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Training geophysicists for industry: a Malaysian perspective

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Abstract: Universiti Sains Malaysia is the only Malaysian university offering a full-fledged programme in geophysics at the undergraduate level. Since its inception in 1972/73 the Geophysics Programme in USM has proven itself to be popular and relevant to the country's trained manpower needs. Its graduates are in demand in industry especially in the petroleum and geophysical sectors. The Programme is essentially a broad-based package which is, by design, multidisciplinary in nature. It has evolved over the years to meet changing needs. Practical training and fieldwork are essential components of the curriculum. An optional industrial training programme has become one of its most attractive features. The Geophysics Programme provides a firm foundation in the basics. Industry conducts its own intensive training programmes to develop more specific skills relevant to particular jobs. Close links have been established and maintained with industry from which the Programme draws considerable support. To date, more than 300 geophysics graduates have been produced. The majority of them work in the oil and geophysical industries. The employment prospects for geophysicists in this region are excellent in the long term.

INTRODUCTION

The field of geophysics is essentially the study of the earth through the application of the principles of physics and the use of quantitative physical techniques. It is therefore a very broad discipline and encompasses such diverse branches as exploration geophysics, engineering geophysics, seismology, geogravity, geomagnetism, geothermometry, geochronology, meteorology, physical oceanography and tectonophysics. Integrating various fields of knowledge, it is truly an interdisciplinary and multidisciplinary subject.

Universiti Sains Malaysia (USM) is currently the only university in Malaysia, whether public or private, offering a comprehensive integrated programme of geophysics courses at the undergraduate level. The two geoscience programmes taught in the Geology Departments of Universiti Malaya and Universiti Kebangsaan Malaysia are essentially geology-based but do offer some geophysics courses. The Geophysics Programme offered in the School of Physics, USM is physics-based and is thus unique in the local education scene (Lee, 1982).

From its humble beginnings in the 1972/73 academic session as a specialization within the Bachelor of Science (with Honours) degree in Physics, the Geophysics Programme has progressed by leaps and bounds to become a full-fledged undergraduate programme leading to the Bachelor of Applied Science (with Honours) degree in Geophysics.

Over the last quarter of a century the Programme has proven itself to be a very popular choice. It is relevant to the country's trained manpower needs in this specialized field. Its graduates are in great demand in industry especially in the petroleum exploration and related geophysical sectors.

THE GEOPHYSICS PROGRAMME IN USM

Providing sound basic training and a firm foundation in geophysics has always been the primary objective of the Geophysics Programme in USM. The aim is to prepare graduates to play meaningful and productive roles in the petroleum, geophysical and allied geoscience industries. Due to the cyclical fluctuations in demand for geophysicists, the Programme necessarily has to be broad-based and not be too narrowly specialized so that its graduates are in a better position to avail

themselves of other employment opportunities as they arise and adapt themselves accordingly.

It is for this very practical reason that a rather broad range of courses has been incorporated into the Programme since its inception. Building upon a firm foundation of basics in physics, mathematics and geology in the First Year, students are taught solid-earth geophysics, exploration geophysics, meteorology, oceanography, data analysis and remote sensing in their Second and Final Years. In the Final Year they have the opportunity to specialize by picking up more advanced elective courses.

Over the last quarter of a century, the Geophysics Programme has evolved to meet ever-changing needs, priorities and interests. At its inception in the 1972/73 academic session only four Geophysics elective courses were offered under the "paper" system adopted by USM at that time. With the introduction of the "unit" system in 1976/77, the Geophysics component comprised 18 units out of 80 for all Physics courses for a total graduation requirement of 120 units for the Physics degree. Taking advantage of a university-wide revamp of course structures in 1981/82, the Geophysics Programme was able to increase its component to 35 units out of 80 for all Physics courses.

The next big leap forward occurred in 1986/87 when the Geophysics Programme was first offered for the new Bachelor of Applied Science degree in Geophysics. The Geophysics component then was 52 units out of 80 units from the School of Physics for a total graduation requirement of 126 units. After another university-wide restructuring of all programmes in 1994/95, Geophysics courses made up 70 units maximum out of 98 Physics units for an increased total of 140 units for graduation. The most recent major change came in 1996/97 when most undergraduate programmes in local universities were repackaged for a duration of three years instead of four. With this change the Geophysics component became 63 units maximum out of 87 units for Physics with a graduation requirement of 118 units.

In addition to these major changes, readjustments and fine-tuning have been done from time to time in response to specific needs. For example in 1998/99 a new course in engineering and environmental geophysics has been introduced. This enhances the current Geophysics component to 67 units out of 87 for all Physics courses. With this progressive increase in the percentage of Geophysics courses, the graduates now have a much firmer foundation in the various aspects of geophysics to better meet the expectations of an increasingly demanding employment market.

PRACTICAL AND INDUSTRIAL TRAINING

Geoscience is necessarily a field-oriented discipline. Consequently practical training and fieldwork constitute very essential components of any geoscience curriculum worthy of its name. Hands-on experience is extremely important in many aspects of the discipline. This has long been reflected in most geoscience curricula throughout the world.

This fact has been recognized by USM since the very beginning of its Geophysics Programme. Laboratory and field practicals have always been part and parcel of the curriculum. Currently they consist of geology practicals in the First Year and Geophysics practicals in the Second Year. In addition, there are two compulsory geology field trips for First Year students and a one-week compulsory Geophysical Field Camp for Second Year students. The latter is designed to simulate the working environment and involves fieldwork with various geophysical techniques in an integrated field programme to study specific aspects of a particular area. It encompasses data collection during the day and data analyses, interpretation and report writing at night. The programme culminates in a final report, a viva voce and a critique. Teamwork is emphasized. We have found this to be a very useful tool for field training. The students consider it interesting and educational albeit challenging and stressful. Geoscience educationists have long considered field camps to be indispensable parts of training (for example Kirchner, 1997; AGI, 1997).

During the Final Year students undertake a compulsory research project involving some elements of field data acquisition, data processing and interpretation, laboratory measurements, physical modelling, computer simulation and literature survey. Students are required to submit a Final Year Project report and present their results at a viva voce before a panel of examiners. By and large, students find this course probably the most rewarding and challenging, though time-consuming, in the whole curriculum. This is because it provides excellent training and the reports are useful at subsequent job interviews to impress potential employers about their ability to carry a project through to completion.

One of the most popular and attractive features of the Geophysics Programme is industrial training. Although not compulsory most students do opt for it. This very successful programme is open to all Geophysics students who have completed their penultimate year. This training is conducted during

the long vacation for a duration of approximately two months. Petroleum, geophysical and geotechnical companies as well as relevant government agencies have been very helpful and forthcoming in offering places for such training. While most of the training is within the country, students have occasionally been sent overseas to India, Australia and Indonesia for example. Monetary benefits vary but the companies generally pay an allowance of between RM500 and RM1,500 per mensem. Some of the more generous firms provide accommodation and return airfare as well. However, the main benefits are non-monetary.

In some cases the term "industrial training" is a misnomer. While some companies do prepare a systematic training programme, most of them are too busy to do so and offer instead on-the-job experience under close supervision. The interns learn as they go along, pick up certain skills and expertise on the way and get a good feel for the job of a geophysicist. They acquire hands-on experience and get good exposure to the real world as opposed to a purely academic environment. This stands them in good stead in their future careers. Not only do they establish invaluable contacts with potential employers, they also acquire a good overview of the job market and a feel for the work environment. This stint of attachment with a major company often becomes a proud and priceless addition to the student's resume and provides an indication to potential employers of his ability to perform in an actual working situation.

The benefits to employers who offer such an internship programme arise from the fact that it avails them of the opportunity to promote themselves to the pool of potential employees and the chance to observe and identify potential additions to their staff. Our records, in fact, show that many trainees eventually do end up working for the very companies in which they did their industrial training.

A strong case can be made for making industrial training compulsory, with credits being given for such work-based learning and recorded in academic transcripts (see, for example, Thomas, 1992). In USM it has not been practical thus far to make it compulsory, mainly because a sizeable number of academically weaker students need to use the long vacation to make up for courses failed during the regular semesters. To reschedule such training during a regular semester would only be at the expense of other courses. Although this issue merits further consideration, the status quo has served our purposes very well so far.

While a university should try to prepare its graduates well for the jobs they are likely to perform, it is definitely in no position to provide all the relevant training required for an increasingly complex and specialized job market. This is true for most fields and is especially so for geophysics today. Most employers recognize the fact that a university can only provide a firm foundation in the basics upon which the graduates will have to develop and hone more specific skills. Tarling (1996), for example, discussed this issue in the British context. All major oil and geophysical companies, in fact, have their own intensive and comprehensive training programmes during which specific skills are taught and special expertise peculiar to the requirements of that particular job or company is developed. In this regard universities and industry do and must complement one another.

POSTGRADUATE STUDIES

The generally good demand for Geophysics graduates has made attracting sufficient numbers of postgraduate students a perennial problem. The modest stipends which USM offers under its graduate assistants scheme can never compete with the salary a graduate commands in industry. Money is not the main criterion but the fact remains that only a handful have so far enrolled for postgraduate degrees in Geophysics via research, and fewer still have actually graduated. Most of these who eventually drop out do so because of subsequent irresistible job offers outside.

The majority of employers in Malaysia tend to do most of their recruiting at the bachelors degree level. Applicants with masters qualifications do not generally enjoy any significant monetary advantage. What seems to count more is working experience. There is thus no real monetary incentive to pursue a postgraduate degree. Indeed the fact that a masters graduate loses two years' income, experience and seniority is a powerful disincentive. The situation is different in the U.S. for example where there is an increasing trend among oil companies to hire at the masters level (Larner, 1991). Unfortunately we have not reached that stage of development yet.

In recent years the feasibility of offering masters programmes via coursework in Applied Geophysics and Atmospheric Science has been looked into. Again the main stumbling block has been the lack of sufficient interest, given the generally favourable employment climate. These plans had to be shelved until a more opportune time. One way around the problem is to open up these programmes to foreign students as well. Otherwise the small numbers expected would not make these programmes viable in the long term.

Table 1. USM geophysics graduates by year and degree classification.

Degree / Year	First Class	Second Upper	Second Lower	Third Class	Pass Degree	Total
1974			1			1
1975		3	1			4
1976						0
1977			6		1	7
1978		1	1		1	3
1979		3	1		1	5
1980		2	4		4	10
1981					5	5
1982		5	3		8	16
1983		4	4	1	1	10
1984		4	6	3		13
1985		5	8	4		17
1986		10	10	12		32
1987		7	5	5		17
1988		1	3	2		6
1989		2		4		6
1990	1	4	2	1		8
1991		1	9	4		14
1992	3	3	5	4		15
1993	2	3	2	5		12
1994		3	5	4		12
1995		8	9	5		22
1996	1	4	15	7		27
1997	1	5	12	12		30
1998		3	8	5		16
Total	**8**	**81**	**120**	**78**	**21**	**308**

Table 2. Employment of USM Geophysics Graduates by Sector.

Employment Sector	Year of Graduation		
	1974-98	1974-89	1990-98
Geophysical/Geotechnical/ Mining/Meteorological Companies	27.0%	14.4%	41.7%
Oil Companies	16.2%	22.3%	9.2%
Government Agencies	10.4%	10.8%	10.0%
Education	19.7%	23.0%	15.8%
Factories	14.3%	12.2%	16.7%
Business	12.4%	17.3%	6.6%
Total	100.0%	100.0%	100.0%

GRADUATE PROFILE

At least 308 graduates have been produced by the Geophysics Programme in USM up to 1998. (Records for the early 1970s are incomplete; consequently there is some degree of uncertainty as to the actual number of students who took up the Geophysics Option in the early years. Some took a combination of options. The minimum numbers quoted here therefore only take into account known unambiguous cases.)

Table 1 shows the number of graduates according to year and degree classification. In the early years there were only a handful of graduates each year even though most Physics students at that time chose the Geophysics Option. The numbers began to pick up in 1982 in response to increasing market demand during the boom years of the oil industry worldwide. It peaked in 1986 with a total of 32 graduates. Unfortunately for them 1986 was one of the worst years for the employment market. The greatly reduced numbers of graduates for 1988 to 1990 was in direct response to the worldwide recession of 1986 to 1987. There is a lag-time of approximately three years between sharp fluctuations in employment trends and the corresponding response in the number of graduates. In recent years we have tried to maintain an intake of between 20 and 25 students per year because experience and feedback have shown that this is about the right class size for an average year.

From 1983 USM began awarding the Third Class Honours degree in place of the Pass degree. The introduction of the Bachelor of Applied Science degree in Geophysics in 1986/87 attracted better students. This was reflected in better overall performances four years later in 1990 when the first ever First Class Honours degree in Geophysics was awarded. This started a very encouraging and healthy trend in the quality of graduates.

Incidentally, the first female students enrolled with the pioneer batch for the Bachelor of Applied Science degree in 1986. Since then they have constituted approximately 20 to 30% of each class. Interestingly enough, 5 out of the 8 First Class Honours degrees awarded so far have been to females. They also contribute a significant number of the Second Class Upper degrees. Thus the overall academic performance of the fairer sex has been above average.

EMPLOYMENT DATA

Since 1977 I have been informally compiling data on the employment of USM Geophysics graduates. This information is based on personal feedback from graduates and employers. To date, out of the total of 308 graduates, data on 259 are available. This percentage of 84.1% that we have been able to keep track of is high, considering the fact that the data were obtained by word of mouth and not through any systematic survey.

Table 2 gives the breakdown of employment by sector, based on the last known employer of each graduate. In addition to overall data for the years of graduation 1974 to 1998, data for 1990 to 1998 have been separated from that for earlier years to highlight more recent employment trends. Most of the graduates (53.6% overall, 47.5% for 1974–89 and 60.9% for 1990–98) work directly in the geophysics field in geophysical/geotechnical/mining/meteorological companies, petroleum companies and government agencies involved in geosciences. In recent years there has been a marked increase in employment opportunities in geophysical/geotechnical firms and a decrease in the oil companies.

In the earlier years approximately a quarter of the graduates go into the education sector which includes teaching in universities, colleges, schools and private institutions or pursuing diplomas or higher degrees locally or overseas. In the 1990s this figure dropped to about 16% reflecting better prospects in the primary field. Whilst about 30% pre-1990 ended up working in factories (mainly electronic) or in other business enterprises, only about 23% did so in the 1990s, showing again that these are secondary avenues for employment. The rather wide range of occupations our graduates engage in is a healthy reflection of their versatility and adaptability!

Job mobility is another interesting aspect of their employment profile. Approximately 80% of the graduates have worked for at least two employers. This is especially true for those working in the geophysical industry in which there is a global trend for competent personnel with valuable experience to move on after a few years to another competing company for a better-paying position. Some of our graduates have worked for as many as five or six different firms.

LINKS WITH INDUSTRY

Throughout its existence the Geophysics Programme has enjoyed strong support from industry. In the initial years oil companies had been very helpful in providing samples, maps, charts and data for use as teaching materials. Technical talks to staff and students as well as guest lectures have been given regularly by personnel from the petroleum and geophysical companies.

The tremendous support from industry has enabled us to run the very popular, successful and

beneficial industrial training programme mentioned earlier. Career talks and recruitment exercises have been conducted on a regular basis on campus by some of the major companies involved in the oil and geophysical industries. Senior personnel from industry have been appointed University Associates to provide comments, suggestions and feedback on the academic programme. This helps to ensure that the curriculum is kept current and relevant to the needs of industry.

Since 1978 Esso Production Malaysia Inc., one of the major upstream oil companies operating in the country, has been donating an annual cash contribution of between RM5,000 and RM7,000 for the exclusive use of the Geophysics Programme. In 1993 Schlumberger Geco-Prakla, a Paris-based multinational giant in the geophysical industry, awarded on US$10,000 grant from its Schlumberger Stichting Fund to the Geophysics Programme in recognition of its "unique position of being the only tertiary education institution offering a Geophysics Program as well as for contributions to the advancement of Geophysics in your country". This is recognition of the highest order for which we can justifiably be proud. Other major oil companies have provided funds from time to time for staff and students to participate in conferences.

The very close, cordial and enduring links that have been established and maintained with industry have been extremely beneficial in many ways and are a source of strength and support for the Programme.

PROSPECTS AND CHALLENGES

The petroleum industry is the largest single employer of USM Geophysics graduates. One feature of the oil industry worldwide is the highly cyclical nature of employment trends in response to a whole range of economic and political factors. The industry is one of high risks and vast profits. Predicting employment trends in the oil sector has been notoriously difficult (Johnson, 1992). In the last two decades or so, the Far East has been one of the "hot spots" for oil exploration activity. Consequently a large part of the downturns experienced by the industry in the West has been cushioned considerably in this region, making the situation here relatively more stable. The consensus of opinion of employers and academics is that the prospects for employment of geophysicists in the petroleum and related geophysical industries in this region are good to excellent in the long term. However, in the short term, it is extremely difficult to predict such prospects in this highly volatile sector with any great degree of certainty.

Geophysical activity in mineral exploration and mining in Malaysia is still on a relatively modest scale. Thus, employment opportunities in this area are currently few and far between although the potential is there. Whilst still in its relative infancy, the use of geophysics in geotechnical surveys, hydrogeological investigations and environmental studies will become increasingly important as the country develops and environmental concerns come to be taken more seriously. Significant increases in employment opportunities in these fields can be expected.

A major challenge is to keep the Programme current and relevant. This is a continuing process. Thus far, the Geophysics Programme has met this challenge well, as shown by the many changes in the structure and content of the curriculum over the years. The increasing usage of high technology and information technology in industry presents another challenge for the Programme to produce graduates who are able to handle them. The tremendous resources available through the Internet should be harnessed to enhance the Programme. Maintaining the attractiveness and appeal of the Programme to potential students as a path to a rewarding professional career will always be a continuing test of our resourcefulness.

CONCLUSION

The basic strength of the Geophysics Programme in USM is its unique position in the Malaysian educational system. No other local university offers any comprehensive geophysics package of comparable scope and depth. In that sense geophysics has long been synonymous with USM. It has been a highly successful, popular and useful programme relevant to the trained manpower requirements of the nation, particularly in the economically vital petroleum industry. The importance of practical training cannot be over-emphasized. The Programme's broad-based multidisciplinary curriculum produces graduates with firm foundations in the basics who are sought after by industry.

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