Enabling Geographic Information Systems and Remote Sensing in a graduate curriculum for Natural Resource Management: a case study of the COGS- BIOTROP relationship.

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Abstract

A three year relationship between the Southeast Asian Regional Centre for Tropical Biology (BIOTROP), based in Bogor, Indonesia and the Centre of Geographic Sciences (COGS), based in Lawrencetown, Nova Scotia, Canada is discussed in the context of internationalizing geographic information systems (GIS) and remote sensing (RS) curriculum development. The COGS-BIOTROP relationship offers a model for extensible and flexible transnational co-operation in addressing educational needs in developing countries. The specific product is an M.Sc. in Information Technology for Natural Resources Management.

The case study presented in this paper illustrates the respective roles of BIOTROP and COGS in curriculum design, program delivery and program evaluation. Issues identified in the literature which merit discussion include cultural imperialism, content localization, student-teacher relationships, and academic equivalencies between developed and developing countries and assessment strategies. The paper concludes with a set of recommendations for the next cycle of the program which encourages self-sufficiency in program delivery, joint research projects and long term technical support.

1.0 Introduction

In a recently published collection of papers on the state of geographic information systems (GIS) (Longley et. al., 1999), Forer and Unwin (1999) describe GIS in education as a progression from GISy (Geographic Information Systems) to GISc (Geographic Information Science) leading to GISt (Geographic Information Studies). This orderly progression, while interesting, does not match the experienced gained in the hands-on delivery of technical education in spatial information technologies over the last fifteen years (Maher and Wightman, 1985). In this arena, we see the interpenetration of technology, science, social and cultural values in the study of the earth's environment and human use (see Jackson 1987 p. 62 for a discussion of the similar implications for agriculture).

In this paper, we describe an approach to a request for the inclusion of two technologies (GIS and Remote Sensing or Image Processing (IP) Systems) within a larger suite of information technology (IT) tools, for the purpose of developing a graduate degree program in natural resource management in Indonesia. Cross-cultural differences between Canadian and Indonesian participants, as well as the capacity of the host institution to assimilate a new, technically challenging and complex program required the design of not only carefully thought out courses and content, but also protocols with which to address pedagogical issues. Throughout this process, the Forer and Unwin (1999) model of GIS education is at best only partially relevant and an alternative conceptualization was necessitated for the local conditions encountered in the host nation.

A second aspect of concern with the universality of Forer and Unwin's (1999) GISy? GISc? GISt model is their identification of five curriculum design dilemmas. They distinguish between education and training; GIS and xIS; breadth and depth; hands-on and hands-off approaches to course content and delivery; and option contrasted against integrator. While these dilemmas in instructional curriculum design may represent academic discussion points, in practice curricula often evolve more organically in response to a complex of demands which include, among others, institutional factors, cultural and financial concerns, as well as educational objectives, all which should remain central but can be pushed into the background by virtue of other 'immediate' considerations. The mix of ingredients will also be impacted by the best-suited learning styles for the group of students, variations in faculty attitudes as to what issues should be covered in the curriculum and how courses should actually be delivered. There will be a recognition that there is a diversity of IT tools available, some of which can be combined to address more effectively certain classes of problem than others. To define a problem requires an understanding of the pertinent concepts, the available methodologies, the limitations of the tools, as well as the social context in which use of the tools is taught and in which the

tools will be put to practical use. Clearly, in a developing country with national values and objectives that may differ substantially from other contexts, the approach to curriculum development must be crafted sensitively and not necessarily in compliance with any universal pedagogical goals or models in mind. More to the point, such contexts are not well suited to the smooth transition from one form of curriculum design and delivery implied by Forer and Unwin (1999).

At the Southeast Asian Regional Centre for Tropical Biology (BIOTROP), the first approximation of IT tools to be introduced for the new graduate program in natural resource management, included GIS, IPS, spatial modelling and decision support systems. The perspective adopted by the Canadian curriculum designers and deliverers from the Centre of Geographic Sciences (COGS) in Nova Scotia was first that *their* experience was primarily with the first two technologies. Further, it was also apparent to the curriculum developers that spatial modelling and decision support systems were dependent, to some degree, on core instruction in the first mentioned technologies, at least, if the program was to focus on the spatial and temporal distribution of natural resources and their management. To appreciate better the COGS context, Figure 1 shows the setting for the post-graduate GIS and RS diplomas offered at the centre in Nova Scotia. The diagram illustrates the historical roots of these two technical pillars in the IT department, in comparison to the programs offered under the Geomatics department. Effective June 2000, all of the programs at COGS now reside in a single Geomatics department. Another framework relevant to the design of the new program at BIOTROP is the layering of IT, which provides a useful, albeit highly general, context for the design of a graduate curriculum in the use of spatial information technologies (Figure 2). This framework suggests that in order to achieve an operational understanding of the GIS/IPS (Image Processing Systems) environment, an appreciation of the supporting technologies is necessary before any sensible customised solutions can be developed (both curriculum-oriented as well as application-oriented).

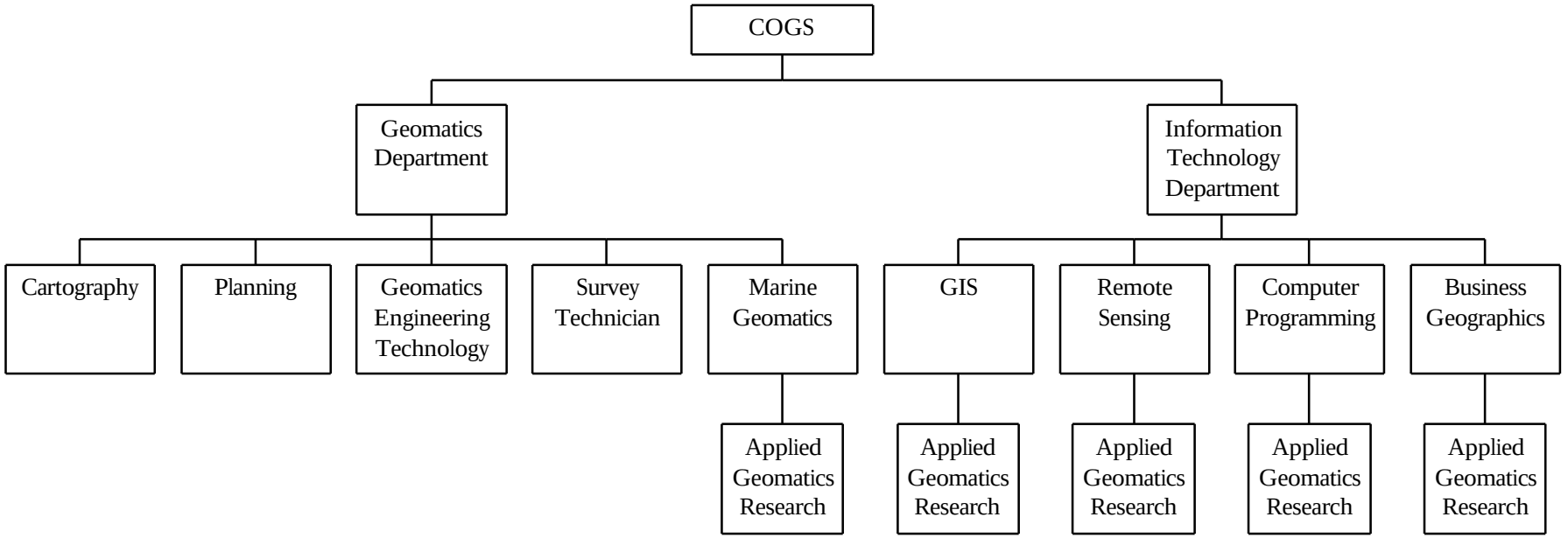

Figure 1 Current Programs at the Centre of Geographic Sciences (COGS) June 2000

*effective June 1, 2000, all programs will be under a single Department of Geomatics.

Aside from the specific definition of IT adopted for the BIOTROP program, it was also necessary to define natural resources management in terms that complied with the objectives of the program and, more importantly, that were in concert with resource issues that are important in Indonesia. The latter

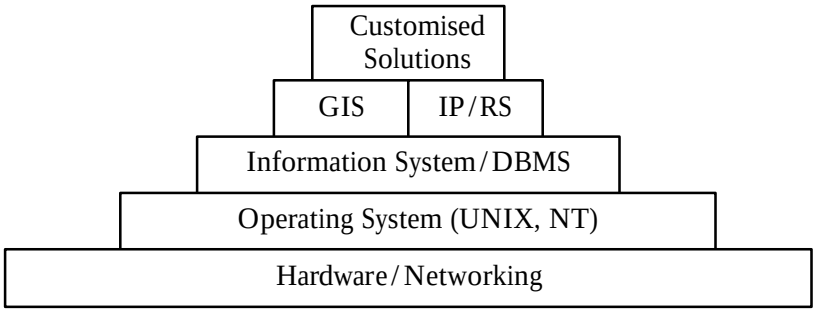

Figure 2 Layering of Information Technology

includes forestry, fisheries and agriculture. Without cognisance of local attitudes toward and understanding of the commonly accepted concept of natural resources, there could be little hope for achieving acceptance of management perspectives and approaches in the delivery of the courses. This latter point is particularly important as many of the initial group of students comprised applied science faculty from provincial universities. In this sense, the program design and content was very much a matter of teaching the teacher and working within the parameters of accepted interpretations of the subject matter in the first instance.

A further important issue for this new program was the relationship between technology and development. Rowe (1990, 63) gives his definition of technology (T) as:

> "An inclusive definition of T is: a reproducible and publicly communicable way of doing things. The keyword, communicable, shifts T into the world of ideas, language, belief, culture – which explains why T-transfer from industrialized to non-industrialized nations is difficult until, either directly by acceptance or indirectly by acculturation, the receiving populations adopt Western values, beliefs, perceptions."

Hall (1999) alludes to similar challenges and problems for GIS education and infrastructure transference from developed to emerging countries. He, likewise, recognises the complexities of the issues and the need for technical, financial and managerial inputs, while allowing for flexibility and appropriateness to be assessed on a case-by-case basis.

In developing a relationship between the two institutions considered in this paper, each from a substantially different part of the world, there must be explicit recognition of both the similarities and differences in educational culture. The COGS objective was to develop a shared curriculum. In

achieving this objective, COGS staff would provide the resources for technical education in GIS and IP/RS, including the language and the style of delivery, developed in and modified from the COGS environment. BIOTROP, on the other hand, would provide its resources in and expertise in modelling and decision support systems and, importantly, also its knowledge of natural resources management concepts and practice in Indonesia. Common characteristics between both groups were that all the teaching must be in English, regardless of faculty nationality, and Internet-enabled computer labs would be available in all of the courses for completion of practical hands-on assignments.

Besides considerations of matters concerning curriculum content, COGS and BIOTROP shared common concerns on financial management, technology upgrades and long-term sustainability of the program beyond its initial delivery. To address these issues, it was necessary to expand the list of stakeholders to include the private sector in Indonesia and to deliver short courses targeted at the spatial information technology marketplace. Moreover, a basic understanding was that participating institutions would collaborate on the submission of research proposals to international development and aid agencies and to undertake joint research and consulting activities.

2.0 The BIOTROP-COGS relationship

In 1997, BIOTROP was successful in its request for funding from the Asian Development Bank (ADB) to establish a new M.Sc. degree in IT for natural resources management. IT was defined at the outset to correspond to four technologies: GIS, IP/RS, Modelling and Decision Support Systems. As noted above, natural resource management embraces forestry, agriculture and fisheries, as well as several other fields including geology, hydrology, land use and coastal zone management.

The initial Canadian contact was in January 1998 via the National Centre for Geographic Analysis and Information (NCGIA), University of California, Santa Barbara. It connected the senior author, then Director, Centre for Environmental Information Management at Royal Roads University and John Rostron, Canadian consultant resident in Jakarta, Indonesia and advisor to the Ministry of Higher Education. The Indonesian counterparts had a very aggressive time line for the initial delivery of the program, namely twenty-four students from Southeast Asia had to be enrolled in the new program by September 1998. The key events over the next nine months were:

(a) institutional assessment/Canadian study tour by Indonesian team
(b) curriculum development workshop
(c) student recruitment
(d) faculty recruitment

(e) program start.

Each of the events leading to the ultimate delivery of the courses in Indonesia is outlined in somewhat more detail below.

a) *Institutional assessment/Canadian study tour*

The Association of Canadian Community Colleges has developed an institutional assessment methodology for bi- or multi-lateral international projects such as that described in this paper (Rostron, 1999). This methodology was used by first organising a three person Indonesian delegation to visit North America in March. The delegation included the Deputy Director of BIOTROP, who has a background in agro-climate modelling, a private consultant with expertise in both GIS and RS and a private consultant with interests in education and training. The group visited several educational institutions in California, British Columbia and Nova Scotia. They determined that to meet their education and training needs, the working environment and educational philosophy at COGS offered the best fit of the institutions visited. This decision was based upon the level and intensity of practical training in the two core technologies: GIS and IP/RS.

b) *Curriculum development*

The development of a curriculum for a new graduate degree program is a very formal process in Indonesia and certainly cannot be approached independent of context. It requires broad consultation with Government, the private sector and the educational community. To facilitate this consultation process, a weeklong workshop was required to reach consensus on the appropriate suite of courses, their description, content, pre-requisites, delivery sequence and outcomes. At the end of the workshop in April, 1998, in which COGS faculty fully participated, there was a public hearing which generated awareness, feedback and further refinement of the basic degree proposal.

Based upon the initial consultation and its subsequent refinement, a suite of courses was identified for the launch of the two-year program (see Table 1). In addition to outlining the specific courses, Table 1 also shows those courses which were to be delivered with a Canadian instructor during the initial launch. For the GIS and IP courses, BIOTROP basically adopted the COGS curriculum for its one year GIS/IP/RS post-graduate diploma. This diploma demands intensive practical instruction, emphasising the development of skills in the application of GIS and IP/RS tools, with a focus on programming skills. Table 2 illustrates the main topics in GIS and IP/RS taught during the first year.

Year 1 – Courses	
Semester 1	***Semester 2***
Introduction to Programming	Information Systems
Modelling of System Dynamics	GIS and Remote Sensing Applications
Natural Resources Inventory and Management	Advanced GIS*
Fundamentals of GIS*	Advanced Image Processing/RS*
Fundamentals of Image Processing/RS*	
Year 2 – Courses	
Semester 3	***Semester 4***
Decision Support Systems	Seminar
Project Design	Project
Spatial Database Management*	
Selected Topics	
Elective Topics	

* Indicates courses taught by a Canadian Instructor

Table 1 Curriculum Design

Semester 1 GIS and Image Processing	
Fundamentals of GIS	***Fundamentals of IP/RS***
Database capture	Geometric and radiometric correction
Database building	Interpretation, enhancement, classification
Introductory Modelling	3D functions/GIS integration
GIS/RS Integration	Electromagnetic Theory & Sensor Characteristics
Semester 2 GIS and Remote Sensing	
Advanced GIS	***Advanced IP***
Advanced Avenue	Orthorectification, advanced 3D modelling, PCA, change detection, mosaics, HIS colour theory, Interferometry concepts, thermography, radargrammetry, Radarsat and SAR images processing
Surface & raster modelling	
Network analysis & dynamic segmentation	
Web-based GIS	

Table 2 Course content for GIS and IP/RS courses

c) Student recruitment

The Southeast Asian Ministers of Education Organization (SEAMEO) has twelve centres located within the member states. BIOTROP is one of these. SEAMEO consists of nine member countries, namely, Brunei, Cambodia, Indonesia, Lao PDR, Malaysia, Philippines, Singapore, Thailand and Vietnam. Funding permitted four students respectively from Thailand, Malaysia, Lao and Cambodia and twenty students from Indonesia to be recruited for the initial offering of the new degree course. The recruitment was competitive within each country. Prerequisites included a good command of English and strong technical computing skills. Most of the students held lecturer positions at a provincial University in their country of origin. Upon graduation, they were expected to return to a faculty position at their home institution.

d) Instructor recruitment

Given the rapid start up and the initial heavy emphasis on the COGS curriculum for the first year, the most efficient recruitment strategy was to hire recent graduates from COGS to teach in the program and transfer their recently gained knowledge and experience, not only to the students but also to faculty who would replace the Canadian instructors after the initial institution building was in place. The Canadian instructors have a previous first degree in some aspect of natural resource management, had developed practical expertise with GIS and IP tools, and clearly were familiar with the COGS curriculum as they had graduated from that institution. The two instructors were recruited in August which allowed them to gain experience with ERMapper IP software and pcArc/Info GIS software at COGS before relocating to Bogor.

e) *Program start*

The program started formally on schedule in September 1998. The academic year was divided into two semesters, September through December and February through May, with courses and sequencing as specified in Tables 1 and 2. In May 1999, the instructors returned to Canada to pursue post-graduate research. The implications of this transience of overseas-based instructors, which were built into the overall program planning, are considered below.

Resources and Supporting activities

BIOTROP maintains a separate campus, but it is part of Institut Pertanian Bogor (IPB), at the University in Bogor, which is the degree granting authority. The primary research emphases on the BIOTROP campus are Tropical Ecosystems, Biodiversity Conservation, Environmental Information Management and Biotechnology. Not unlike many Canadian educational institutions, BIOTROP seeks a degree of financial autonomy in its activities and to support these it offers a number of short courses, workshops and other activities designed to bring revenue into the institute or, at least, to cover costs.

To support GIS and IP/RS activities at BIOTROP, an Internet-enabled PC networked lab was established, as per the terms of reference for the graduate program. The software environment for GIS instruction and research is pcARC/INFO and ArcView and ERMapper is the platform for IP/RS activities. To facilitate minimal cost recovery in these new activities, BIOTROP offered four-week duration short courses in both GIS and IP/RS. These courses, funded by the Canadian International Development Agency (CIDA), were first delivered in April 1999 and subsequently in November 1999. Further, through its links to the private sector in Indonesia and elsewhere in South East Asia, BIOTROP can provide customised training on specific spatial information technology application use for a particular client. These courses are typically less than a week long and they have been supported

by the Environmental Systems Research Institute (ESRI), suppliers of the GIS software used in the graduate program using ESRI's Virtual Campus on the Internet, where appropriate.

3.0 Issues

Sustainability:
Clearly, there are several dimensions to the sustainability of a program such as that developed at BIOTROP. Typically, technical, financial and educational considerations have to be assessed and planned well in advance of the program launch. Any new programs in Indonesia receive an initial infusion of Government funding. This allows for the acquisition of the technology infrastructure, instructor resources and student scholarships. Technology infrastructure depends on the relationship of the institution with suppliers of hardware and software. Given the rapid rate of change, these relationships need to be long term in order to achieve continuity and to ensure that students have access to an infrastructure that is comparable with equivalents available in the developed world. Further, the relationships can be mutually supportive, with graduate research demonstrating the application of these tools. Graduates, with their new skills, find positions in industry or with agencies/universities who wish to apply the technology.

Financial sustainability implies diversification. This includes meeting the market demand for short courses, as well as funded research, where the funding comes from external agencies or the private sector. Without a reliable revenue source it is impossible to sustain the initial investment in infrastructure and staffing.

Educational sustainability depends on a viable technology transfer plan. The ongoing use of Canadians or other expatriates as instructors of IT-based courses in any developing country is non-sustainable. Hence, there must be over at least a five-year time frame, a mechanism to replace Canadian instructors with local, in this case Indonesian, instructors in the core technologies. If this occurs for the GIS/IP/RS steam, then the Canadian focus can shift to joint input into the other technologies in the BIOTROP program, such as spatial modelling and decision support systems. Currently, the program depends on Indonesian faculty for the 'problem definition' of natural resource management. For effective Canadian input into this component a joint research program needs to be explored in more detail, thereby facilitating direct Canadian contributions to the application domain.

International Acceptance:
With increased globalisation, it is important for the graduates of the BIOTROP program to meet the highest international standards (ISO/TC211 1999). One potential mechanism to achieve this goal is to

seek funding for student/faculty exchanges between Canadian and Indonesian institutions or from other home countries of students within the SEAMEO group. The first step of this process was achieved with COGS graduates working as instructors at BIOTROP in the initial program launch. However, there are a number of additional possible combinations that could facilitate achievement of this objective:

a) for BIOTROP students: one year at BIOTROP and one year at COGS or an equivalent Canadian institution, leading to an M. Sc. degree;
b) for COGS students or Canadian equivalents: one year at COGS and one year at BIOTROP, leading to an M. Sc. degree;
c) for BIOTROP faculty: teach courses at COGS or equivalent, especially in Tropical Biology, Modelling and Decision Support Systems;
d) for COGS or equivalent faculty: teach courses at BIOTROP, especially in data collection e.g. the use of RadarSat and other imagery technologies;
e) for both COGS or equivalent and BIOTROP faculty and students: initiate joint research projects e.g. coastal resource management with field work and data collection work in Canada and Indonesia.

These types of exchanges between institutions would serve to enhance the quality and diversity of the curriculum at BIOTROP, while also satisfying an important strategic planning objective of Canadian institutions namely, to make their programs world class and international.

Other Issues:
Hardwick et. al. (1999), in their paper on delivering courses internationally, have identified five issues that must be addressed, namely:

(a) cultural imperialism,
(b) content localisation,
(c) student-teacher relationship,
(d) academic equivalencies, and
(e) assessment strategies.

At the end of the first year of delivering 'hands on' GIS and IP/RS courses in Indonesia, these categories have been used as a framework for reflection.

a) *Cultural imperialism:*
The teaching style, format and content, by design, of the BIOTROP program followed the model developed by and used at COGS. However, significant adjustments had to be made to accommodate the differences in educational culture and expectations between the two contexts. These differences centred especially on the authority relationship between faculty and students. In general, the Canadian style is more flexible and relaxed, whereas many of the Southeast Asian students were used to a more formal, rigid and authoritarian style of student/instructor relations. In Indonesia, there is less comfort

on the part of students with open-ended questions, ill-defined or ambiguous procedures. Adjustments were also made in the evaluation of the students with a greater emphasis on structured tests and examinations than might be true of the Canadian context.

The software and the analysis techniques used in the curriculum were based on the North American marketplace. In Canada, this has direct relevance to the careers of students, where agencies and companies can afford and have access to the same hardware and software. In Southeast Asia, many of these products may not be as readily available. This is definitely an issue for graduates returning to provincial universities with limited funding or to provincial Government offices that lack the resources of highly centralised Governments structures.

b) *Content localization:*

Students enter the BIOTROP program with very specific regional interests. For their major research projects, this can pose a problem. In many parts of Indonesia, spatial data availability is either , non-existent, limited or of poor quality. Hard copy maps, in some cases, are restricted in their use by the military, especially in areas of national strategic interest. Away from Jakarta, there is a lack of metadata standards. Further, the differences in the geography of Canada and Indonesia, where local landscape features do not have an equivalence, for example, mangroves, oil palms, rice fields, presented an initial challenge to the Canadian instructors until they extended their skills into the substantive domains relevant to the regional context of the BIOTROP program.

c) *Student-teacher relationships*

All of the courses in the Masters program are delivered in English. Effective communication requires the extensive use of visual aids and a procedural approach to problem solving. Initially the Indonesian students were reluctant to approach the instructors with questions and concerns. This was improved by easy access to email (a non-threatening alternative).

d) *Academic equivalencies*

Even though the BIOTROP program established a set of prerequisites, there was a need for some remedial coaching to bring the students up to an acceptable level of familiarity with the concepts and the technologies being introduced into the curriculum. This was not unexpected, given the relative recency of the diffusion of spatial information technology to South East Asia. The main areas of need, beyond spatial information concepts, were to improve computing knowledge, to develop better problem solving skills and to enhance understanding of English. Since a number of the students had come from provincial universities, their field of interest could be very narrowly defined for a particular issue of regional significance. Every effort was made to try and broaden their horizons.

e) Assessment strategies

The M. Sc. students receive courses from both Canadian and Indonesian instructors. Given the different cultural backgrounds, there were different instructor expectations. This was evident, especially, in the practical laboratory work, where the instructors and students had to reach a new understanding and a level of equivalence in presentation and performance.

One of the intentions of the BIOTROP program was to gain 'international' status. This has important implications for the students from the provincial universities in terms of the career prospects both within their workplace and in general. To achieve this status will require further effort by both parties including the introduction of student and faculty two way exchanges.

4.0 Future Directions

In general the technology transfer between BIOTROP and COGS was very successful. A second team of COGS graduates assisted with the second year of the Masters program (1999-2000). This team of three graduates has had responsibility for the first year GIS and IP/RS courses and also a second year, Spatial Database Management course, plus a CIDA-sponsored short course in IP/RS. In September 2000, the downturn in the Indonesian economy and the availability of new Indonesian graduates from the Masters program has allowed the GIS and IP courses to be delivered by Indonesian faculty.

During the first year of the Masters program, alternative funding was sought from Canadian sources for Canada-Indonesia faculty and student exchange. These ventures proved unsuccessful, partly because of changes in the political and economic climate in Indonesia and partly because of changes in Canada's international policies.

5.0 Conclusions

The relationship described in this paper between BIOTROP and COGS exists at several levels. First, there has been a successful technology transfer through the Canadian instructors (using a Canadian teaching model including established course content that is practical, intensive and delivered with a hands-on style). Secondly, the involvement of Bio Geographics International, Waindo Specterra, and JKR Associates, private sector consulting companies in Canada and Indonesia, allowed flexible management, rapid response, access to software and a sensitivity to the trends in the marketplace. This approach proved both cost effective for the BIOTROP graduate program and also facilitated the delivery of short courses for the Indonesian marketplace. This same approach to technology and knowledge transfer has the potential to be extended to other countries, not only within South East

Asia but also elsewhere. With additional funding, improvements can be made to strengthen the relationships that have been established. Graduates from COGS, with the combination of a first degree and the post-graduate diploma, could be eligible for international internships to support further the existing relationship.

At present, after one year overseas teaching, the COGS graduate find themselves returning and then enrolling into a full time Canadian graduate program, specialising in spatial information technology. A more integrated relationship between the two institutions could allow Canadian students to conduct their research in Indonesia and return to Canada for completion of their Masters degree through institutions involved in an extended collaboration. Another logical extension would be funding for BIOTROP students to spend their second year at COGS or at an affiliated Canadian university.

Cross-cultural education and training relationships depend upon long-term commitments (up to ten years). If the network of connections is rich (that is, student:student; faculty member:faculty member; consultant:consultant), then there is a greater likelihood of long-term success. The key role of the private sector in this set of connections is its understanding of the marketplace in both North America and South East Asia. As a result, they can initiate projects which generate funds complementary to those provided by the traditional funding agencies. Forer and Unwin (1999) described the issues that impact GIS programs in the western world. In this paper, the process of curriculum transfer from COGS to BIOTROP (or Canada to Indonesia) demonstrates the critical nature of external factors. Of particular significance, is the common linkage between industry and academia which promotes internationalization of education in Spatial Information Technologies in developing countries. The active involvement of the private sector in both countries is needed to fund the technology, internships and joint research and consulting work.

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