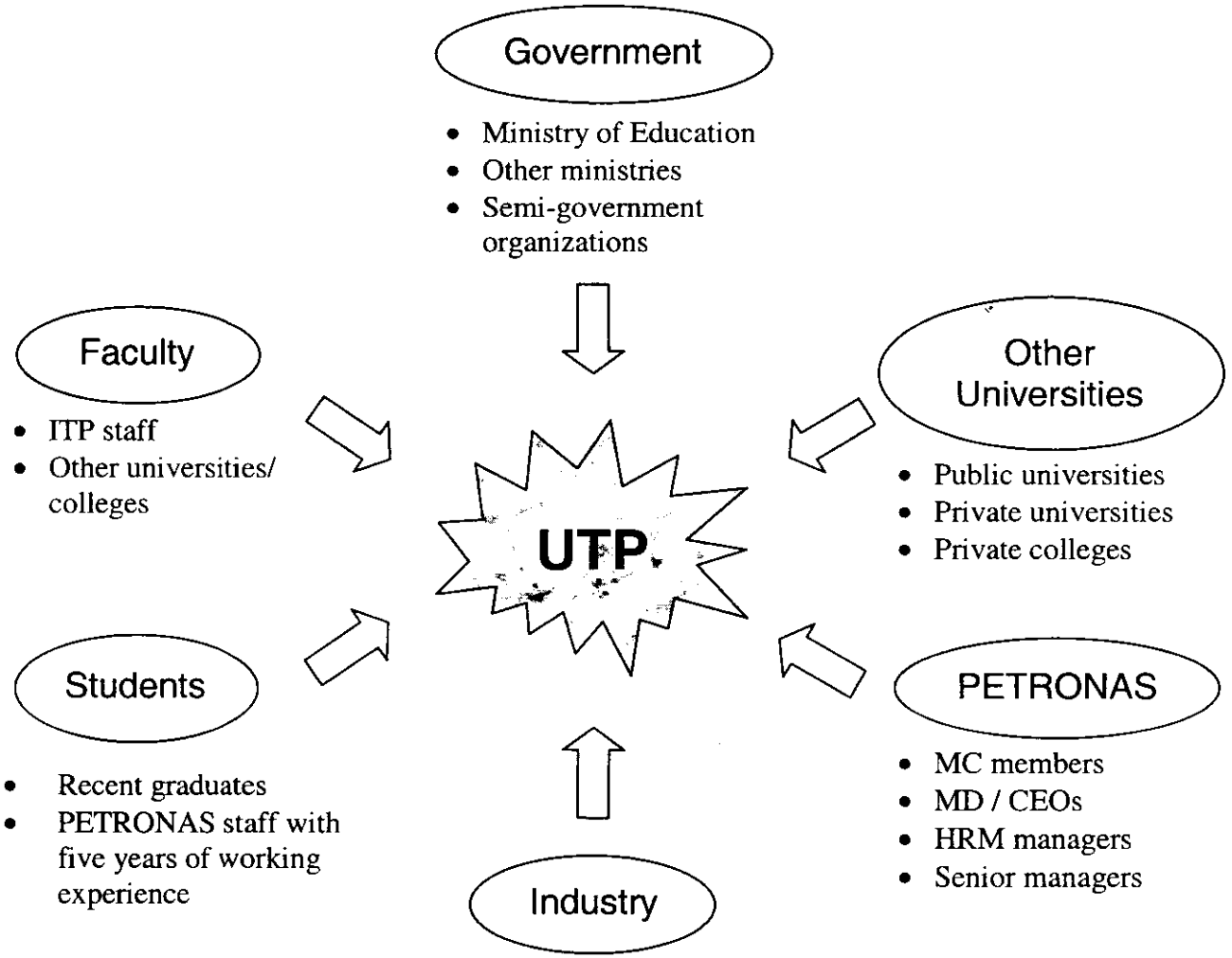
UTP's Program Objectives and Quality Philosophy

Considering that UTP is relatively a "newcomer" in the field of higher education and research, the university must ensure that it continues to strive to meet the expectations and demands of its stakeholders. For an academic institution like UTP, these would be the students and their parents, the faculty, the industry and the prospective employers, accreditation bodies, professional associations, UTP's parent company *PETRONAS*, the government and the society at large. Figure 5.4-1 on the following page illustrates the various stakeholders for the case of UTP.

Extensive interviews, surveys and workshops of a selected sample group of these stakeholders were performed as part of the initial feasibility studies carried out prior to the establishment of UTP. From this exercise, the stakeholders' needs were amassed and summarized for the purpose of ascertaining and establishing missions

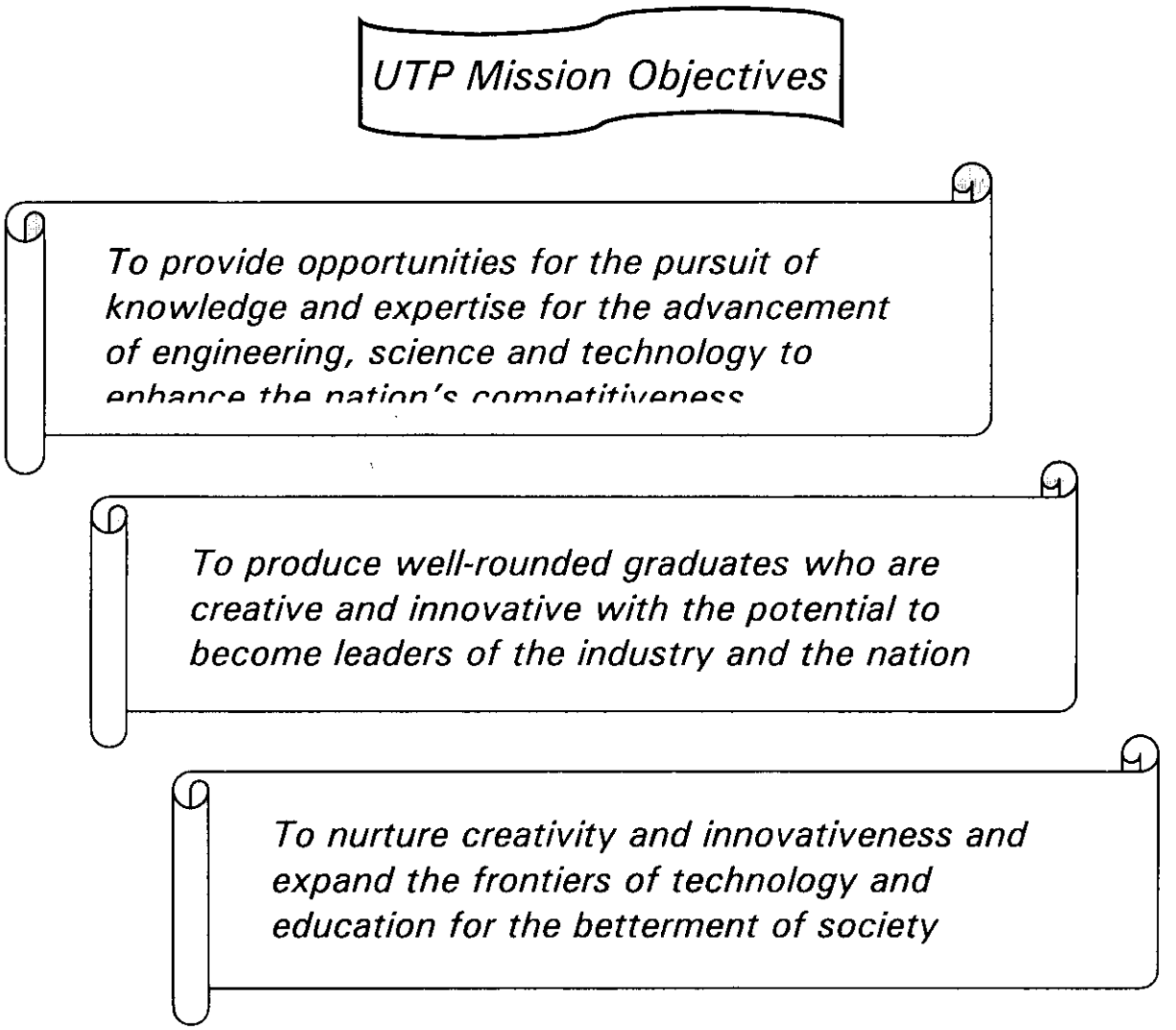
and visions of the university. The newly conceived visions and strategies were continuously reassessed throughout the formation process of the university, to ensure that they were both technically and economically feasible.

Figure 5.4-1: Stakeholders of UTP



Reproduced from

Thus, since its inception in 1997, UTP has continuously labored to develop academic programs that focus on the development of students so as to be able to achieve the following mission objectives of the university, as stated in the university charter[16].



Quality student graduates are the product of Universiti Teknologi Petronas. It is envisioned that through systematic and quality educational processes and academic opportunities, UTP will mold and develop its students to be well-rounded graduates with several key qualities as listed on the following page. This concept of "high-quality, well-rounded" graduates, along with the desired qualities they are to develop and achieve at UTP, was also drawn up and identified by UTP's stakeholders.

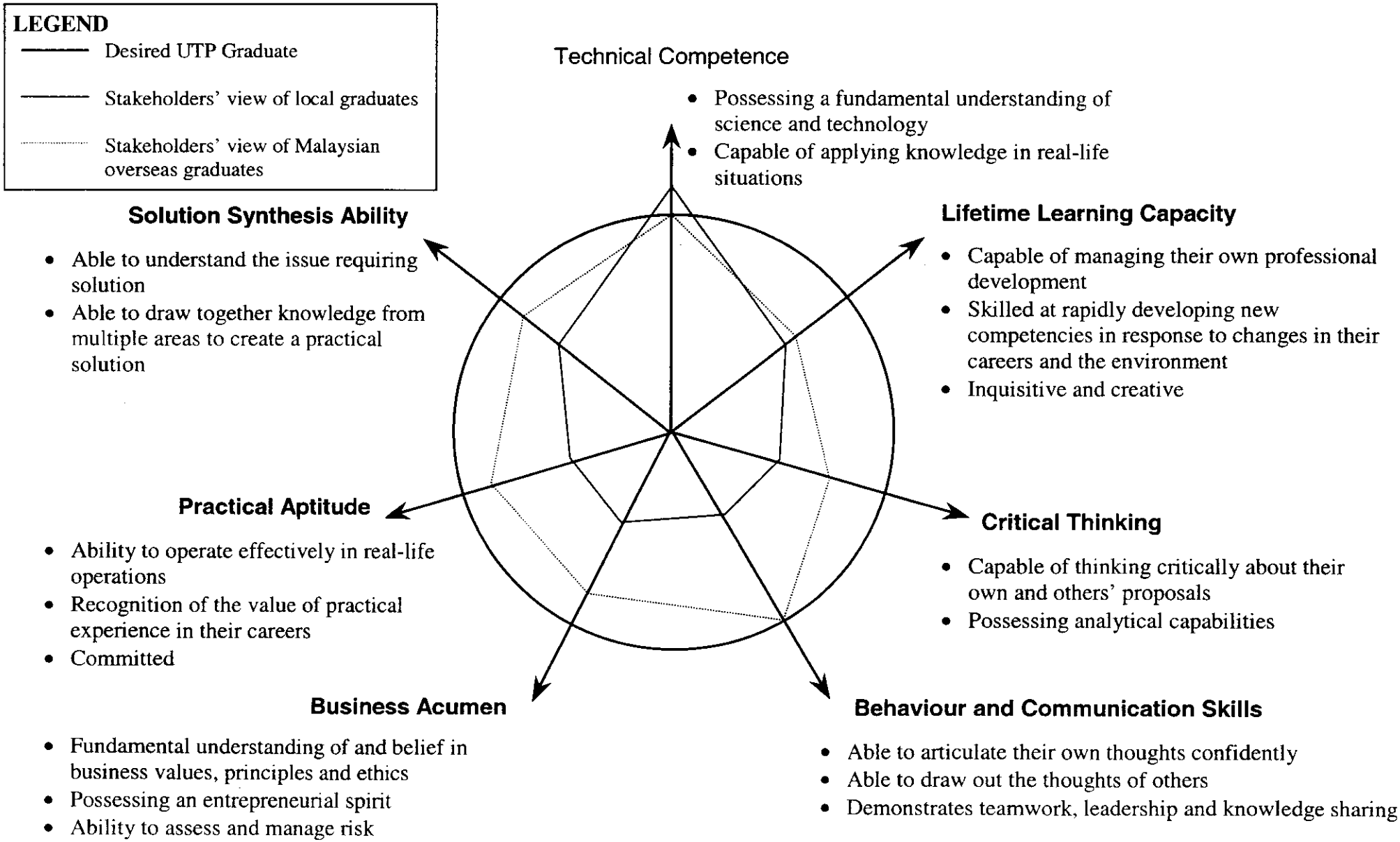
Desired qualities of a UTP graduate

- Technical Competence
- Lifetime Learning Capacity
- Critical Thinking
- Behaviour and Communication Skills
- Business Acumen
- Practical Aptitude
- Solution Synthesis Ability

These desired qualities are explained in Figure 5.4-2 on the following page, in an illustration that reflects the stakeholders' view of local and overseas graduates and how they fare in these qualities, along with their target for UTP graduates.

Thus, as a new player in the field of tertiary education, UTP needs to instill confidence in the general public in the university's ability to provide a consistent, systematic and quality education. Towards this end, UTP has exercised great effort and has succeeded in obtaining academic accreditation at the national level, from *Lembaga Akreditasi Negara* (the National Accreditation Board or LAN in short.) As for quality assessment and gaining international recognition, the university has attained the internationally-recognized ISO 9001 quality and standards certification. These subjects are explored in the following pages.

Figure 5.4-2: Desired Qualities of a "Well-Rounded" UTP Graduate



Academic Accreditation, Quality Assurance and International Recognition

Through conscientious and diligent effort of the university's pioneers, UTP was able to achieve accreditation for three of the four undergraduate engineering programs offered at UTP, from the National Accreditation Board. Having acquired LAN accreditation for an undergraduate program fosters confidence in the eyes of the general public as it means that the program has passed the scrutiny and satisfied the minimum standards of the academic and professional community.

In Malaysia, the National Accreditation Board (LAN) is responsible for the accreditation of private institutions' programs while both the Institute of Engineers Malaysia (IEM) and the Board of Engineers Malaysia (BEM) jointly accredit engineering programs of public universities. Although UTP is categorized as a private university, it has received accreditation for the three engineering programs from not only the National Accreditation Board (LAN) and the Public Services Department - a government organization overlooking the public sector's workforce - but also from the Board of Engineers Malaysia (BEM).

Tables 5.4-A and 5.4-B on the following pages show BEM accreditation and LAN accreditation information respectively for UTP's undergraduate programs[51].

Table 5.4-A: BEM Accreditation for UTP's Engineering Programs

Degree	Course	Program Duration	Accreditation Date	Discipline
Bachelor of Engineering	Electrical & Electronics Engineering	5 years	2001-2006	Electrical/Electronic
Bachelor of Engineering	Chemical Engineering	5 years	2001-2006	Chemical
Bachelor of Engineering	Mechanical Engineering	5 years	2001-2006	Mechanical

Source: Board of Engineers Malaysia

Table 5.4-B: LAN Accreditation for UTP's Engineering Programs

COURSE NAME	SERIAL NO	ACCREDITATION DATE	ACCREDITATION DATE VALIDITY	
			START	END
BACHELOR OF ENGINEERING (HONS) CHEMICAL ENGINEERING (A 0018)	**20**	**19-Jul-99**	**01-Sep-99**	**31-Aug-04**
BACHELOR OF ENGINEERING (HONS) ELECTRICAL / ELECTRONICS ENGINEERING (A 0019)	**21**	**19-Jul-99**	**01-Sep-99**	**31-Aug-04**
BACHELOR OF ENGINEERING (HONS) MECHANICAL ENGINEERING (A 0020)	**22**	**18-Oct-99**	**01-Nov-99**	**31-Oct-04**

Source: National Accreditation Board

Having both LAN and BEM accreditation serves as major testimony and assurance of quality and parity of tertiary education standards – UTP students can be assured that the quality of education they receive has been assessed and shown to satisfy all the requirements pertaining to:

- Quality academic program that includes curriculum and syllabus, laboratory work, project work and industrial training
- Quality academic staff and students
- Quality learning facilities
- Quality management system

In addition to being locally recognized by gaining accreditation from national accreditation bodies, the university also needs to have an international outlook right from the start. With this objective in mind, UTP challenged itself to implement an internationally recognized quality assurance system based on the ISO 9000 standards. UTP has recently succeeded in obtaining ISO 9001 certification and thus, the university has since then been ISO 9001-certified in its operation as an academic institution of higher learning, meeting and conforming to the quality standards and requirements of ISO 9001[18].

Indeed, registration to the ISO 9000-series of standards for quality assurance is growing among academic institutions and other educational systems, following the worldwide acceptance and achievement of the ISO-based quality management systems in the manufacturing sector. Implementation of a quality assurance and management system based on the ISO 9001 standards ensures that systematic and consistent quality assurance practices are in place and are accessible to the university's stakeholders, which will assist in ensuring that the university is meeting the requirements for quality education and researches as desired by the stakeholders[53].

Quality assurance in higher education is indeed a very broad subject of discussion. It is thus beyond the scope of this paper to explore all conceivable issues pertinent to UTP's quality assurance system, such as advantages and disadvantages of its ISO 9001-based quality system compared to other quality assurance methods in higher education.

Nevertheless, maintaining a quality assurance system based on an internationally accepted quality control standard such as the ISO 9001 is indeed of utmost importance if UTP desires to be regarded as an international education provider, in the same rank as the more "seasoned countries such as the United States, Australia and the United Kingdom" [50].

5.4.2 *Effectiveness of UTP's Petroleum Education*

After evaluating UTP's engineering program from the general perspective of program objectives and quality philosophy, accreditation and quality assessment, the subject of effectiveness of UTP's petroleum specialization program can be specifically explored. In the following sub-sections, this issue is investigated and discussed along the following lines: suitability of program design, sufficiency of courses and finally, recommendations for program improvement.

Aptness of UTP's Specialized Petroleum Stream

Although the Malaysian oil & gas industry is fast expanding, as previously discussed in the monologue of section 5.1.1 and will be further deliberated in the Conclusion section, focusing a very large quantity of students into the study of petroleum and later into the oil & gas employment sector can have impractical implications. Results of the 7th Malaysian Plan and a 1992 manpower forecast for the petroleum & petroleum-related industry in Malaysia for the period 1993-2000 estimated that less than 20 % of all Malaysian engineers would be involved in the oil & gas industry, and this trend is expected to continue for the next 20 years[14].

For this research project, a number of individuals working in the local oil & gas industry were given a questionnaire for the purpose of gathering current, first-hand views of industry professionals regarding various education and employment issues in the industry. Responses from this activity suggest there is consensus in the industry that there is no need for a duplication of the pure petroleum engineering program of *Universiti Teknologi Malaysia,* which has specialized in producing degree and diploma graduates in the field since the inception of its petroleum engineering department in 1975[48,49].

Thus, as an alternative, UTP's model of producing mechanical and chemical engineering graduates with an adequate amount of exposure to the knowledge and

practice of the upstream and downstream oil & gas sectors respectively should be able to engender a breed of broad-based engineers with sound knowledge in a fundamental engineering discipline and an added value of oil & gas engineering competence.

Furthermore, analysis of oil & gas companies' recruitment trends as illustrated in Figure 5.4-3 shows that employers in the industry are not expected to have a substantial increase in recruitment activities. Operating companies such as *PETRONAS*, *ESSO* and *SHELL* are the main employers in the oil & gas industry and their recruitment trends have not shown much growth in the past 5 years but remained relatively constant even through the most recent Asian economic crisis[14]. Obviously, the petroleum industry's service companies hire employees based on the current or expected projects at hand and considering the relatively smaller size of service company operations in Malaysia, their hiring capacity would be even much smaller compared to that of the operating companies.

Figure 5.4-3: Number of Science & Engineering Graduates Employed in the Malaysian Oil & Gas Industry

Industry Sector	Company	1996	1997	1998
Oil & Gas Exploration & Production Operating Companies	PETRONAS	132	130	130
	Sabah Shell Petroleum Co.	15	15	15
	Shell Sarawak Bhd			
	ESSO Malaysia Bhd & ESSO Production Malaysia Inc.	40	40	40
Service Company	Antah Sperry Sun Drilling Services	5	6	6
	Drillquest (M) Sdn Bhd	4	4	4
	Anadrill (M) Sdn Bhd	4	10	4
	Kota Minerals & Chemicals	5	8	10
Engineering Fabrication & Construction Company	Brown & Root	2	4	6
	KNM Steel Construction	2	4	4
	Kvaerner Petrominco	-	50	70

Adequacy of UTP's Petroleum Courses: SPE's Competency Criteria

The Society of Petroleum Engineers (SPE) has established a guideline for minimum competency level for petroleum engineers practicing in the United States. Although these guidelines are established for the needs of the US industry, due to the global nature of the petroleum industry, such competency requirements can be employed and referenced for curriculum assessment of petroleum engineering education programs of universities in other parts of the world.

Furthermore, it is believed that these guidelines will be beneficial globally, as standards of competency not only for practicing oil & gas professionals but also for education programs of academic institutions and training organizations worldwide. They were formulated out of the feedback received from about 2,150 SPE members working as engineers in the oil and gas industry and was further refined by industry experts[40].

Thus, the competency matrix is arguably an accurate reflection of what the industry requires of its engineers, with regards to proficiency. These guidelines serve as criteria for evaluating both the breadth and depth of aptitude in the petroleum engineering field, which a graduate engineer with four to six years of working experience should maintain, to be deemed as being competent.

Tables 5.4-C through 5.4-G present excerpts of these competency guidelines - categorized by sub-discipline within petroleum engineering - derived from the Society of Petroleum Engineers' breadth and depth competency matrix. Three of these sub-fields - reservoir, production and drilling are dealt with by three of the four petroleum courses offered under UTP's mechanical engineering program: Reservoir Engineering, Petroleum Production and Drilling and Well Completion. Thus, as mentioned above, the SPE's competency criteria for these three areas of knowledge can be used to determine whether the three UTP courses are sufficient in furnishing students with the knowledge required by the industry, in the respective sub-disciplines.

Table 5.4-C: Excerpt of the Competency Matrix established by the Society of Petroleum Engineers (SPE) - Sub-Discipline: Reservoir

Task	Minimum Competence: *Breadth*	Minimum Competence: *Depth*	Above Minimum Competence
Determine initial Oil or Gas in place	Calculate original oil or gas in place per acre-ft from rock and fluid properties. Understand material balance principles for determining initial oil or gas in place for volumetric reservoirs	Determine initial oil or gas in place from geologic maps and rock and fluid properties. Apply material balance techniques, including gas cap and water influx, for determining initial oil and gas in place	Incorporate J-curve Sw vs height into oil and gas in place calculations. Manipulate various forms of material balance equations and determine most appropriate form for use for any type of situation to calculate original oil and gas in place
Analyze reservoir/ fluid recovery under secondary or improved recovery mechanisms	Understand the principles of waterflood / gas injection	Assess optimum water flood/ gas injection based on reservoir zonation, flood patter analysis, injectivity and flood design	Calculate recovery for area/vertical sweep, infill drilling, fractional flow and frontal advance. Estimate recovery from gas cycling in retrograde gas condense reservoirs, determine optimum sweep, efficiency

Table 5.4-D: Excerpt of the Competency Matrix established by the Society of Petroleum Engineers (SPE) - Sub-Discipline: Production

Task	Minimum Competence: *Breadth*	Minimum Competence: *Depth*	Above Minimum Competence
Tubing Design for dynamic producing/Stimulation Conditions	Awareness that tubing shortens or lengthens because of changes in pressures and temperatures during stimulation	Can calculate the specific length changes or packer forces due to the piston effect, ballooning, temperature, helical buckling	Design for high temperature/pressure corrosive environment, e.g. H2S, CO2, impact on design
Artificial Lift	Awareness of the various options to assist in lifting produced fluids; the basic ranges or pressure and fluid volumes for each lift option, and the hydraulic and mechanical forces associated with each option	Able to select and design the appropriate artificial lift system for the typical range of pressure and fluid volumes for conventional operations including the use of various downhole pumps with associated surface equipment. Incorporate P/I performance in design and economic evaluation of completion/lift options	Design the appropriate artificial lift system for horizontal completions or harsh conditions such as arctic, offshore or subsea operations

Table 5.4-E: Excerpt of the Competency Matrix established by the Society of Petroleum Engineers (SPE) - Sub-Discipline: Drilling

Task	Minimum Competence: *Breadth*	Minimum Competence: *Depth*	Above Minimum Competence
Maintain Well Control	Calculate mud weight necessary to maintain well control or volume of mud required to fill the hole while tripping out	Design and/or implement procedure to successfully circulate out an influx	Design and/or implement procedure to successfully control an underground blowout
Develop Casing Program (sizes, setting depth)	Understand the relationship between desired production flow rates and tubing/casing configuration	Determine the surface casing setting depth required to protect fresh water sands. Prepare pore pressure and frac. pressure versus depth plots. Define the setting depth of protective pipe, if required	Optimize the number and depths of protective casings. Optimize the size of the casing strings and liners

Table 5.4-F: Excerpt of the Competency Matrix established by the Society of Petroleum Engineers (SPE) - Sub-Discipline: Formation Evaluation *

Task	Minimum Competence: *Breadth*	Minimum Competence: *Depth*	Above Minimum Competence
Determine formation properties (porosity, saturation, net pay) from well log	Determine properties form log readings in clean sands	Determine properties form log readings in both clean and shaly sands. State most common water saturation models	Be able to depth-shift and normalize in complex lithology, multiwell field
Determine formation properties (drainage area pressure, permeability, skin, distance to boundaries) from well test analysis	Determine formation properties for single-phase flow of oil or water in build-up or constant rate flow test. Boundaries limited to single no-flow boundaries. Formation can be homogenous and isotropic	Determine formation properties for single-phase flow of oil, gas or water in build-up or multi rate flow test. Boundaries include single, multiple or complete closure. Formation can be heterogeneous and an isotropic	Determine formation properties for multi-phase flow of gas, oil, and/or water in buildup or multirate flow tests. Reservoir boundaries can be closed, partially sealing or constant pressure. Formation can have complex heterogeneities, be anisotropic, and have fluid contacts within the area of influence or the test

* This sub-field is not covered under UTP's petroleum specialization syllabus since it is highly specific to the petroleum industry and falls beyond the scope of upstream mechanical discipline

Table 5.4-G: Excerpt of the Competency Matrix established by the Society of Petroleum Engineers (SPE) - Sub-Discipline: General *

Task	Minimum Competence: *Breadth*	Minimum Competence: *Depth*	Above Minimum Competence
Maintain regulatory compliance	Identify what regulatory bodies have jurisdiction and where to find documentation of the applicable regulations	Complete necessary regulatory permitting and reporting specific to the sub-discipline	Work with regulators on rule and changes and exceptions
Perform decision and risk analysis and contingency planning	Understand decision and risk analysis concepts and the value of contingency planning	Conduct risk assessments within sub-discipline and prepare plans to manage risks	Conduct risk assessments across sub-disciplines for a project and prepare contingency plans

* This sub-field is not covered under UTP's petroleum specialization syllabus since it is highly specific to the petroleum industry and falls beyond the scope of upstream mechanical discipline

Comparing the content of the three elective courses offered under UTP's petroleum specialization stream - elaborated earlier in Section 5.1.2 of this paper - with the SPE's competency guidelines for the respective sub-disciplines as tabulated above, it appears that the three UTP courses are capable of delivering knowledge as per the breadth competency level proposed by the SPE.

Bearing in mind that the above competency criteria was intended for engineering personnel with four to six years of practical experience, it can thus be argued that the three petroleum courses offered at UTP would satisfy an above-minimum proficiency requirement for entrant engineers into the industry.

Furthermore, as stated much earlier, the aim of the petroleum engineering specialization program at UTP is to engender graduate engineers who not only possess the fundamental expertise in the field of mechanical engineering but also have the added value of *breadth of study*, skills and working knowledge of petroleum engineering and the upstream oil and gas activities.

Therefore, since three of UTP's petroleum courses are able to meet the minimum *breadth* competency requirements as proposed by the petroleum industry's most regarded authority on professional and educational practices, it can be claimed that these courses are capable of sufficiently furnishing its students with the knowledge needed to achieve UTP's petroleum specialization program's curriculum objectives.

Some Recommendations for Improving UTP's Petroleum Courses

As discussed in the first monologue on the Malaysian oil & gas industry, there exist several key areas in the industry in which local expertise has been identified as deficient and in need of immediate consideration. Incidentally, these knowledge areas are also not addressed in UTP's petroleum specialization courses offered under the mechanical engineering program.

Nevertheless, since there is correspondence of subject matter and much relevancy between these knowledge areas and the petroleum courses offered at UTP, coverage of the areas can be included in UTP's courses without drastic change to the current syllabus. The table below shows those critical knowledge areas and suggests how these sub-topics can be incorporated into UTP's four courses:

Additional Topics for Incorporation into UTP's Petroleum Courses

Knowledge Area	Corresponding UTP Course for Incorporation of Topic
Enhanced Oil Recovery	Reservoir Engineering
Subsea Development & Deepwater Technology	Production Engineering
Oil & Gas Pipeline Design & Construction	Production Engineering
Abandonment of Offshore Structures	Offshore Structures

Enhanced oil recovery is an extensive field all by itself. To provide a comprehensive coverage of the subject can consume the full 14 weeks allotted for UTP's *Reservoir Engineering* course. Additionally, a detailed study of enhanced oil recovery is considered more appropriate for advanced courses on reservoir engineering and is thus beyond the scope and ability of UTP's petroleum elective course, which covers relatively introductory material on reservoir engineering.

Since the objective of the petroleum specialization stream is to provide students with the exposure to and working knowledge of key sub-fields of petroleum engineering, incorporating basic theories and background knowledge of enhanced oil recovery into the reservoir engineering course would be adequate to ensure that students understand the rationale for implementing enhanced oil recovery projects. Examples of implementation methods of enhanced oil recovery systems into various scenarios should be incorporated to allow students to comprehend the practical aspects of the topic.

As the development of fields in Malaysia moves toward deeper waters, knowledge of subsea development and deepwater technology becomes increasingly crucial. Therefore, at least an overview of subsea development concepts should be presented in UTP's *Production Engineering* course. In this course, students are exposed to the various factors considered in the development of offshore fields, which include among others, the pros and cons involved in deciding for either a platform or subsea development. Should a subsea development be chosen, students should thus be introduced to the technologies currently available and those that are potentially available - as they may still be in field trial - for subsea development purposes.

Transmission of oil and gas is an area of major concern in the production process as it consumes a huge amount of CAPEX and requires a large OPEX to ensure smooth operation, product deliverability and facility availability. Therefore, petroleum engineering students need to be aware of the considerations involved in the design, fabrication and installation of an oil & gas pipeline. With the mega-project *Trans-ASEAN* gas pipeline currently being built and soon to come online across the borders of various

cooperating *ASEAN* countries, there exists a local and regional demand for expertise on transmission pipelines.

It is thus both suitable and within the scope of UTP's course *Production Engineering* to include a discussion on the diverse factors considered in the design of an oil & gas pipeline. Issues of material selection, corrosion, fabrication and installation will broaden the discussion of the topic. The subject of subsea pipelines, which call for additional considerations in terms of material selection, environmental and installation issues among others, should also be addressed in the course.

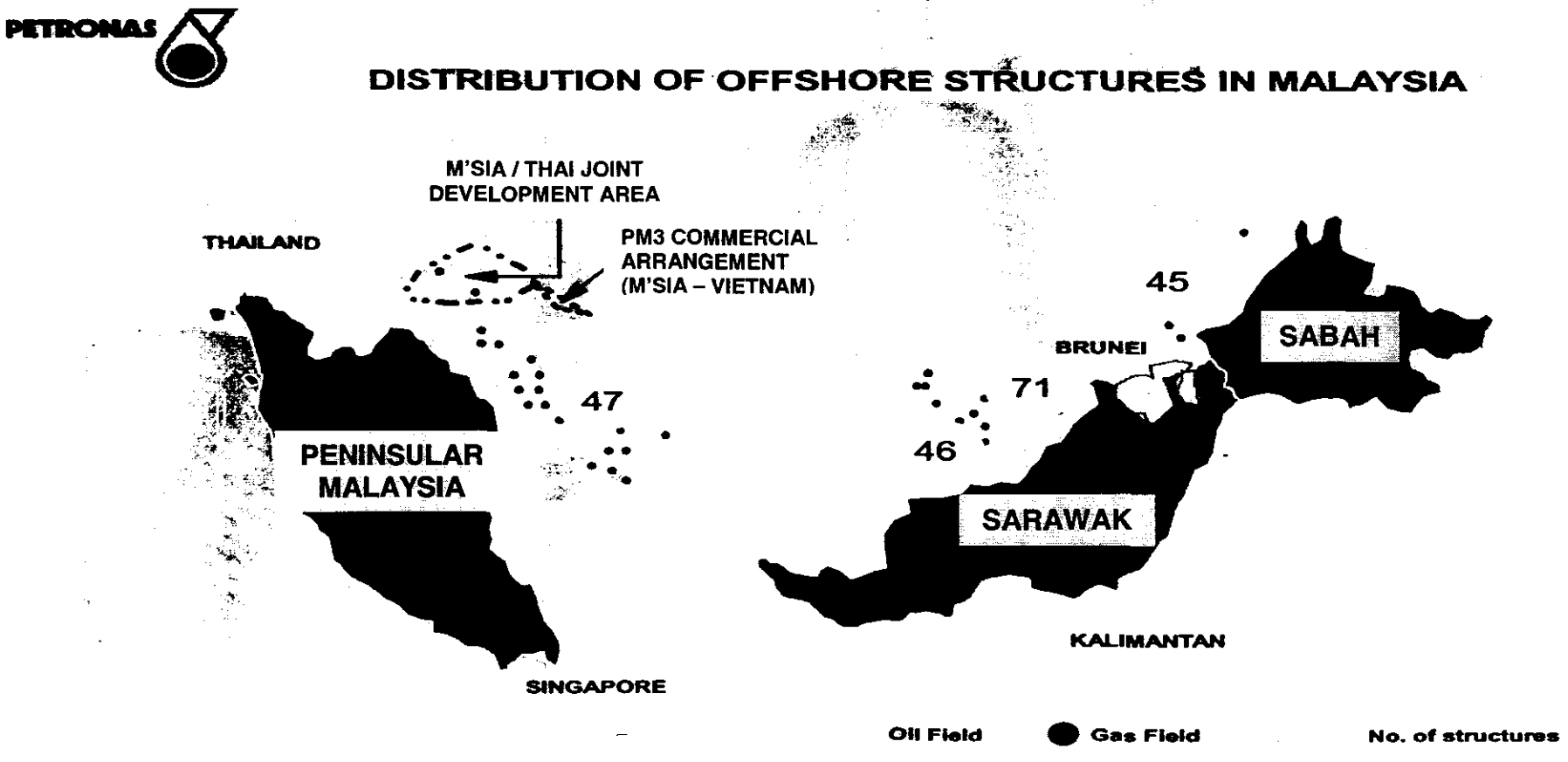
Finally, issues pertaining to the abandonment of offshore structures should be covered in UTP's *Offshore Structures* course. Essentially, this course is planned to provide students with knowledge on the design aspect of offshore structures, which include the topic of forces, failure, fabrication and installation. However, the course contents do not discuss issues of decommission and abandonment of these structures.

As previously discussed in the first monologue on the Malaysian oil & gas industry, there is an urgent need for skills in this area, as there are currently 209 structures scattered offshore across the Malaysian exploration and production acreage (See Figure 5.4-4) and the local industry is lacking the experience of decommissioning and abandoning of these offshore structures.

Thus, the study of this very important subject, from both the Malaysian and global perspectives should be integrated into the *Offshore Structures* course and will impart an added dimension of knowledge unique to UTP's curriculum. As there are currently no local experts in this field, UTP's adjunct lecturer scheme would be an ideal platform whereby the university can get an experienced practitioner from this region or from other parts of the world to endow UTP's petroleum programme with insights into this subject matter.

The best practices and lessons learnt from neighboring countries can be shared and considered for application on the Malaysian scene, bypassing much of the learning curve and avoiding "reinventing the wheel" so as to avoid costly mistakes in terms of both facility and environmental damage.

Figure 5.4-4: Distribution of Offshore Structures in Malaysia



Monologue II: Economic Significance of Petroleum Education for Malaysian Oil & Gas Industry

For the past 7 years, Malaysia's revenue from petroleum-related industries has been steadily increasing in terms of total GDP values, as can be seen in Figure 6-1. These earnings are derived from both the upstream and downstream sectors of the oil & gas industry. During the Asian economic crisis of 1997 however, fluctuation of the Malaysian Ringgit led to the collapse of many Malaysian companies. The domestic petroleum industry emerged as the country's sole saviour as transactions in petroleum-related industries are customarily performed in US Dollars.

As discussed earlier in the first monologue on Malaysian oil & gas industry, Malaysia's crude oil reserves as of January 1st, 2000 are at 3.4 Billion barrels and the nation's natural gas reserves are at 84.4 Trillion standard cubic feet. Assuming no new discoveries, with the relatively constant crude oil production of 600,000 bbls/day of and an increasing gas production of roughly 5500 MMscf/day implies that Malaysia's crude oil reserves will only last approximately 15 years while its gas reserves will last another 30 to 45 years[15]. It is also expected that by the year 2005, the demand for crude oil will exceed the constant production of 600,000 bbls/day making Malaysia a net oil importer (See Figure 6-2).

Figure 6-1: Malaysia's Revenue (in Total GDP) Derived from Petroleum-Related Industries

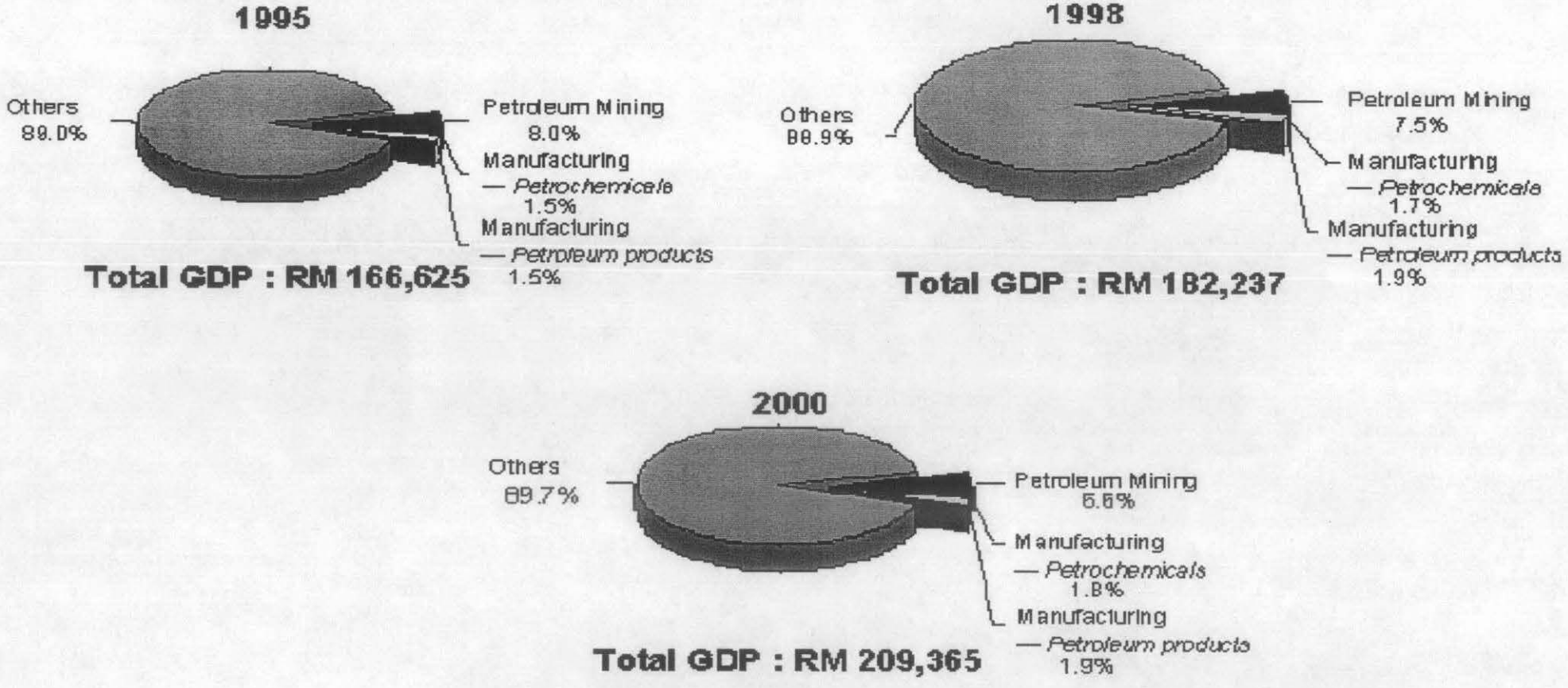


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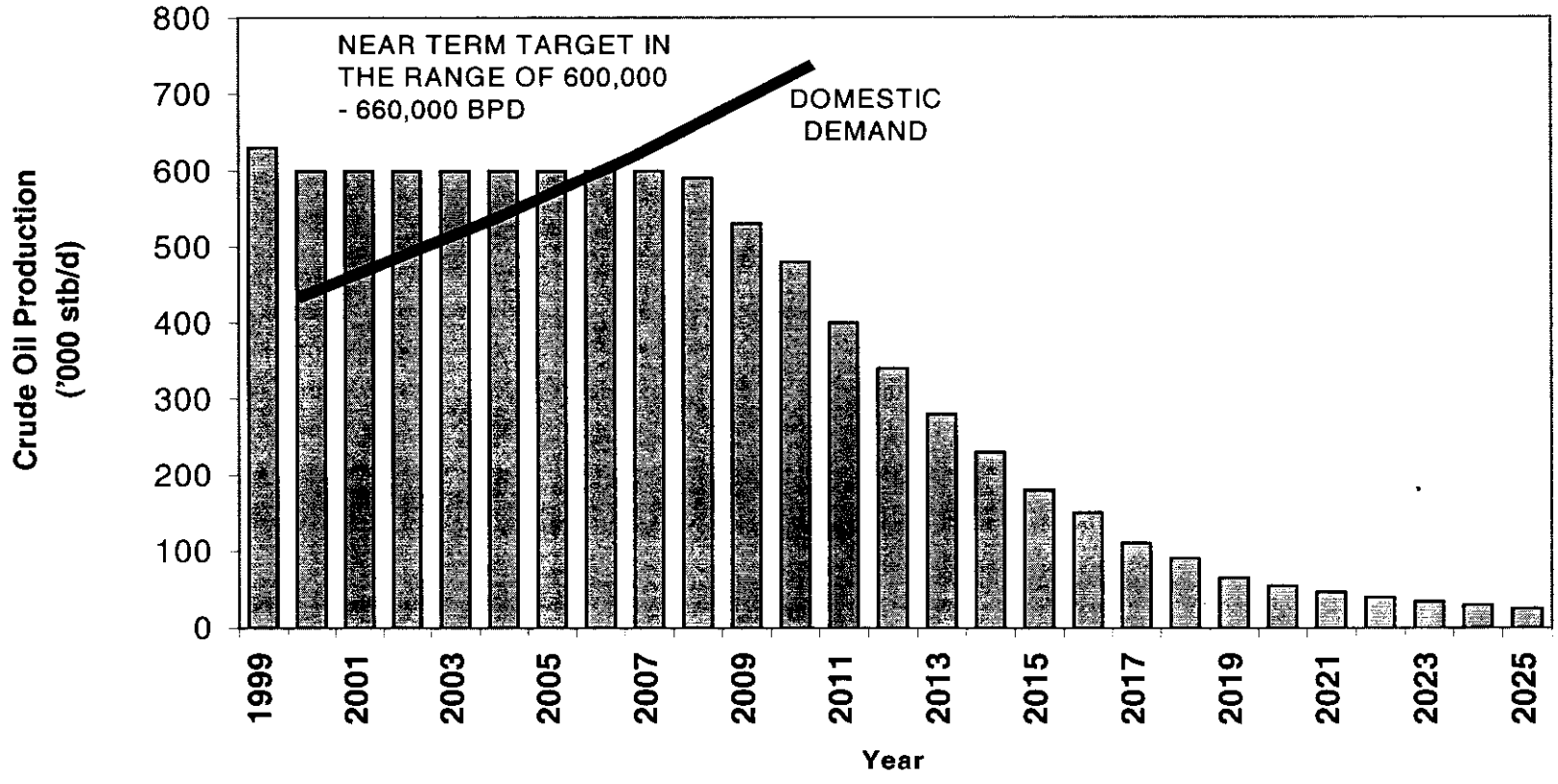
Figure 6-2: Long Term Crude Oil Production Forecast



Malaysia is projected to become a net oil importer in the year 2005

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With no new domestic discoveries of reserves, Malaysia's future production will gradually decline. Thus, at present, there is most definitely an urgent demand for increased exploration activities and improved oil recovery practices in the hope of discovering new reserves and improving production efficiency of current reserves.

With this in mind, budgets for exploration and production activities such as seismic, wildcat drilling and infill drilling for the year 2000 were increased to more than 7 Billion Ringgit compared to around 5.6 Billion Ringgit and 2.7 Billion Ringgit allocated in 1998 and 1999 respectively[15]. This expenditure trend is expected to remain the same especially to secure national petroleum stockpile considering the current volatile oil market, due to a probable U.S. invasion of Iraq.

In addition to domestic E&P activities, to ensure future continuity of its positive revenue, *PETRONAS* has, since 1994, set strategic plans of becoming a multinational oil and gas operator. Thus, to date, the company has invested in capitals in more than 14 countries, with the number increasing steadily as it identifies more and more business opportunities and partners globally, as shown in Figures 6-3 and 6-4 [15].

Therefore, to support these demanding oil & gas activities, domestic and international, UTP's educational platform of producing mechanical engineering graduates with an appropriate extent of exposure to and knowledge of the upstream oil and gas industry will greatly benefit the national manpower needs generally and *PETRONAS'* human resource needs specifically, in this all-important economic sector.

In the near future, the petroleum specialization programme at UTP will grow and evolve to eventually assume the role of a national and regional centre for the exchange of ideas, knowledge and experience and for research and development activity in oil & gas engineering. The centre will cater for the country's anticipated growing need for engineers with specific expertise in the area of oil & gas. As a start, the university is embarking on identifying an

international partner to collaborate on developing a Master of Science or Master of Engineering program in an effort to upgrade the existing local pool of technical personnel in the oil & gas industry.

Figure 6-3: Petronas Current International E&P Projects: CLMTV & Asia Pacific

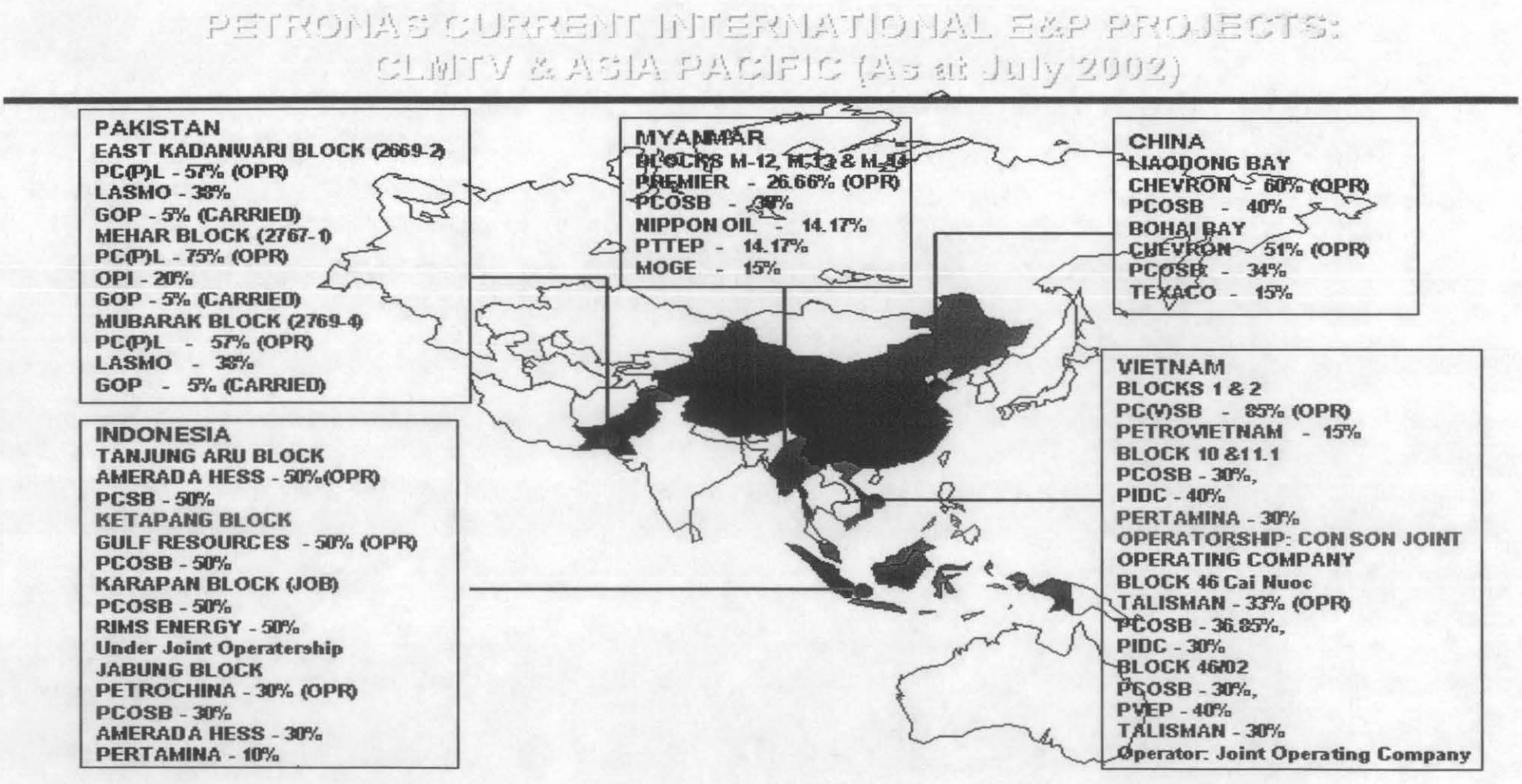
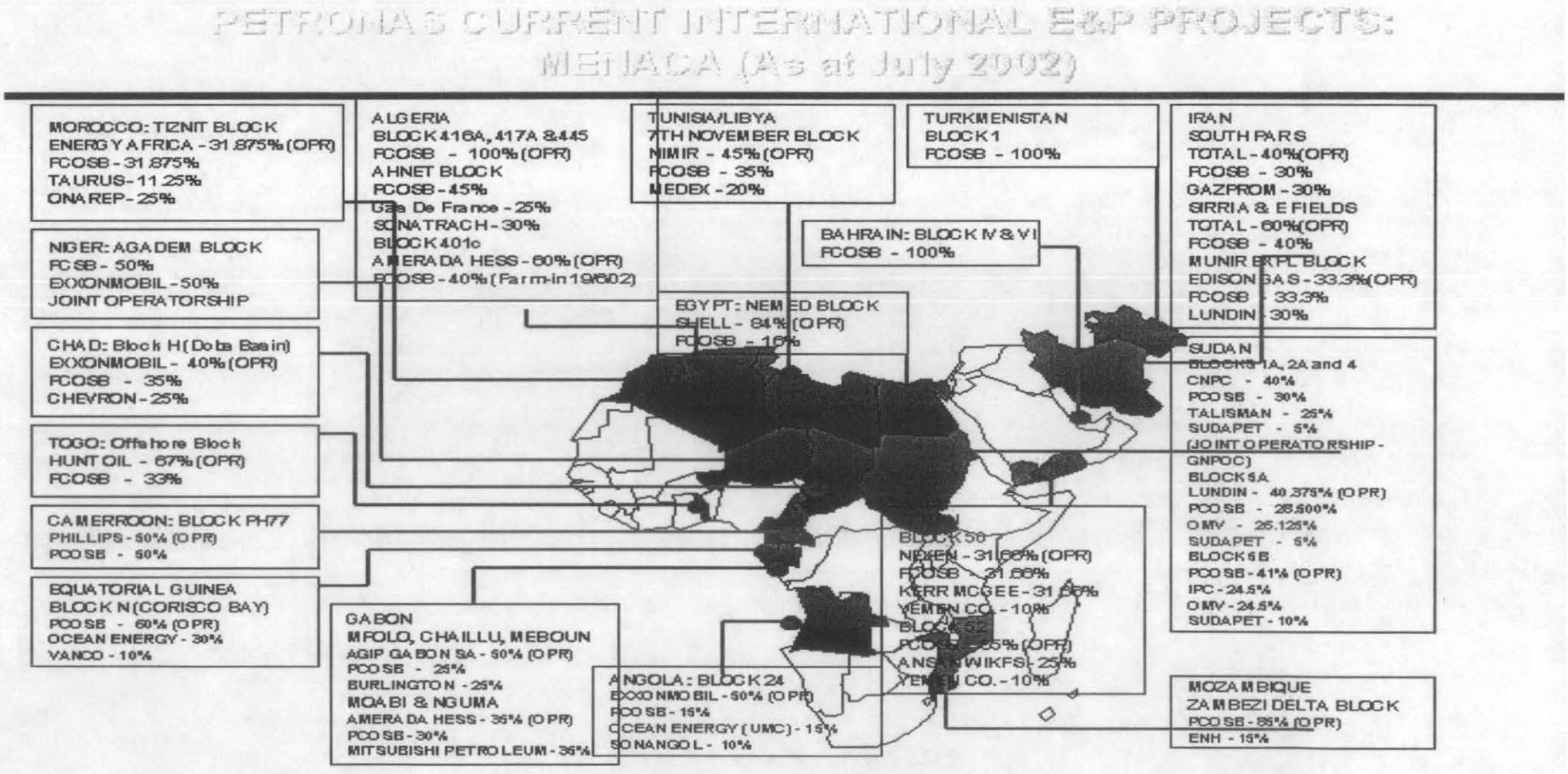


Figure 6-4: Petronas Current International E&P Projects: Menaca



Currently, expatriate services are employed to fill the specialist manpower needs of the oil & gas industry[47,48,49]. Feedback from the industry towards the questionnaire on petroleum education and employment conducted for this paper, indicate that Malaysia is investing in its own homebred talent, aimed at gradually taking over the expatriate positions in the local industry and some of these local experts will themselves work as expatriates representing Malaysian interest throughout the various *PETRONAS'* international E&P ventures.

6.0 CONCLUSION

The objective of *Universiti Teknologi PETRONAS* in providing education on petroleum engineering is to undertake the challenge of producing exceptional graduate entrants who shall become life-long contributors to the oil and gas industry. UTP's petroleum specialization program is intended to attract engineering undergraduates who are interested in the study of petroleum.

These students are potential entrants into the oil and gas industry, for which there exists a broad range of employment opportunities for both the upstream and downstream sectors. Like other students, they would be concerned over how, upon graduation, they will fare in the search for an entrant position in the job market.

By having a petroleum program as a specialized stream under a main engineering discipline rather than a pure petroleum degree, UTP attempts to increase the employment chances for these graduate entrants, who will have wider employment options carrying a more general engineering degree and thus not be regarded as being "over-specialized."

At the same time, with UTP's appropriate amount of exposure to the skills and knowledge of the oil & gas industry as an added value to an otherwise "bland" engineering degree, these graduates acquire an advantage over those without such exposure, in securing a position in the industry.

An effective baccalaureate program on petroleum engineering has to be carefully designed around the current and future requirements, expectations and recruitment patterns of the Malaysian oil and gas industry. Thus, since the objective of UTP's program is to produce mechanical or chemical engineers with specialized skills in the upstream oil & gas industry - not to produce specialist drilling, reservoir or production engineers - UTP will avoid producing an excess of specialists in this field, which for the specific case of the Malaysian industry, has a much smaller hiring capacity compared to the more general disciplines of mechanical or chemical engineering.

Unfortunately, at the time this research project is conducted, UTP's petroleum specialization program under mechanical engineering has not yet taken off ground; thus, there is of yet no graduate product of the program. Consecutively, it is not possible to conduct a comprehensive assessment of the program's effectiveness.

Nevertheless, once the program is initiated and courses start to be delivered, UTP's existing quality assurance system must ensure that student feedback of these courses and industrial feedback gained from the industrial internship program are critically considered and closely scrutinized for quality assessment purpose and further improvement of the courses in particular and the program in general.

Additionally, after the program starts to produce graduate engineers into the workforce, UTP should implement a post-university feedback system of recent graduates as part of the effort to assess the effectiveness of UTP's petroleum engineering program in meeting its curriculum objectives and the continually evolving expectations of the industry.

The system shall be able to keep good contact with recent graduates of the program, in whatever profession or industry they may be and reasonably follow their career development. Questionnaires and surveys should be sent out to them on specific and appropriate intervals, with suitable queires so that the following objectives can be achieved:

- To determine whether UTP's petroleum engineering program is of good standing, maintaining quality and parity with other tertiary programs on petroleum education
- To evaluate whether the program is meeting the objectives of its curriculum and the expectations of its students and industry
- To assess the standing of the graduates in an absolute sense and in a relative manner by having them to benchmark their own performance against petroleum graduates of other reputable universities
- To gauge the effectiveness of UTP's petroleum courses, whether they are sufficient in furnishing students with the knowledge required by the industry and needed to achieve curriculum objectives

- To ensure that the needs and requirements of all UTP's stakeholders are fulfilled

As was raised in the 1997 Asia Pacific Colloquium on Petroleum Engineering Education, there exists no institution in the Asian region that can act as an accreditation body on petroleum engineering education[39]. Thus, while there is an absence of such authority, an effective way to assess the credibility of UTP's petroleum program is to benchmark against identical and reputable programs of other universities, which not only have received accreditation in their respective countries but are also acknowledged and highly regarded internationally.

To enhance the effectiveness of UTP's quality assurance effort, a system for continuous improvement at the more specific program level - in this case the petroleum specialization program - must be implemented and maintained. This will enhance UTP's quality management strategies from being "located, owned and operationalised" at the university level to the more specific program level, as proposed by N J Jackson in the paper *Specification for a University Department Quality Management System*[54].

Such continuous improvement program at the departmental level should involve the following activities. Many of these would rely heavily on and benefit significantly from information gained through existing students' feedback and recent graduates' survey, as explained in the paragraphs above. These activities shall include[54,55]:

- Studying possible incorporation of other courses, e.g., Economics/ Field Development, Risk and Reliability or of other material into existing courses to improve the effectiveness and suitability of program syllabus in achieving curriculum objectives

- Exploring various methods of instruction, e.g. simulated learning, e-learning, sharing of resources, the Internet, to maintain and even improve student's

interest in the field and motivation to succeed, thus enhancing their academic performance and work quality

- Analysing other education tools in the effort to provide students with additional exposure to the petroleum industry, enrich their academic experience and encourage early involvement in professional practices, such as attendance and involvement in conferences and seminars

- Examining possibility of incorporating research work and other educational activities such as student paper contests, journals & publications review, into the syllabus

- Studying the strengths of other petroleum programs of highly competitive universities, assimilating those aspects that can be adopted into UTP's program and learning from their past experiences in delivering undergraduate education on petroleum engineering

- Examining suitability and effectiveness of the choice of textbooks and other reference materials utilised for the courses

- Implementing human resource policies and development programs that can improve enthusiasm, motivation and skilling of academic staff and instructors

- Maintaining contact with the industry – While students are given the opportunity to undergo industrial internship, lecturers too have similar opportunity for industrial attachment in a related industry. Additionally, on a regular basis, industrial practitioners are invited as adjunct lecturers to give first-hand accounts of the latest research and development activities in the field or of the current technologies employed in their line of work.

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