EIS EDUCATION IN AFRICA – THE GEOMATICS PERSPECTIVE

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Key words:

ABSTRACT

The paper outlines the role of Geomatics in EIS, discusses international trends in education and identifies some of the key capacity building problems specific to Africa and in particular to EIS education. Some possible solutions to these problems are briefly sketched out. The paper closes with some thought on the role of International Donor agencies in EIS education. In an appendix, a brief overview is given reporting on the status of Geomatics education in Southern Africa and in parts of East Africa.

1. INTRODUCTION

The growing recognition of the relevance of the protection and management of the environment and the earth's natural resources, combined with the advance of computer technology has lead to the development of computer based Environmental Information Systems (EIS). Such systems manage and make available spatially referenced information - Geo-information - for environmental decision making.

While the so-called First World and large sections of the Developing World have embraced the EIS concept enthusiastically and implemented EI systems in a wide range of applications, Africa has lagged behind in EIS applications, education and training, research and development, establishment of EIS agencies, and installation of technology. In those cases where EI systems have been developed on the continent they have had little impact on the development process.

This poor response to a powerful new concept can be primarily attributed to a lack of EIS awareness among decision-makers and the limited availability of local EIS expertise.

Since the mid-nineties a number of initiatives have been taken to develop digital spatial data sets. Examples in southern Africa are the SADC topographic data sets developed by the SADC Regional Remote Sensing Unit in Harare – Zimbabwe, the vegetation cover map developed by VegRIS in and for Zimbabwe, and the same map developed by the CISR in and for South Africa. However, there is still a shortage of a complete set of spatially referenced data in digital form to support the wide spectrum of EIS activities, which makes it difficult to demonstrate the potential of EIS to African politicians and other decision-makers, and thus to create much needed support for educational programs. Lack of EIS awareness and insufficient capacity building are merely symptoms of underlying political and socio-economic conditions, which cannot be discussed in this paper. Instead, the paper focuses on the realities and problems of capacity building aspects of EIS in

Africa in general, and attempts an analysis of the education and training situation in Geomatics, one of the disciplines that contribute to EIS. However, before elaborating on Geomatics education in the EIS context, a brief inspection of the present educational needs and development is required.

2. INTERNATIONAL TRENDS IN EDUCATION

Before discussing education in Africa some observations on international trends are necessary. At present, the international education scene is undergoing a process of redefinition of its core activities. Universities and polytechnics worldwide are critically reviewing the relevance and efficiency of their educational methods and philosophies and significant paradigm shifts are either taking place naturally or are forced on educational institutions. In addition to this there is a trend to require University Departments to become self- funding, a tendency which adds significant to the workload of academics and which distracts from the core business of teaching and research.

Paradigm shifts in Education	
From	To
Specialised departments	Outcomes based programmes
Specialised education	Interdisciplinary education
Broad knowledge	Outcome competency
Pure research	Applied science
Research	Teaching
Standards	Access
Full Government funding	Self- financing

These paradigm shifts are relevant to EIS education and deserve brief consideration.

'Open-ended' degrees, such as the traditional Science degrees, are, at many educational institutions, replaced with a range of specific programmes, each streamlined towards a predefined outcome, a specific career. As this process is in its early stages it offers an opportunity for EIS to be established as one of these programmes or as part of a programme and it would appear advisable to promote this concept to tertiary education institutions involved in this process.

The ever-accelerating growth of the knowledge base of all areas of technology and science has softened the boundaries between disciplines, and education and training at undergraduate level is becoming increasingly interdisciplinary. The interdisciplinary nature of EIS is an example of this trend.

Scarcity of resources and the need to rely on industry funding have made pure research a luxury for many educational institutions and application oriented research is taking its place. EIS with its focus on application fits well into this development.

The move from a research focus to a greater emphasis on teaching as well as the broadening of the student base through improved accessibility to polytechnics and universities are of more general educational relevance and have no specific bearing on EIS education.

With a few exceptions, the African education environments appears untouched by these international developments and at present most institutions in Africa are engaged in solving elementary educational and resource problems rather than embracing new philosophies. Priorities are, by necessity, different to those of the developed world, and the widespread lack of human and financial resources overshadows all other issues. In this environment of restrictions and limitations it is important to 'economise' and jump evolutionary stages wherever possible. There is no justification to complete an inappropriate or outdated process and repeat the mistakes of the education systems of the developed world. Instead, African education should adopt the realities of the new trends wherever they appear appropriate.

In addition to this, there is a tendency to initiate research and to start courseon the basis on available funding rather than on real needs. Instead of working according to a well planned educational curriculum, curricula are designed with a view to possible donor funding or assistance from Universities or Organisations from the developed world.

3. GEOMATICS IN EIS

Environmental Information Systems represent a computer-based collection of spatially referenced information relevant to the natural environment. An EIS system comprises the four principal components of data acquisition, data management, data analysis and modeling and data presentation and communication. These components are supported by a variety of disciplines and professions. Principal among these are environmental science for the analysis and decision-making and Geomatics for data acquisition, management and spatial modeling. Many other disciplines, such as computer science, botany, agriculture and geology underpin EIS.

The lack of accurate, current and appropriate geo-referenced spatial data has caused the failure of many information system projects in Africa. The relevance of quality spatially referenced Geo-information in EIS cannot be over-emphasised. It is typical for the data acquisition component of a spatial information system to be underestimated with respect to time and cost. There appears to be a perception among decision-makers and even EIS planners that the necessary data are either readily available or can be acquired quickly and cheaply. In reality however, and especially in Africa, such data are either badly out of date, inaccurate or not available at all. Estimates for the cost of data acquisition for spatial information systems are as high as 90% of the overall project costs

The following table is an attempt to identify the disciplines involved in the various activities which provide the skill base for EIS

Activities	*Supporting Disciplines*
data acquisition	Geomatics/surveying (remote sensing, photogrammetry, mapping) environmental and natural sciences (environmental attribute data acquisition)
data management	Geomatics (GIS), computer science, information technology
data analysis and modeling	environmental science, environmental engineering, geography, Geomatics, applied mathematics, statistics, urban and regional planning, agriculture, forestry, nature conversation
data representation and communication	computer science ,computer vision, CAD/GIS, digital mapping, Geomatics

One of the underlying difficulties in providing education and training in EIS is its interdisciplinary nature. In itself and in its present form, EIS is not sufficiently broad to justify the creation of an independent degree, although this could be changed by broadening the EIS discipline. Subsequently there are at present no EIS degrees at either polytechnics or universities and experts are typically specialised in one area with some knowledge in the other aspects of EIS. It is essential for the optimised design and use of EI systems to integrate these disciplines, at present however, EIS education still takes place in separate entities one of which is Geomatics.

The discipline of Geomatics, a modern information-technology-oriented extension of the traditional activities of surveying, photogrammetry and environmental, provides the spatial reference for EIS. Surveying, or land surveying, has until recently been able to rely on its long history and reputation and resisted change in its philosophy, while adopting new technologies. The birth of the information society has now enforced a change and surveying in its conventional form as a data acquisition and management technology has formally embraced the information technology domain and placed greater emphasis on spatial data management, analysis and presentation.

Geomatics can be defined as the modern scientific term referring to the integrated approach to measurement, analysis, management, and display of spatial data. Geomatics activities include, but are not limited to, cartography, control surveying, digital mapping, geodesy, geographic information systems, hydrographic surveying, land information management, land surveying and mining surveying, engineering surveying and industrial measurement, photogrammetry and remote sensing.

Among these sub disciplines, digital mapping, geographic information systems (GIS), photogrammetry and remote sensing stand out as especially relevant to EIS. It is important for the EIS community to acknowledge that environmental information systems without spatially referenced information cannot exist, and thus, that Geomatics practitioners and Geomatics education are essential for the creation of Environmental Information Systems.

There a number of Universities (Fig.1) , Technikons (Fig.2) and Regional Centers which offer Geomatics/Surveying at graduate and postgraduate level, in addition to this a significant contribution is made through in-house training at Government Agencies (National Mapping and survey Departments), commercial GIS agencies and , to a lesser extent, software vendors.

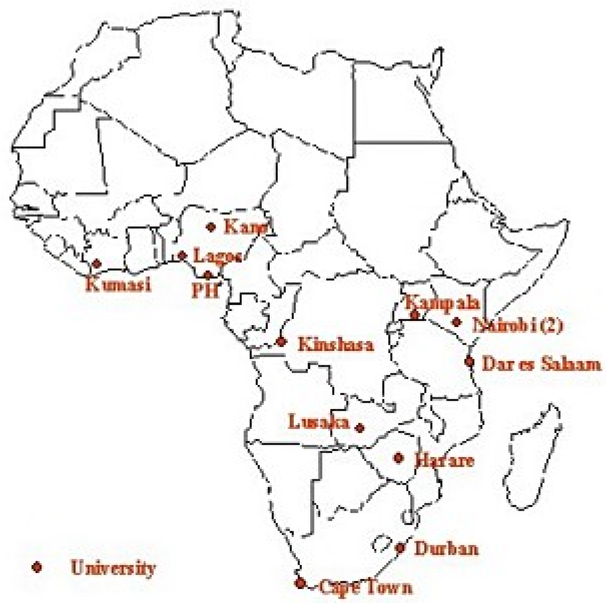

Fig 1. Universities with Geomatics/Survey Departments

Fig 2. Technikons with Geomatics/Survey Departments. (Note, the Technikons shown here are likely to be only an incomplete selection as the author was unable to locate a comprehensive list of Technikons in Africa.

4. THE ROLE OF GIS IN EIS

GIS is the principal data management and analysis tool for EIS, and education and training in this field must necessarily play a central role in the development and use of environmental information system. GIS is frequently referred to and depicted as an independent discipline worthy of a full 'stand-alone' degree. In the authors opinion this is an incorrect perception of GIS. While environmental science, geography, computer science and Geomatics are full degrees, remote sensing, photogrammetry, image processing and GIS are not. They are merely tools, albeit complex one's, which contribute to the aforementioned disciplines. GIS cannot stand on its own without the theoretical back ground provided by other disciplines such as Applied Mathematics, Statistics, geography and Geomatics and one must guard against attempts to upgrade GIS to a discipline or profession worthy of a separate degree. However, this is not to say that GIS is not a central component in EIS education, GIS courses as standalone short courses or as components of a degree must form part of EIS education at all levels.

5. KEY PROBLEMS IN EDUCATION IN AFRICA

Over the past years a number of highly correlated problem areas have emerged in EIS education in Africa, many of these are not restricted to EIS and common to education in Africa in general. The following lists some of the key areas of concern. Each of the problems identified requires a detailed analysis and none has an easy solution. Notwithstanding this, the author has added some thoughts - most of them obvious - towards possible solutions, more in the spirit of a challenge inviting discussion than as definitive proposals:

(a) Educational systems in Africa are generally modeled exclusively on First World criteria and First World publications dominate the academic scene. Thus little Africa-oriented expertise is generated in Africa.

This can be addressed by Africanisation of education and research while striving for, or retaining, international links and standards.

(b) There is a lack of communication between educational institutions in Africa (South-South links) which are neglected in favour of contact with the First World (South – North links).

(c) The education and research networks existing in Africa are often merely nominal and their activities are restricted to meetings with little follow up.

Points 2 and 3 can be addressed by emphasising the sustainability of networks through tangible and more clearly defined objectives, donor/government imposed network discipline and the introduction of mechanisms which provide networks with problem solving capabilities.

(d) There appears to be limited confidence in African educational institutions in Africa as well as the developed world. Subsequently an over-reliance on educational institutions in the First World has developed.

(e) As a result of lacking confidence in African educational institutions, student numbers at African institutions are low when compared with First World institutions and revenues from tuition fees are often insufficient to the support adequate staffing, equipment and research projects.

(f) Also resulting from the limited faith in African education is an African 'brain drain' especially in the academic area, with top students and academics being lost to better-resourced educational institutions in the First World.

In the final analysis, faith in African education can only be created through a continent-wide tangible improvement of academic standards and capacity.

(g) Most research projects in Africa are driven and funded by the First World and very few joint South-South research projects are in existence

(h) Many African institutions of higher education are not engaged in any research, thus limiting staff development

Donors and governments could be encouraged to fund Africa-oriented research projects, jointly designed and executed by African institutions, and employ African consultants to work alongside those imported from outside the continent.

(i) Varying academic standards and degree criteria at African educational institutions make it difficult for students to move between institutions.

A centrally administered accreditation of diplomas and degrees could contribute much towards student mobility, especially in the area of postgraduate research.

A similar, voluntary, accreditation scheme for EIS professionals and experts at all levels, administered by a regional organisation, could serve to generate confidence and trust in EIS among decision-makers and the public.

(j) Only a few educational centres provide EIS related education in Africa .

A needs assessment should be initiated and universities and polytechnics should be encouraged to introduce EIS courses, provided a need for such courses can be established. Africa wide co-ordination of EIS education would have to be a principal criterion in this process.

(k) The role of EIS practitioners and professionals is not yet clearly defined, no standards or competency expectation have been formulated and subsequently no syllabus for the training and education of EIS experts exist at polytechnic or university level.

The design of a skeleton EIS syllabus should be encouraged and the role of EIS experts at all levels should be defined through a detailed list of knowledge, skills and competencies.

(l) Many technologies, among these some components of EIS core disciplines, have changed to black-box solutions, allowing unqualified 'experts' to claim work previously reserved for the professional. Predominant in EIS in this regard are remote sensing, photogrammetry and mapping. Because of the apparent ease with which software produces results, the complexity of spatial data acquisition is often overlooked by the lay-user of off-the-shelf solutions. This can result in serious errors and in turn bring disrepute to professions, potentially reduce interest in sound education and ultimately undermine polytechnic and university education.

Users of EIS products must be educated to an awareness of the danger of superficial solutions without expert backup and the need for technically sound methods.

(m) A problem specific to Geomatics is the common perception that spatial data acquisition aspects of EIS are trivial. The data acquisition disciplines are seen as service providers rather than as a core expertise, frequently resulting in the acceptance of poor spatial data produced by non-experts.

As for the previous point users and decision-makers must be sensitised to the need for expertise and thus quality education in EIS and Geomatics. This could be achieved through an awareness campaign.

(n) In his capacity as external examiner at various African Universities, the author has, in some cases, observed a striking gap between the students apparent knowledge as displayed in written examinations and their ability to respond to questions and to solve problems in oral follow ups. This would seem to be a clear indication of a tendency towards ‘road learning’; students often regurgitate material presented in lectures without fully understanding the subject.

Teaching methods must be modernised and team problem solving, critical analysis and team learning need to be encouraged.

(o) Salaries of academics in African educational institutions are often so low that, in order to survive, academics frequently have to spend a excessive amounts of time on consulting activities. Under these circumstances teaching and especially research must necessarily suffer.

The solution to this is obvious, however the chances of significantly improved academic salaries in Africa are dismal and thus it is left to dedicated individuals to make personal sacrifices in the interest of education.

The complexity of the educational situation on the African continent in general, and in EIS and Geomatics specifically, cannot be overemphasized. The solutions to the problems outlined are expensive in terms of material and human resources and require governmental as well as donor support. However, as daunting as the challenges may be, they are manageable, provided the critical, and, in the author’s view, most decisive ingredient towards an improvement of education in Africa exists and this is the personal commitment of individual academics and those related to education.

6. SOME THOUGHTS ON THE RELATIONSHIP BETWEEN DONORS AND EIS EDUCATION

Education at tertiary level in Africa relies extensively on donor support and 'capacity building' and 'sustainable development' are today seen as the *sine qua non* of many donor supported activities. There is a wide range of ways in which students and academics are supported, from full time degree studies via postgraduate degrees to post doctoral studies, from attendance of conferences via sabbatical leave invitations to participation in research at institutions around the world. All this is extremely valuable and beneficial to the individual, exposing him/her to high levels of state-of-the-art expertise, modern equipment and different cultures, and when or if he/she returns the newly gained knowledge can be transferred to the home country. However, there are also some dangers associated with such support.

As pointed out in the previous section, one of the central problems impeding the building of capacity in Africa, is the 'pull of the First World'. Donor funding for tertiary education outside Africa is typically provided for the best students and graduates. They are the ones most likely to succeed and become high-level achievers. As a consequence they are frequently lured away to First World positions with better facilities, higher salaries and a quality of life perceived by some as superior to that in their African home. This phenomenon has a dual affect. Not only is there a South-to-North brain-drain, making it difficult for African institutions of higher education to attract staff, it also has a negative effect on student intake. Subsequently university departments, and among these especially the smaller ones, find it difficult to recruit students. The revenue from student fees is reduced and departments become uneconomical and eventually have to close down.

It is not suggested here that donor funding for education in the First World is inappropriate, there can be no doubt concerning the benefits of such exposure to the First World for student or academic. What is suggested however, is

- increased emphasis on institutional capacity building as opposed to the support of individuals. Individuals are much more likely to succumb to the attractions of the First World than salaried staff members employed by an institution.
- increased emphasis on the support of students for studies in education institutions in Africa and exchange of staff between African Institutions. This would expose students to an educational structure which reflects African standards and appropriate technologies as opposed to those of the First World standards. At the same time institutions of higher education in Africa would improve revenues from student fees and increase their chances of survival.
- support of joint South-South research. The author believes that exposure to research is one of the corner stones of good teaching.

There is the additional less tangible phenomenon for which no solution can be proposed and that the tendency of some first world universities to use over-lenient selection criteria for candidates from the developing world. It is not always the "best" student who is selected. This is aggravated by, what appears to be, a separate set assessment criteria for such students when it comes to the awarding of degrees, as reflected in low failure/drop out rates. This is especially true for diplomas and post graduate degrees.

7. STRUCTURES OF EIS EDUCATION

Education and training in Geomatics can be loosely classified into seven, partly overlapping levels

- University Education
- Polytechnic Education
- Continuing Education
- Project related training
- Training through short courses
- In house training
- Remote Learning

- **University courses**

  University education typically takes the form of a B.Sc. degree of three years duration, when associated with a Science Faculty, and four or five years in an Engineering Faculty or an independent department. Most universities provide the option to continue with a Masters degree, usually as a Masters of Science or Applied Science. This degree can be taken as a course based degree, a research degree or a combination of both. The standard research degrees requires two years, while some course based degrees can be obtained in one year. The continuation to a Ph.D. will, as a rule, take the form of research. In addition to this some departments offer diplomas for non-degree purposes to polytechnic graduates.

  A university course in Geomatics/surveying typically contains two to three years of courses in mathematics, science and computer science in addition to the topics listed in the definition above. Generally courses in environmental science, geology and management form part of the curriculum.

- **Polytechnic courses**

  Polytechnic education in Geomatics/surveying is offered at various levels and in a variety of forms, the most common being a three-year course. The course is often presented in a sandwich structure, incorporating a practical year between the first and third year. Polytechnic courses are at present more ‘outcomes-based’ than universities and still frequently teach method rather than background. There is a need for graduates from both the university and the polytechnic with university/polytechnic student ratios varying from 1:3 to 1:7 being quoted as optimal. However, these ratios must be seen as highly correlated to local conditions and cannot be seen as generally valid.

- **Continuing Education**

  The current information-, knowledge- and technology- explosion has reduced the half-life of professional knowledge substantially and additional education will be required at ever decreasing intervals. The professional and technician of the future must expect to have to frequently write-off part of his/her knowledge as obsolete and replace it with up-to-date expertise. This is most prominent in the computer and software related areas.

- **Project related training**

  Internationally funded projects are more often than not associated with a capacity building component. This takes the form of courses presented in the donor country or on site. Such courses are valuable, but due to their project related objectives, generally restricted to specialised and narrow training exercises rather than education.

- **Short courses**

  Polytechnics, universities, NGOs and a variety of other institutions and individuals offer short training and advanced education courses. Such courses are an efficient way of training individuals for specific activities or introduce them to a new technology. The author sees their main use in continued education.

- **In house training**

  An approach, widely employed in Africa, is the in-house training of staff members of government offices and large companies. The rapid developing of new equipment and technologies makes it impossible for tertiary education institutions, especially in an environment with severely limited resources, to provide hands on training on state-of-the art equipment. Tertiary education must provide problem solvers and not machine or computer operators. Government offices and larger organisations on the other hand are more likely to be equipped with modern technology and must take responsibility for training in these areas. In-house courses tend to be highly stream lined and efficient and make an important contribution to capacity building in Africa.

- **Remote Learning**

  Remote learning has become a possible alternative to conventional classroom teaching and it is slowly making its way into Africa. Especially Australian universities have recently shown an interest in expanding their activities into Africa through remote learning and the EIS community must take note of this new technology as a potential capacity building tool. However, in which form and at what level remote learning can be employed to contribute the EIS education, requires a careful investigation and the merits and disadvantages of remote learning are too complex to be discussed in this paper.

The entire range of education and training options must be explored with respect to their potential to EIS expertise in Africa. The optimal solution to capacity building will most certainly be a combination of the different approaches and this combination will vary from country to country and with time.

8. CONCLUSIONS

After discussing some international trends, which are likely to have an impact on EIS/Geomatics education in Africa and after defining the role of Geomatics as one of the principal components of EIS, the paper concentrated on identifying problem areas in EIS education in Africa. It is clear that EIS education cannot be divorced from education in Africa in general. The majority of the educational problems in EIS are in fact not specific to the discipline but rather a result of more generic shortcomings in African education.

The emphasis on problem areas has lead to a somewhat one-sided picture of the African scenario and it must be stated that some excellent educational work is done on the continent. There are, albeit a limited, number of success stories of educational institutions with excellent staff, sound programs, and reasonable equipment. There can be no denying though that, at present, and with only a few exceptions, EIS/Geomatics education in Africa is not at the same level as in the First World. This is primarily due to a lack of resources and a limited infrastructure. A significant amount of work, personal involvement and, above all, resources are required to create an environment in which education can thrive and reach First World levels. However, it is up to those involved in education to develop the great, as yet largely untapped, potential of Africa and create an environment in which African educational institutions are equal partners in the international education scene.

APPENDIX - A Brief Account of Geomatics Education in Southern and East Africa

Southern Africa

In the absence of complete and detailed information on African Geomatics education, the following attempts an overview without any claim to completeness.

A number of developments, prominent among these being changes in technology (the black box syndrome), political instability, lack of resources and other phenomena, which are beyond the scope of this paper, have resulted in a severe decline of Geomatics education, certainly in South Africa but also in other African sub-regions.

In the seventies there were five Survey Departments at South African universities (Cape Town, Durban, Fort Hare, Johannesburg and Pretoria), today there remain only two. The Department of Surveying and Mapping at the University of Natal, has recently been amalgamated with the Department of Civil Engineering, leaving the Geomatics Department at the University of Cape Town as the only fully independent department of Geomatics/Surveying in South Africa. Student numbers have been reduced drastically and at present there are not more than 80 undergraduate students in South Africa studying surveying/Geomatics at university level under the guidance of less than ten Geomatics academics. The average of less than 10 candidates expected to graduate from South

African universities annually in the next years is unlikely to fulfill the needs of the Southern African spatial data market and urgent steps need to be taken to improve this situation. The situation at polytechnic level is similarly critical. Six departments offer survey courses at polytechnic level with a total of about 240 students and an expected yearly number of 80 finalists.

In the countries surrounding South Africa, only the University of Zambia and the University of Zimbabwe offer full university degrees in surveying/Geomatics. Student unrest and/or economic problems have severely reduced the educational capacities of the Geomatics departments at these two universities and, from an outsider's perspective, their survival appears threatened. Government priorities in the region have shifted to more immediate needs, such as primary education, unemployment, community health and housing needs and Universities suffer severe financial constraints. This situation is likely to deteriorate.

The Department of Civil Engineering at the University of Botswana offers a diploma in Geomatics and there is an initiative to upgrade this diploma to a full B.Sc. degree.

Namibia, Lesotho, Swaziland, Mozambique and Angola do not offer a Geomatics or environmental degree at a university.

East Africa

In the absence of detailed information only very rudimentary picture

In Tanzania, the former Ardhi Institute has been transformed and upgraded from polytechnic to university level and renamed UCLAS, University College for Land and Architectural Studies. The Department of surveying at UCLAS offers a full B.Sc. degree in surveying including photogrammetry, GIS and remote sensing. The ten academic staff members provide courses for some 120 students.
A survey degree is offered in Kenya by one of the oldest survey departments on the continent. In Uganda surveying is taught at the Makerere University. In addition to the Geomatics courses, environmental courses form part of other degrees at universities in the region.
In Uganda a Surveying Degree is offered at the Department of Surveying at the Makerere University.
In Ethiopia Geomatics is offered at the polytechnic in Addis Ababa.

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