Remote Sensing Education in Malaysia: A systematic approach at Universiti Teknologi Malaysia.

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Key words: Systematic, Education, Training, Research, Remote Sensing, GIS, Integration.

ABSTRACT

The current approach that has been adopted in remote sensing education at the Universiti Teknologi Malaysia (UTM) is presented in this paper. A systematic formulation of syllabus that addresses cognitive learning issues, the integration of remote sensing with other related technologies, opportunities to conduct research, undergoing training and promoting the technology to others are viewed as systematic approach in remote sensing education and further discussed in this paper. Suggestions are also made to have knowledge fusion between remote sensing and related technologies and inclusion of remote sensing elements into primary and secondary school syllabus in Malaysia. Research shows that UTM has adopted near systematic approach with rooms for improvement. With the Memorandum of Understanding signed between UTM and Malaysian Centre for Remote Sensing (MACRES), further development in the aspects of human resource development programme, technology transfer, research, consultation, and data/information exchange is expected to happen in remote sensing.

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1. INTRODUCTION

Remote Sensing is a rapidly growing technology and is one of the important spin offs in the space research. Remote Sensing is always viewed as a discipline that is integrated with other disciplines such as photogrametry, GIS and computer science. As with the introduction of remote sensing and related technologies, education plays a pivotal role in its widespread adoption. This is because education is a medium that channels knowledge and understanding of concepts and applications of the technology using the formal system of school, college or university. In addition, education also provides opportunities for the learners and teachers to conduct research and training activities.

Systematic review is a uniquely powerful mechanism for teaching, and they offer teachers a new opportunity to model rational and effective use of information (Robert et al, 1997). In the context of remote sensing, systematic education is reviewed as the (i) integration of remote sensing with other related technologies such as GIS, GPS, Photogrammetry and computer science. Integration of satellite based remote sensing with photogrammetry and GIS has enhanced its capabilities in the areas of resource management and solving environmental or spatial related problems very rapidly and efficiently in comparison to exploiting just one of the technology alone. Remote sensing and photogrammetry provide a means of creating and revising data in GIS. Satellite data is an essential component in GIS as data to be stored, analyzed, retrieved at will and produced end products that are used to solve problems. Therefore, it is worthwhile to treat remote sensing as an integrated disciplines of photogrammetry, GIS and computer technology. In addition to that, systematic education in remote sensing must also cover (ii) research into new areas, (iii) appropriate training activities to both the learners and teaching/ academic staff in related fields, and (iv) promotion/ awareness of the technology to other remote sensing society or other communities. The combination of all the 4 above mentioned aspects are considered here as a systematic approach in remote sensing education and further discussed in this paper. In addition, recommendation paths for improvement and advancement in remote sensing education is also made in this paper.

2. REMOTE SENSING BACKGROUND IN MALAYSIA

Remote sensing education had fairly a late start in Malaysian universities due to the lack of expertise, facilities and the late realization of the technology (Mohd Ibrahim Seeni Mohd, 1993). In Malaysia, there has been considerable growth in all areas of remote sensing and GIS since the publication of report on manpower education and research prepared for Malaysian government by the University of New South Wales in 1987 (Forster, 1993). Such development in that field has emerged the needs for education, research and training. This is

because these three aspects are the heart of development for any rapidly growing technology. Remote sensing had its prominent step in Malaysia via a general Memorandum of Understanding (MOU) that was signed between the Australian government and Malaysian Ministry of Science, Technology and Environment in December 1985. Via the memorandum, a number of collaborative programmes in remote sensing were developed and the establishment of MACRES was one of that.

The establishment of MACRES, has increased the application of the technology in government departments and other sectors. The ever increasing demands in the technology of remote sensing however, arose problems when the demands were not accompanied by proper trained personals in order to fulfill both the short and long term demands. As a result of that, the National Remote Sensing Committee (NRSC) in its meeting dated 16 September 1995 had requested UTM to offer bachelor courses in remote sensing in order to increase professional manpower in that field. To date, only UTM offer B.Sc in remote sensing in Malaysia. This is due to the Centre for Remote Sensing at UTM, (CRS) that is well equipped with infrastructure and facilities like complete digital image processing system and academic staff who have wide experience and skills in the field to conduct such courses. Whereas at other universities, remote sensing /GIS are taught only as subjects leading to degrees in other related disciplines like engineering, information technology, forestry, environmental science etc.

Of all the 14 universities in Malaysia, there are several universities which offer remote sensing and GIS courses as one of the elective or compulsory subjects in order to be awarded the bachelor degree. The postgraduate (master or PhD) courses have long been offered in many universities through research. The list of universities and the status of remote sensing and GIS subjects are shown in appendix 1.

3. REMOTE SENSING EDUCATION AT UTM

Education in remote sensing and related technologies has its origin from the undergraduate programme in Land Surveying at the Faculty of Surveying and Real Estate (now called Geomatic Engineering at the Faculty of Geoinformation Science and Engineering) (Mohd Ibrahim Seeni Mohd, 1993). Remote sensing has been taught as a compulsory subject as well as an optional subject in this course. However, with the increasing importance given to remote sensing and related technologies in order to fulfill the human resource development needs of the country, a four year undergraduate programme was started in May 1997 at the faculty leading to the B.Sc. (Remote Sensing) degree, whilst, the postgraduate programmes in remote sensing have been offered since 1986.

The Department of Remote Sensing at UTM (DRS) is relatively a young department which was established in July, 1998. However, the concept and application of remote sensing technology has already been implemented in UTM as early as 1986 via the establishment of CRS which has objectives to provide courses and training at undergraduate and postgraduate levels in remote sensing, facilities for staff to carry out activities in remote sensing and related fields, consultation services for government, semi-government and private sectors and training for users from government, semi-government and private sectors. To date, the

department consists of 9 lecturers, two tutors and three laboratory assistants. In addition to that, the course is also supported by lecturers from other departments at the faculty such as the departments of Geomatics and Geoinformatics. The central mission of the department and CRS is to achieve excellence in teaching, research and professional activities in applied remote sensing and GIS, and to promote the awareness of the technology within the remote sensing community and outside world.

3.1 Education

3.1.1 Undergraduate Programme

DRS provides education and training in remote sensing and GIS to a group of undergraduate students. Student intake was begun in May 1997 with the intake of 28 students. Currently introductory and advanced level remote sensing and GIS are taught to 123 students from year one to three. The first batch graduated in 2001. The entrance requirements for the B.Sc. (Remote Sensing) course are, to have passed the Sijil Pelajaran Malaysia (equivalent to Cambridge O level exams) with credits in stipulated subjects. The new study period for the course is 8 semesters (4 years) and the maximum allowed study period is 12 semesters.

3.1.2 Curriculum

The B.Sc (Remote Sensing) curriculum was modified by UTM upon the consent of NRSC and also based on the curriculum of similar programs at oversea institutions. A total of 139 credits are needed in order to fulfill the requirements to be awarded the degree. The credits come from 7 study sections. The composition of the study sections is shown in Table 1 and 2.

Table 1. Subject categories and the corresponding credits for the B.Sc (Remote Sensing) course at UTM.

Subject categories	Credits	Percentage
Core	90	64.7
University	16	11.5
Basics	21	15.2
Elective	12	8.6
Total	139	100

Table 2. Details of the subject categories for the B.Sc (Remote Sensing) course at UTM.

Subject categories	Number of subjects	Credits	Percentage
Science of mapping & surveying	3	9	6.5
Computer science	2	6	4.3
Physics, Maths, Statistics	3	9	6.5
Environmental subjects	10	27	19.4
Pure RS subjects	11	31	22.3
RS related/ supporting subjects	13	41	29.5
University subjects	9	16	11.5
Total	51	139	100

A systematic organization or formulations of syllabus that addresses cognitive learning issues and infuse appropriate earth system science and global change is highly needed to embed complete knowledge about remote sensing discipline. Integration of remote sensing with other related technologies/ disciplines such as GIS, photogrammetry and computer science also essential to acquire complete benefits of this technology. However, in most universities in Malaysia the separation between remote sensing and GIS departments are apparent and the students at DRS are not well exposed to the technology of GIS and students in GIS programs do not receive enough knowledge and sufficient training in image processing. Therefore, knowledge fusion between GIS and remote sensing or photogrammetry needs to be conducted and all students from both departments must be exposed to the technologies at undergraduate levels. However, students are given choice to select either one of these technologies or integration of both during their final year projects. In this way, upon the completion of their studies the students will have a complete knowledge fusion of remote sensing and related technologies and skill which ensures prospective job opportunities.

3.2 Training

Training provides the students with practical skills/ direct experience that can be used to solve problems in the real world .All the courses of remote sensing, GIS and photogrammetry at undergraduate levels rely on a mixture of theory and practical applications. Weekly laboratory exercises for every subject are designed to complement recent lecture topics in order to create a seamless teaching environment. The classroom training objectives for students include the development of skills in

a) the use of remote sensing data for the purpose of: knowledge of image acquisition methods, data merging, image rectification, image enhancement, image classification, and image algebra
b) the use GIS including the knowledge of the characteristics of spatial data and spatial data handling systems, data acquisition, analytical operations and construction of output products
c) the integration of image processing with GIS and

d) analysing remotely sensed data and applying GIS tools to address issues in natural resource management and environmental monitoring.

Laboratory exercises are conducted using imagery from the local region so that students will be familiar with the study sites and encouraged to conduct necessary ground truthing. Besides that, students are also trained to use data collecting equipment like radiometer and hand held GPS or other conventional methods of data collecting such as boat for oceonographic applications.

Besides that, remote sensing camp, an intensive practical exercise as part of the real environmental exploration is also conducted at the DRSUTM. In this program, the students are placed at places farther from the varsity for conducting environmental analysis using satellite imageries. For instance, the first batch students went to East Coast of Peninsular Malaysia and exposed to marine applications of RS and related technologies, whilst, the second batch students were exposed to the capital city of Kuala Lumpur and nearby new administration centres of Putra Jaya and Cyber Jaya to modes of ransportation, problems arising from transportation and mapping the main routes, land use land cover mapping, techniques to collect data on pollution indicators, and etc.

The final year (4^{th} year) students in this course also participate in independent undergraduate degree projects which carry 6 credits towards the end of the semester. This requirement encourages students to experiment the learnt theory and remotely sensed imagery or GIS techniques to topics of personal interest to them. This exercise involves students moving away from textbook-driven, teacher-led instruction to 'hands-on", learner centered and cooperative learning approaches where students are actively engaged in their own learning process.

Learners are encouraged to collect and scientifically analyse samples related to the topic of their interest. For instance, based on the first batch undergraduate projects, 93.5% were related to exploration and resolving of environmental issues covering land applications (67.6%), marine applications of 19.4% and 6.5% of atmospheric studies. The rest 6.5% are related to pure digital image processing works.

In addition, the department also arranges industrial training for students besides the classroom practical/ laboratory training. This industrial training is formulated with four main objectives as follows:

a) To expose students to the aspects of remote sensing, GIS and other related technologies that are practiced in government departments and private sectors.
b) To give opportunity to students to experience the real working environment.
c) To relate both the learning process and the real working environment.
d) To have a good relationship between university and industries with the objective to have job placement for students upon the completion of their course.

The training locations are at government or private departments/ agencies that have the application of remote sensing in their daily activities. This includes, the utilization and

extraction of geospatial data using remote sensing data, integration of remote sensing with GIS technology and other related technologies. Among the agencies/ departments are; the MACRES, Department of Agriculture, Department of Forestry, Department of Meteorology, South East Asian Fisheries Development Centre (SEAFDEC), Department of Environment, Forest Research Institute of Malaysia (FRIM), Institute of Mineral Research, Institute of Fishery, Malaysian Agricultural Research and Development Institute (MARDI), Palm Oil Research Institute of Malaysia and other private companies.

With the systematic formulation of syllabus that covers principles and applications of remote sensing and related technologies infused into earth science system and practical trainings both in classroom and at user agencies, the graduates to be produced are expected to be always ready to use this technology to solve problems, be able to work in a group of professionals from various disciplines and possess competing ability and entrepreneurship.

3.3 Graduate Course

In addition to the 4 year undergraduate programme the department also offers Master (both by research and taught course) and doctoral programmes in remote sensing to support the needs of the country in this field. Currently, there are 13 master students and 1 PhD student have registered and undertaking their research in various fields. At present, only master course through research and PhD are available at the department. However, running master course through course work is hindered by the insufficient number of candidates, because it requires a minimum of 5 candidates to start the course. The specification of the postgraduate courses at the department and some of the past and present research works by the students are summarized in Table 3 and 4 respectively.

Table 3. The requirements for M.Sc and PhD at the Department of Remote Sensing, UTM

Requirements	*M.Sc (Taught course)*	*M.Sc (Research)*	*PhD*
Academic qualification	A relevant bachelor degree recognized by the university	A relevant bachelor degree recognized by the university	A relevant master degree recognized by the university
Total credit hours	24 (taught subjects) 6 (master's project)	30	30
Subjects	Courses offered within interfaculties	Own thesis topic	Own thesis topic
Study Period (years)	2	2	3-4

Table 4. The past and present projects that have been undertaken by the post graduate students at the CRS.

Current postgraduate research projects	*Previous postgraduate projects*
Mapping topography using SAR Interferometry techniques	Atmospheric and Radiometric Corrections
Extraction of coastal zone information using SAR	Bathymetry from clear and turbid waters
Potentional of Radar data for estimation of soil moisture	Sea bottom features mapping
Remote sensing and Hydrological modeling in flood prediction studies	Suspended sediment concentration studies
Extraction of marine sea grass information using Landsat TM	Sea surface temperature studies
Remote sensing for sea Oil spill studies	Coastal/highland erosion mapping
Haze determination from NOAA AVHRR	Vegetation studies with vegetation indices
Landsat TM and Radarsat SAR data Fusion for improving landcover classification	Urban hydrology applications
GIS for oil spill monitoring	Studies on seagrass and ocean colour
	Radar remote sensing for coastal and land applications
	Mathematical morphology and image processing
	Remote sensing and GIS integration for environmental analysis
	Inference on landslide studies
	Software development

3.4 Research and Consultancy

3.4.1 Research

Innovations, new understanding and advancement in remote sensing will only occur when great amount of effort put towards research activities. CRS has a proven track of records of developing research in the field of remote sensing and GIS. The initiation of this field of research began as early as 1986. At present staff and postgraduate research projects span as diverse as marine applications, topographical mapping, vegetation mapping, hydrological analysis, spatial variability studies and natural hazards monitoring. The development in the field of research and also consultation activities are greatly supported and enhanced by the well-equipped centre. Amongst the facilities available at the centre are exhibited in appendix 2. Below are some of the current research projects at DRSUTM:

(i) Development of direct satellite data readout for daily monitoring of haze and coastal environments
(ii) Integration of remote sensing and GIS for oil palm spatial variability studies
(iii) Ocean Variability studies using SEAWIFF data
(iv) Generation of Spectral signature database
(v) Videogrammetry system for ship building, repair and maintenance

3.4.2 Bilateral projects

Links have also been made with external organisations both for development of research and funding. UTM proactively involves with foreign organisations to undertake joint research projects. It started to have collaboration with Japanese Society for the promotion of Science (JSPS) since 1991 which was scientists exchange programme and from 1999 the both institutions has taken part in cooperative projects. Their focus is mainly to study the variability of ocean condition that involving application of SeaWifs data and ADEOS satellite. Besides that, UTM also involve with British universities like University College London under Committee for International Cooperation in Higher Education (CHICHE) scheme to undertake topographical mapping in Malaysia using SAR data. Through these collaborative/ bilateral projects UTM aims not only to exchange techniques and skills but also to produce graduate students.

3.4.4 Consultancy

The centre has been offering consultancy services since 1990 to many local government, and private user agencies and also to some foreign agencies like Bintan Resort Management Pte. Ltd. The areas of consultancy services rendered by CRS can be grouped into; water depth mapping, seagrass mapping, sea surface temperature mapping, coastline variation mapping of Peninsular Malaysia, coral reefs mapping, land use mapping, estimation of water volume in reservoirs, modelling of sedimentation in reservoirs, pipeline corridor mapping analysis, and digital mapping.

3.5 Awareness and Promoting Activities

3.5.1 Seminar, Workshop, Short Courses

Any new technology will not expand without promotion. In addition to undergraduate and graduate education, the department and centre has a strong commitment to promoting awareness of remote sensing and GIS throughout the academic and commercial sectors. This is achieved both through presentation of papers at conferences and hosting specific conferences at UTM. There were 2 seminars/ conferences had been hosted in UTM. The first was “The South East Asian Regional Conference on Education and Research in Remote Sensing” held in 1993. This was followed by “The Integration of Remote Sensing and GIS for Applications in South East Asia seminar hosted by UTM in 1995. Since the adoption of the technology many papers have been presented by specialist staff and postgraduate students at various National and International GIS and RS conferences. (for detail information refer to the department homepage at http://www.fksg.utm.my).

The department and centre for remote sensing also offer short training courses. The first short course was held in 1992 for personnel from government agencies and other user departments and it was proved to be successful. The first short course was mainly on the application of remote sensing for marine studies. However, realizing the lack of remote sensing basic knowledge among many user departments, this programme has been extended to include courses on the basics of remote sensing to form a strong foundation among the users of the technology. The department has conducted 5 courses until 1999 on a yearly basis. The ever-increasing number of participants from year to year (from only 10 in 1995 to 25 in 1999) (DRSUTM, 2000) shows the realization of the importance of this technology in many aspects of resources development in developing countries like Malaysia. The 2 month short course covers many parts on RS, GIS, Photogrammetry and other related fields as diverse as the basic concepts, application, field data collection and finally the presentation of the output.

3.5.2 Remote Sensing / GIS for School Children

Suggesting the inclusion of remote sensing/GIS technology into primary and secondary school syllabus is another way of promoting this technology/discipline. This way can create interest in them and more students will apply for remote sensing/ GIS courses at universities after their SPM (O) level. Looking at the importance given by the Malaysian governments towards IT, authors trust that such proposals will get a warm welcome in the near future. Suggestions will be made to the Ministry of Education to insert elements of remote sensing and GIS into subjects like geography (secondary school), Human and Environment (primary) and physics or computer subjects.

Satellite, computer and mapping are interdisciplines that can be designed to show students how remote sensing is used to solve environmental problems. A variety of tools including the Internet, GIS, and GPS can be explored as students are exposed to coordinate systems in geography or cartography for instance. Similarly, satellite images or maps in computer can be used to show locations and or further to analyze, interpret and generate their own hypothesis and critical thinking skills to solve their problems.

4. CONCLUSION

The major objective of DRS and CRS at UTM is to produce qualified graduates or trained professionals in remote sensing and related technologies to fulfill the needs of NRSC to overcome the natural resource management problems in Malaysia. The approach that has been adopted and implemented in higher educational institutions in Malaysia like UTM can be said as near systematic approach. However there is still room for improvement. First of all the integration between GIS and other related technologies should be further enhanced. This can be achieved by having a mutual understanding between those departments or sections that are available at the same university or employing staff who has wider experience is such fields. UTM has always taken effort towards research into new areas and promoting this rapidly growing technology to remote sensing community via hosting seminars, workshops and short courses. Meanwhile, inclusion of remote sensing and GIS elements to the primary and secondary school will increase the awareness of the technology among Malaysians. UTM

and MACRES are two important institutions involve in developing and promoting remote sensing and related technologies in Malaysia. In order to facilitate cooperation between the two parties, a Memorandum Of Understanding (MOU) was signed between UTM and MACRES on 16 February 2000. The objective of MOU covers human resource development programme, technology transfer, research, consultation, and data and information exchange.

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APPENDIX

Appendix 1. The status of remote sensing and related technologies at higher learning institutions in Malaysia.

University	*Department/Faculty that offers remote sensing/ GIS*	*Status*
Universiti Teknologi Malaysia	Department of Remote Sensing	B.Sc programme in Remote Sensing Postgraduate studies
University Malaya	Geography/ (Arts and Science Social), Electrical Engineering	Optional and compulsory subjects in undergraduate Postgraduate via research
National University of Malaysia	Geography, Geology, Engineering, Marine Science, Environment	Compulsory in Geology and optional and compulsory at other departments
University Putra Malaysia	Engineering, Forestry, Environmental Science, Fishery	Subjects at undergraduate Postgraduate studies
University Science Malaysia	Engineering, Physics, Humanities	Subjects at undergraduate Postgraduate studies
International University of Islam	Town and Regional Planning	Subject at undergraduate level
University Institute Technology Mara	Geomatic Surveying Sciences/ Faculty of Architecture, Planning and Surveying	Diploma in Geomatics and Surveying Science B.Sc in Geomatics and Surveying Science
University Sabah Malaysia	Electric and Electronic(Faculty of Engineering and Information Technology)	Subject at undergraduate level
University Malaysia Sarawak	Faculty of Information Technology	Subject at undergraduate level
University Multimedia Telekom	Faculty of Engineering	Subject at undergraduate level
University Tenaga Nasional	n.a	n.a
University Technology Petroleum	n.a	n.a
University Tun Abdul Razak	n.a	n.a
North University of Malaysia	-not offered	--not offered

n.a = data not available

APPENDIX 2.

The facilities available at CRS to conduct research in remote sensing and GIS.